# Autodesk 3ds Max 

Autodesk ${ }^{\circledR}$ 3ds ${ }^{\circledR}$ Max 2011
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## Introduction


#### Abstract

Welcome, and congratulations! You've just bought a ticket to the world of Autodesk ${ }^{\circledR} 3 \mathrm{ds}$ Max ${ }^{\circledR}$. Hang on and get ready for the ride of a lifetime! With 3ds Max, you can create 3D places and characters, objects and subjects of any type. You can arrange them in settings and environments to build the scenes for your movie or game or visualization. You can animate the characters, set them in motion, make them speak, sing and dance, or kick and fight. And then you can shoot movies of the whole virtual thing.


You can use 3ds Max to visualize designs of real things that will actually be built, such as buildings and machines. The File Link feature of 3ds Max lets you base visualizations on designs created in AutoCAD ${ }^{\circledR}$ or Autodesk Revit ${ }^{\circledR}$ Architecture: When the design changes in these other applications, the revisions can be automatically updated in your 3ds Max scene. Add lighting and materials, then render to still image or movie formats.

These tutorials teach 3ds Max through a series of hands-on exercises. Prepare to be entertained and fascinated by the awesome power at your fingertips.

## Acknowledgements

Special thanks are due to a number of hardworking and talented individuals who helped create this volume of tutorials. A tip of the virtual hat to:

- All those customers and users who have allowed us to showcase their artwork, whether in the User Showcase on page 5 section or elsewhere in the help and tutorials.
- All those who have contributed models and methods used in these tutorials, including Jean-Marc Belloncik (skinning and quadruped animation), Michele Bousquet (two-legged Biped animation), Mark Gerhard (Set Key animation and the character studio introduction), and Amer Yassine (models, methods, and artwork too numerous to list). There are other contributors whose names aren't available: We apologize for omitting them, and thank you for your help as well.


## Where to Find the Tutorials

The Tutorials link on the Help menu takes you to the HTML tutorials. These are located on the Web at www.autodesk.com/3dsmax-tutorials-v2011.

## Where to Find Tutorial Files

To access the scenes and other resource files you need to complete the 3ds Max tutorials, go to www.autodesk.com/3dsmax-tutorials-scene-files-v2011.

## How to Learn 3ds Max

Besides the tutorials found in this collection, a number of other resources are available to help you learn 3ds Max. In particular, consider the online Help file an important adjunct to the tutorials; if you encounter a feature you'd like to learn more about, look it up in the 3ds Max Help. There you'll find general descriptions, detailed descriptions of all the controls, usage notes and tips, and procedures for accomplishing various tasks.


## Yesterday, The Lost Time

Zhelong Xu

## Autodesk 3ds Max 2011 Documentation Set

- Autodesk 3ds Max 2011 Help: The online help covers fundamental concepts and strategies for using the product, as well as details about the features of 3ds Max.
Access the reference online by choosing Help > Autodesk 3ds Max Help.
■ Additional Resources: A number of additional help files are installed with the software and are available from the Help > Additional Help menu.


## 3ds Max on the Web

Links to the following Web sites are available from the Help menu within 3ds Max. These pages provide access to a wide range of product information and support resources: searchable Knowledgebase, FAQs, technical bulletins, tested hardware information, and product downloads.

- Online Support
- Updates


## Resources <br> - Partners <br> Training

## Autodesk Training Information and Resources

- Learning Path: Autodesk provides you with a single access point to an interface overview, discussion groups, essential skills movies, technical support, training resources and more. To access the this site, go to: http://www.autodesk.com/3dsmax-learningpath.
- Training Resources on the Web: You'll find additional training resources for 3ds Max at http://www.autodesk.com/3dsmax-training.

■ Other Resources: There is a wealth of information written about using 3ds Max. There are third-party books that specialize in teaching the software for various industries. There are magazines devoted to 3D design and animation, as well as user groups and mail lists. Communities of users trade secrets daily, and if you ask a question, you're likely to get answers from experts all around the world.

Some of the above programs or contact details might not be available or applicable in your country. Please check with your local Autodesk Authorized Reseller or Autodesk office for details.

## Browsing the HTML Tutorials

The title bar of each tutorial page contains both browse buttons and contextual links.

You can use the three buttons in the upper-right corner of the page to browse the tutorials. The button with the left arrow goes to the previous page, and the button with the right arrow goes to the next page. The upward-pointing arrow goes to the parent page; if there is no parent, this button is blank.


When you move your cursor over one of these buttons, the browser displays the name of the page that the button points to.


The other three buttons at the upper right of the title bar provide additional controls:


Show in ContentsUpdates the Contents panel at the left to show the page you are reading.


Add to FavoritesCreates a bookmark to this page on the Favorites panel at the left.


Home: Autodesk 3ds Max TutorialsGoes to the graphic Welcome page.

In addition, a series of links appear above the topic title. These show the path of the topic within the 3ds Max tutorials.

> Renderina Tutorials > Reducina Complexity in Your Renderinas > mr Proxies >
> Loading Proxy Files Into a Scene

The first link on the left is the chapter (top-level page) that contains the page you are reading. If there are additional container pages, these appear in order after the chapter link. Click any one of these links to go directly to the topic it names.

## User Showcase

In the 3ds Max tutorials, we teach you the tools to use the software. Put those tools in the hands of talented artists and magic happens.

Here is a gallery of images by creative individuals from around the world using this software. We hope you find these images inspiring before you set out on your journey of learning 3ds Max.

Le Rabbit
José Alves da Silva
josealvessilva.daportfolio.com


Composition: Childhood Toys
Vincent Dany
Copyright © 2008
ermite.net

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Gull and Me
Dejan Kober
berko.3dhr.net


Office Floor
Jamie Cardoso, GMJ Design Ltd


Chinese Opera
James Ku
www.3dartisan.net/~kuman/

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The Ancient Indian Crown
Kameswaran Ramachandran lyer, India
www.kameswaran.com


Ice Cubes
José Manuel Elizardo, Autodesk, Inc.


## Apples

José Manuel Elizardo, Autodesk, Inc.


## Pete Draper

xenomorphic.co.uk
Deconstructing the Elements with 3ds Max, Third edition
Elsevier (Focal Press), © 2009

Only Human
Jacques Pena
www.9dkid.com


Unpleasant Company
Metin Seven


A Living Room
Frances Gainer Davey


Guardian of the Enchanted Forest
Marc Tan, Insane Polygons


Old Courtyard
Pradipta Seth

by Tommy Hjalmarsson
home.swipnet.se/~w-19339/GALLERY/frame.htm

by Tommy Hjalmarsson
home.swipnet.se/~w-19339/GALLERY/frame.htm


Student Breakfast
Jean-Yves Arboit, Belgium
www.cgitrainer.com


Electric Water
Johannes Schlörb
www.schloerb.com

The Sky Fisherman
Akin Bilgic
cggallery.com


Ripples of Spring
Casey McGovern
molerocket@hotmail.com


by Ben Paine


Environment

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Thilan Harshadhamma


Old Sunflowers
Joana Garrido (Caixa D'Imagens), Portugal


Pistol Pete


Sommar Torp: "Summer House"

## Sören Larsson, Sweden



Anibal
Daniel Martínez Lara (Pepeland)


Yesterday, The Lost Time
Zhelong Xu
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## Getting Started: Animated Battle Scene

This tutorial, intended for those new to 3ds Max, offers a quick introduction to the world of 3D.

Using basic features of the program, you'll create a simple battlefield scene made up of a cannon, a rock, a tree, and a windmill. You'll also add a camera and use it to view the scene from different angles.

The final steps show you how to add some basic animation, then turn the results into a multimedia file.


The battlefield

In this tutorial, you will learn how to:

- Open a scene
- View a scene from different angles and perspectives
- Model objects and apply realistic materials
- Move and animate objects
- Render the scene and save it as a multimedia file

Skill level: Beginner
Time to complete: 1 hour

## Navigating a Scene

In this lesson, you'll open a partially-completed scene of a battlefield and learn how to adjust the view and navigate the viewports.

## Set up the lesson:

1 On the Quick Access toolbar, click

(Open File).


2 In the \scenes\startup folder, highlight battlefield_start.max, then click Open.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.


Perspective viewport

The Perspective viewport should be active, indicated by a yellow border. If no border is visible, click anywhere within the viewport to activate it.

## Navigating the scene:

1 Depending on how your system is currently being used, you might have up to two navigation tools displayed in the viewport. The ViewCube ${ }^{\mathrm{TM}}$ displays in the top right corner and the SteeringWheels ${ }^{\text {TM }} 3 \mathrm{D}$ navigation controls display in the lower left.

2 You will first take a look at the ViewCube. If the SteeringWheels is visible, hide it by clicking the X at the top right of the corner of the wheel.

NOTE If this is the first time you are using SteeringWheels, you will need to click on its icon to activate it.

3 In the Views menu > Viewport Configuration $>$ ViewCube panel Display Options group, turn on Show The ViewCube if it is not already on.
In the When Clicking On The ViewCube group, make sure Fit-To-View On View Change and Keep Scene Upright are on, and click OK.

## Display Options



Only in Active View
ViewCube Size
Inactive Opacity
Small
50\%

When Dragging on the ViewCube
$\square$ Snap to Closest View

When Clicking on the ViewCube $\checkmark$ Fit-to-View on View Change V Use Animated Transitions when Switching Views V Keep Scene Upright

## Compass

$\checkmark$ Show the Compass below the ViewCube Angle of North (degrees): $\sqrt{0.0} \mid \stackrel{\Delta}{\square}$

4 In the Perspective viewport, right-click the ViewCube and choose Set Current View As Home.


5 Click the Left face of the ViewCube to view the scene from the left. As you can see, the ViewCube lets you view the scene from alternative viewpoints with a simple click of a mouse.

Notice how the viewport zooms in to a default scene magnification as it switches to the left perspective. The change in zoom factor is not something we want in this tutorial however, so you'll change it.

6 Right-click the ViewCube and choose Configure from the menu. The ViewCube tab is automatically selected.

7 In the When Clicking On The ViewCube group, turn off Fit-To-View On View Change and click OK.
It is important to keep this setting off if you want to maintain the same zoom factor when switching between viewpoints.

8 In the Perspective viewport, click the Home icon to the upper left of the ViewCube.


The Perspective viewport returns to its initial viewpoint.
NOTE You can reset the Home viewpoint to the current view at any time by right-clicking the ViewCube and choosing Set Current View As Home.

9 Click (Zoom) in the viewport navigation controls at the lower-right corner of the 3ds Max window.

To show that this control is now active, the button is highlighted.


10 With the mouse, drag downward in the Perspective viewport. Your view zooms out so you can see the scene from a distance.

NOTE You can also zoom in or out by rotating the mouse wheel forward or backward.

11 In the viewport navigation controls click . (Orbit), which is below and to the right of the Zoom button. The button highlights when active. A yellow navigation circle appears in the viewport.

12 Position the cursor inside the yellow circle. Click and hold the left mouse button and move the mouse. This action is called dragging.
The point of view orbits around the scene.
TIP Avoid dragging outside the yellow navigation circle, unless you want to roll the entire viewport.

13 Use a combination of the Orbit and mouse wheel to zoom in on the windmill.


14 Orbit your view by dragging to the left or right until you can see the cannon in the opposite direction.

15 Right-click the viewport to exit Orbit mode.

16 Click

(Pan) in the viewport navigation controls and move the mouse in the viewport.
The viewport view now follows the movement of your mouse.
NOTE You can also start a pan operation by holding down the mouse button or wheel as you pan.

17 Return the viewport to its original orientation by clicking the Home icon.
18 Press Shift+W to display the SteeringWheels controls, if they are not already visible.

NOTE In this instruction, "Shift+W" is outlined with a rectangle to indicate that you must press this key combination on the computer keyboard. We use this style consistently in the help and tutorials for both single key presses and key combinations, so that it's always clear when an instruction involves using the physical keyboard as opposed to using the mouse with the software interface on the screen.

The SteeringWheels controls offer an alternative way to navigate a scene.


19 Click and drag each of the Zoom, Pan and Orbit controls in turn, and experiment with how they can be used to navigate the scene.

20 When you're done, click the Rewind button and drag to the left.
21 The Rewind tool passes over a strip of thumbnails, each of which represents a previously selected navigation point. Release the mouse on any thumbnail. The viewport rewinds to that point.


22 Experiment with the Center, Walk, Look. and Up/Down controls in the center of the SteerWheels icon. When you are done, click the arrow at the bottom right of the wheel and from the menu, choose Go Home. This repositions the viewport view to the Home viewpoint.

23 Click the small " X " in the top right of the wheel to hide the SteeringWheels control.

TIP You can press Shift + W to redisplay the SteeringWheels controls.

Next, you'll create a camera and a Camera viewport. The Camera viewport is similar to the Perspective viewport but with different functionality. You can animate it, and add effects to it.

## Creating a camera:

1 Right-click the Top viewport to activate it.
The viewport is outlined in yellow.

2 On the


Create panel, click

(Cameras), then click Target.
3 In the Top viewport, click behind and slightly to the right of the cannon, then drag down to a point just left of the windmill (as shown in the following illustration). Don't worry about the exact camera placement yet: You will adjust this later.


To see what the camera sees, you now need to display one of the viewports as a Camera viewport.

4 Right-click the Perspective viewport to activate it, then press C.
Right-clicking a viewport activates it and keeps any objects in other viewports in a selected state (in this case, our camera object). Left-clicking a viewport deselects previously selected objects.

5 On the main toolbar, click
 (Select And Move).
A tripod of red, blue, and green arrows appears in the Top viewport. This is the transform gizmo. As you move your cursor over the arrows, each axis label and arrow stem turn yellow. When one is yellow, you can click and drag to move the object in a single direction. If you move your cursor
over the inner corners of the transform gizmo, the plane turns yellow. This lets you move in a single plane.

6 Right-click the Left viewport, click the camera's Y axis manipulator, and drag it slightly upward so you can see more of the horizon in the Camera001 viewport.


7 If the cannon is not visible in the Camera001 viewport, then in the Top viewport drag the camera until the front of the cannon comes into view in the Camera001 viewport, as shown in the next illustration.


Next, you'll create a rock and a tree, then add them to the scene.

## Creating a Rock and a Tree

In this lesson, you'll create two primitive objects, then modify their parameters so they take on the appearance of a rock and a tree.

Set up the scene:

- Continue from the previous lesson.


## Create a rock:

1 On the
Create panel, click
 (Geometry), then in the Object Type rollout, click Sphere.
The button highlights to show that it is active and ready to use.


2 Create a sphere in the Top viewport by holding down the left mouse button anywhere to the front and left of the cannon (see the next illustration) and dragging away from where you started. As long as you hold the mouse button down, you can adjust the size of the sphere. When you release the mouse button, the sphere is complete.

TIP Your sphere might be a different color from the one in the illustration.


Create a sphere.


The sphere in the camera viewport

3 On the Modify panel > Parameters rollout, change the Radius setting to 25 and press Enter.


The sphere changes size in the viewport. In 3ds Max, it's typical practice to rough out an object with the mouse, then refine it on a rollout.

4 Click the Modifier List drop-down menu and choose the Noise modifier.


5 In the Noise group, turn on Fractal, and in the Strength group, set X, Y, and Z to $\mathbf{3 0 . 0}$.


The rock is taking shape, but it could be flatter.

6 On the main toolbar, click
 (Select and Uniform Scale).

7 In the Camera001 view, drag the gizmo Z axis downward until the rock object is about two-thirds its original height.


## Change the name of the sphere:

1 In the Modify panel object name field, double-click the name Sphere001 to highlight it.


2 Type in rock to change the name of the sphere. Press Enter to set the new name.

NOTE Pressing Enter is an explicit way to change a parameter. 3ds Max also accepts a parameter change as soon as you click anywhere else in the 3ds Max window.

## Create a tree:

1 On the


Create panel, click

$\square$(Geometry), then from the drop-down list (at present, it shows "Standard Primitives"), choose AEC Extended.


AEC Extended objects are pre-built geometry, including railings, fences, and plants. They are a fast way to add realistic details to a scene.

2 On the Object Type rollout, click Foliage.
3 On the Favorite Plants rollout, choose Generic Oak as the species of tree.


4 Right-click the Top viewport to activate it, and add the tree to the scene by clicking a point slightly below and to the right of the rock.


Create a tree

To give the scene some atmosphere, we'll make the tree appear stunted and battle-scarred.

5 With the tree still selected, on the Modify panel > Parameters rollout, set Height to 150.


6 In the Show group, turn off Leaves, and in the Level-Of-Detail group, turn on Low to reduce the number of branches.

7 If you are not yet satisfied with the appearance of the tree, on the Parameters rollout click New.

Each time you click this button, the Seed value is changed, causing the tree to undergo a random reconfiguration.

8 When you are satisfied with the appearance of the tree, re-name the Foliage001 object in the Name field using the same procedure you followed for the rock. Call this object oak_tree.

9 If the tree is obscuring your view of the windmill, feel free to move it
aside using

(Select And Move) on the main toolbar.

Next, you'll apply a material to your rock using the Material Editor.

## Adding Materials to Objects In the Scene

You add realism to scene objects by adding materials to their surfaces. Material texture can include information from bitmap images, as well as bump maps for a 3D effect. In this tutorial the battlefield terrain, as well as the tree, rock, cannon, and windmill, all get their appearance from bitmap texture mapping.


[^0]

## Rock texture

## Set up the scene:

- Continue from the previous lesson.


## Add a battlefield material:

1 On the main toolbar, choose Editor flyout to open the Compact Material Editor.

The Material Editor opens as a floating window.
The Compact Material Editor is usually more convenient when you want simply to assign materials that have already been designed. The Slate Material Editor, which takes up more screen space, is more convenient and versatile for designing materials.

NOTE If you open the large Slate Material Editor by mistake, then from the Material Editor toolbar choose Modes $>$ Compact Material Editor.


By default, the Compact Material Editor shows six sample slots, each of which is capable of holding a material. Typically, you would have multiple materials to choose from, so you might prefer to expand the number of sample slots selectable from the editor.

2 Click any sample slot to select it. A white outline shows the slot is active. Right-click and from the list, choose $5 \times 3$ Sample Windows. You now have 15 sample slots for future use.

3 Locate the Battlefield material sample slot and click it.


Notice that the name Battlefield appears in the Material Name field below the sample slots.
This material has already been constructed for you. It uses a bitmap as a texture and includes a bump map.

4 Drag the Battlefield material from its sample slot and drop it onto the Field object in the Camera001 viewport.
The viewport now displays a landscape covered by grass and dirt.


5 Drag the Stone material from its sample slot onto the rock object in the viewport. The stone surface updates to a realistic texture.
Next, you will apply a material to the cannon.
All parts of the cannon were previously grouped together into a single entity, called a selection set. This way, when you choose a material, it is applied to all components in the selection set in a single action.

6 From the main menu Named Selection Sets drop-down list, choose Cannon.


7 On the Material Editor, click the Cannon sample slot and then click
 (Assign Material To Selection).
This method is another way to apply materials to selected objects.
The oak tree and windmill already have materials applied to them, so now you're ready to begin animating the scene.

8 Save your scene to your local folder as my_battlefield_scene.max.

## Animating the Scene

In this lesson, you'll bring the battlefield scene to life by animating scene objects.

You'll do this with keyframe animation. The Auto Key tool in 3ds Max lets you record the physical characteristics of an object at any given point in time. This state in time is called a keyframe. 3ds Max then figures out all the in-between states from one keyframe to the next, for a smooth transition of the object.

The following procedure consists of two animations. Between frames 0 to 120, you will advance the cannon to its firing position, next to the rock. Between frames 120 and frame 160, you will raise the cannon barrel in preparation for the first shot.

3ds Max gives you three different ways to create keyframes. One is to turn on the Auto Key button, move to any point in time, and transform (move, rotate, or scale) the object. A second method is to right-click the time slider and then set keys using the Create Key dialog. There is also a Set Key animation mode, designed for professional character animators.

In this exercise, you'll use the Auto Key button.
Set up the scene:

- Continue with your own scene, or
 open battlefield_scene.max.


## Animate the position of the cannon:

1 Right-click the Top viewport, then
 pan the scene so that the cannon and rock are clearly in view.

2 On the main toolbar, click

(Select And Move), then hover your mouse over the rear portion of the cannon.
After a moment, a tooltip appears that says frame.
The tooltip indicates your selection tool is hovering over the frame object. In this scene, frame is the parent object of the cannon, meaning that if it moves, the rest of the cannon assembly moves with it.


3 Click the frame object to select it.
4 The time slider is the wide button located directly above the time scale display below the viewports. Drag the time slider to frame 120 (to create a 4 -second animation when played back at 30 frames a second).


## 5 Click <br> Auto Key <br> (Auto Key) to turn it on.



## Selected

## Set Key

 Key Filters...

The button turns red. You are now in automatic animation mode.

## Auto Key

TIP The time slider bar also turns red, and the active viewport is outlined in red to remind you that you are in Auto Key mode.

6 In the Top viewport,

select the frame object and drag it on its $Y$ axis until the cannon is lined up next to the rock.
Autokey interpolates, or averages out, the cannon position at each frame from its start position at frame 0 to its final resting place at frame 120.

7 Turn off
Auto Key
(Auto Key).
TIP To avoid accidentally creating unwanted animation, develop the habit of turning Auto Key off after animating each movement.

8 Move the time slider back and forth from frame 0 to frame 120, and watch the cannon move forward.
Notice how animation has already been applied to the windmill in the background.

Add a second animated movement:
1 Turn on Auto Key (Auto Key) and advance to frame 160.
2 Press H on the keyboard.
3ds Max opens the Select From Scene dialog.
3 Choose the barrel object from the list, and click OK.


You might have to scroll, or resize the Select From Scene dialog, in order to find the barrel entry.

4 On the main toolbar, click

(Select And Rotate).
5 In the Camera viewport, rotate the barrel on its X axis by $\mathbf{- 1 0}$ degrees.


As you modify the barrel rotation, the axis values update in yellow.
6 Drag the start keyframe at frame 0 to frame 130.


8 In the animation playback controls, click

(Go To Start), then click


- (Play Animation).

Watch the animated cannon prepare its deadly attack on the windmill.
9 Click (Stop, in the same location as the Play button) when you
10 Save your scene to your local folder, this time as my_battlefield_attack.max.

## Rendering the Animation

Rendering multiple frames for a complete animation can be time consuming, even on a fast machine, because each frame is individually processed. Realistic materials, shadow casting, and other factors can slow the process as well. This scene is relatively simple however, so it shouldn't take that long to render.

Set up the scene:

- On the Quick Access toolbar, click
 animation, my_battlefield attack.max. Or, open battlefield_attack.max, located in the \scenes \startup folder.

NOTE If you saved your completed files to a folder other than \scenes \startup, when you open one of your files you might encounter messages about missing files. If you run into this problem, click the Browse button on the Missing External Files dialog. This opens the Configure External File Paths dialog. Click the Add button. Use the Choose New External Files Path dialog to navigate to the folder where you loaded the original file, and then click Use Path. Click OK, and then click Continue.

## Render your animation:

To complete this tutorial, render the animation you made earlier. The rendering time is probably under 15 minutes, depending on the speed of your machine.

1 On the main toolbar, click


3ds Max opens the Render Setup dialog.
2 In the Time Output group, choose Active Time Segment. (If you left the setting at Single, just the currently displayed frame would render.)

Time Output
Single
Every Nth Frame: 1
Q Active Time Segment: 0 To 180
Range:


Frames: 1,3,5-12

TIP If your computer is fast, you may skip the next step.

3 In the Output Size group, change the default ( $640 \times 480$ ) to $320 \times 240$.
Output Size

| Custom |  | Aperture Width(mm): 36.0 |
| :---: | :---: | :---: |
| Width: | 320 | $740720 \times 486$ |
| Height: | 240 | $640 \times 480$ 800x600 |
| Image As | 1.333 | Pixel Aspect: 1.0 考 |

This smaller size has only one-quarter the area of the default, making it much faster to render.

4 In the Render Output group, click the Files button. (You might have to scroll down in order to see this control.)
Render Output
$\square$ Save File
$\square$ Put Image File List(s) in Output Path(s) Create Now.
(o) Autodesk ME Image Sequence File (.imsq)
Legacy 3ds max Image File List (.if)
$\square$ Use Device $\square$ Nen
$\square$ Rendered Frame Window $\square$ Net Render
$\square$ Skip Existing Images

5 On the Render Output File dialog, name your animation mybattlefield_attack.avi. Click Save to save the animation to the default folder (usually \renderoutput).

WARNING You must either add the extension .avi in the file name, or else select AVI as the file type. If you don't tell the program what type of animation format to save in, the rendering won't work.

6 On the AVI File Compression Setup dialog, do the following:
■ If necessary, change the compressor to Cinepak Codec. There are many different codecs to choose from. Cinepak generally gives satisfactory results and is commonly installed on Windows machines, meaning your compressed AVI file can be read by wide audience.

■ Set Quality to high, between 90 and 100.

- When you're finished, click OK.

On the Render Setup dialog, Save File is now on and the output field shows the location of mybattlefield_attack.avi.

7 At the bottom of the Render Setup dialog $>$ View list, choose Camera01.


Always check to be sure you're rendering the right viewport.
TIP In most cases, you will render the camera viewport.

8 Click Render to begin the rendering process.
Watch a few frames to make sure that the rendering gets off to a good start. The Time Remaining estimate gives you an idea of how long the rendering will take.

## Play the rendered animation:

1 When your animation is finished rendering, choose Rendering menu View Image File.
By default, the View File dialog opens in the \renderoutput subfolder.
2 Highlight mybattlefield_scene.avi and click Open to display the Media Player.

3 In the Media Player, play your animation.

## Summary

You have learned how to find your way around the 3ds Max user interface while creating an animated scene. You now know how to navigate the viewports, create simple objects using primitives, and assign materials to them. You've also learned how to move objects as well as animate and render your animation.

## Modeling Tutorials

## 3

Modeling in 3D is similar to sculpting. Many different techniques can be used to create the objects in your scene. The techniques you learn in these tutorials can be adapted to any style of modeling you need to perform. For instance, if you're building models that will be incorporated into a game, you'll be most interested in low polygon modeling techniques. The same techniques will be equally beneficial when building highly detailed models for architectural presentations or motion pictures.


Beyond modeling techniques, the Façade tutorial also exposes you to the Material Editor and shows you how to apply materials to objects in your scene. That familiarity will help when you do the materials and mapping tutorials on page 1057 (or you might want to go through the Materials tutorials first, then return to the Façades section).

## Features Covered in This Section

- Creating primitive objects
- Using a modifier to alter an object's shape.
- Creating and editing spline objects

■ Converting splines into geometry

- Using images to assist your modeling

■ Editing a model at sub-object levels
■ Using the Graphite Modeling Tools ribbon to edit Editable Polygon objects

## Modeling a Helmet Using the Ribbon

The Graphite Modeling Tools ribbon, referred to in this tutorial simply as "the ribbon," is a customizable toolbar that provides you with all the tools you need to edit Editable Poly surfaces.


In this tutorial, you will use the ribbon modeling tools to create a Viking helmet.

In this tutorial, you will learn how to:
■ Use the Symmetry modifier to mirror edits to one side of a model.

- Create loops by connecting polygon edges.
- Extend polygons using various extrusion techniques.
- Create beveled and inset shapes.

Skill level: Beginner to Intermediate
Time to complete: 1 hour

## Using Basic Polygon Editing to Create a Helmet

When you model rounded objects, such as the helmet in this tutorial, we recommend that you avoid using a sphere as a starting point.

The next illustration shows the polygons that make up a sphere. The top of the sphere is composed of triangular polygons whose vertices tend to pinch together at the pole. This can lead to problems later on.


Top of sphere with vertices pinched together at its pole
It is therefore best to model a rounded object, other than an actual sphere, using rectangular polygons only. You will use this technique in this lesson.

## Create the basic helmet shape:

## 1 Start 3ds Max.

By default, a minimized version of the Graphite Modeling Tools ribbon displays directly below the main toolbar.


NOTE The ribbon on your workstation might display differently if you customized the ribbon in a previous 3ds Max work session. This tutorial assumes you are using the default configuration.

2 Click the expand/minimize icon a few times until the full ribbon displays.


The tools in the Polygon Modeling tab are inactive, since no polygon model exists in the scene.

3 From the Customize menu, choose Units Setup, and in the Units Setup dialog $>$ Display Unit Scale group, make sure Generic Units is chosen.


4 Activate the Perspective viewport, and press Alt+W to maximize it.

5 On the
Create panel, activate

(Geometry), then on the Object Type rollout, click Box.

6 Drag to create a box of any size.

7 On the
 Modify panel Parameters rollout, set Length, Width, and Height to 50.0.


Currently, the pivot point is at the base of the object. You need to set this point to the center of the box so you can manipulate the object more easily.

8 In the
 Hierarchy panel > Adjust Pivot rollout > Move/Rotate/Scale group, click Affect Pivot Only to turn it on.


9 In the Alignment group, click Center To Object, then click Affect Pivot Only again to turn it off.

## Alignment:

## Center to Object

Align to Object
Align to World

10 On the main toolbar, click
 box. The box now rotates around the object's center of mass.


12 Right-click the box, and choose

(Select And Rotate) and rotate the

13 Right-click the $\mathrm{X}, \mathrm{Y}$, and Z transform spinners to set each of them to $\mathbf{0 . 0}$.

$$
\text { 오 } x: 0.0
$$

The center of the box is now at the center of the world coordinates.

14 Click

(Select Object) to turn off the Move tool.

## Turn the box into a sphere:

1 On the


Modify panel $>$ Parameters rollout, set Length Segs, Width Segs, and Height Segs to 4.

2 Press F4 to turn on Edged Faces, so you can see the segment divisions in the viewport.


After you press F4, the Shading viewport label should show "Smooth+Highlights+Edged Faces."

3 From the Modifier list, choose Spherify.
Skin Wrap Patch
Slice
Smooth
Spherify
Squeeze
STL Check
Stretch
Subdivide
Sulstitıte


Box with Spherify modifier applied

The object is deformed into a spherical shape, but retains its geometric composition of easily editable quadrilateral polygons.
You only need a hemisphere to create the helmet, so next you will delete the lower half of the box and deform the remaining polygons into a conical shape.

## Refine the shape:

1 In the viewport, right-click the sphere and choose Convert To $>$ Convert To Editable Poly.


The ribbon updates to display a range of polygon-editing tools.
2 Click the Point-Of-View (POV) viewport menu (at present, it reads "[ Perspective ]" and choose Front as the view to display.

3 On the ribbon > Polygon Modeling panel, click | $\square_{\square}^{\square}$ | (Vertex) to go |
| :--- | :--- |

to the Vertex sub-object level.


Region-select all the vertices in the lower half of the object (but not the equator), then press Delete.



You now have a hemispherical dome for the helmet. Next, you will give the object a slightly conical shape.

4 Click the POV viewport label again, and return to the Perspective view.

5


Select the vertex at the top of the helmet and move it upward along the Z axis.


Top vertex after transformation in $\mathbf{Z}$

Notice that only the polygons that share the vertex are deformed. You need to use Soft Selection to involve the adjacent vertices and polygons as well.

6


## Use Soft Selection to shape the helmet:

1 On the ribbon > Polygon Modeling panel, click (Soft Selection) to turn it on.


At the end of the ribbon, on the right, 3ds Max displays a Soft Selection panel, which provides options that control how the soft selection is carried out.

2 On the Soft Selection panel, set Falloff to 30.0.


3


Move the top vertex of the helmet upward along the Z axis again, until the object appears similar to that in the next illustration.


4 On the ribbon Polygon Modeling panel, click $\square$ (Soft Selection) again to turn it off.

Next, you will use the MeshSmooth tools to smooth out the helmet surface.

5 In the viewport, drag to select all the object vertices (or press Ctrl+A), and then on the ribbon $>$ Subdivision panel, click MSmooth.

| MSmooth |
| :---: |
| Tessellate . |
| AUse Displac... |
| Subdivision |

This option takes each polygon and divides it into four, making a smoother, more detailed geometry.



## Save your work:

■ Save your scene as my_helmet_01.max.

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## Working in Symmetry Mode to Add Detail to the Helmet

In this lesson, you will work in symmetry mode on half the helmet. This way, any changes you make will be perfectly mirrored for the other half.

## Set up the lesson:

1 Continue from the previous lesson, or
open helmet_01.max. This scene is in the folder \scenes \modeling $\backslash$ helmet $\backslash$.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

2 If you open the new file, then

select the helmet object, and on the ribbon > Polygon Modeling panel, click Modify Mode.


When active, Modify Mode makes the entire array of Graphite Modeling Tools available.

Add the Symmetry modifier:

1 On the Polygon Modeling panel, activate
 (Polygon) to go to the Polygon sub-object level.


2 Click the ribbon's Selection tab.
Graphite Modeling Tools Freeform Selection Object Paint

3 On the By Half panel, click 4 (Y), then click



This selects half the object based on its Y axis orientation.
4 On the By Half panel, click Invert Axis.


The polygon selection is inverted. The new selection contains the polygons we want to remove.

5 Press Delete.
You will now add a Symmetry modifier to these polygons so that their geometry can be mirrored.

6 On the ribbon, click the Graphite Modeling Tools tab. With the helmet object still selected, go to the


Modify panel and from the Modifier List choose Symmetry.

7 On the Parameters rollout > Mirror Axis group, choose the Y option and turn on Flip.

Mirror Axis:


This properly orients the mirrored half of the helmet.
Notice how the ribbon displays a limited set of modeling tools. This is because the Symmetry modifier is active.

8 On the ribbon > Polygon Modeling panel, click

(Previous Modifier).


Now the Editable Poly object is active again, and the ribbon displays an expanded set of tools for polygon editing.
The mirrored half of the helmet is hidden in the viewport because with the polygon editing controls displayed, you are editing the source polygons only.

9 On the Polygon Modeling panel, click

(Show End Result) to see the mirrored side of the helmet controlled by the Symmetry modifier.


10 Click $\square$ (Show End Result) again to turn it off.

## Preview mesh smoothing:

1 On the Edit panel, click

## 雨

 (Use NURMS).

Edit
The Use NURMS panel displays at the right of the ribbon. (NURMS is short for Non-Uniform Rational MeshSmooth.)

2 On the Use NURMS panel, set Iterations to 2.
This smooths out the object by adding more polygons to the geometry. It is best to specify an Iterations value of no more than 3, because each time you increase iterations by one, the number of vertices and polygon faces can increase by a factor of four. This can result in a lengthy calculation time.

3 If the Show Cage button is already on, turn it off to better see the geometry added by the NURMS iterations.


4 On the ribbon $>$ Edit panel click $\stackrel{\text { 留 }}{\text { (Use NURMS) to turn it off. }}$ Next, you will add two extrusions that will form the rim of the helmet and its vertical ridge.

## Select the seam and rim faces to extrude:

1 On the Polygon Modeling panel, activate $<$ Edge sub-object level.


2 In the viewport,

select a polygon edge as shown in the next illustration, then on the Modify Selection panel, click



3ds Max selects all edges parallel to the first one, in a ring around the object.


3 On the Loops panel, Shift+click
 (Connect).


3ds Max draws a single loop of edges around the selected edges. It also displays the "caddy" controls for the Connect tool.
(When you Shift+click a tool on the ribbon, 3ds Max displays the caddy controls for that tool.)


By default, the loop is placed in the center of the selected edges, but the negative Slide value you will specify in the next step will position it to the left of center.

4 On the third control of the caddy, Slide, drag to the left until the value equals -50, and then click (OK).


Edge slides to the left

5 In the viewport,

click to select a vertical edge on any polygon at the bottom row of the helmet, then on the ribbon $>$ Modify Selection panel, click $\rightleftharpoons$ (Ring).
The Ring tool automatically selects all the vertical edges.


6 On the Loops panel, Shift+click H (Connect).

Once again, 3ds Max displays the caddy controls for the Connect tool.


7 Change the value of the Slide control to -25, then click

(OK).


8 On the Polygon Modeling panel, turn on

(Show End Result) to see how the Symmetry modifier has added a mirrored portion to the helmet.


9 Right-click the helmet and choose Transform $>$ Convert To $>$ Convert To Editable Poly.

The Symmetry modifier is removed and all the mirrored polygons are integrated into the model.

## Select the helmet seam and rim:

1 On the ribbon > Polygon Modeling panel, activate $<7$ (Edge).
2 On the Modify Selection panel, click Loop Mode to turn it on.


3


Click to select one of the edges along the center edge of the helmet.


Because Loop Mode is on, 3ds Max selects the entire loop of edges along the helmet ridge.


4 With Loop Mode still active, hold down the Ctrl key, then click an edge along the rim of the helmet.
3ds Max selects the rim edges as well as the ridgeline.


5 Hold down the Ctrl key again, and on the ribbon Polygon Modeling
panel, activate $\square$ Polygon.
3ds Max selects all the polygons adjacent to the edge selection.


Extrude the helmet seam and rim:

1 On the Polygons panel, Shift+click $\square$ (Extrude).


3ds Max displays the caddy controls for the Extrude tool.


2 On the first control, Group, choose Local Normal from the drop-down list.


3 On the third control, Height, change the value to $\mathbf{1 . 0}$, then click (OK).


4 On the ribbon > Polygon Modeling panel, click
 selection to exit the sub-object level.
$\square$骎 (Use NURMS) and on the Use NURMS
5 On the Edit panel, click $\qquad$ panel, click $\square$ (Show Cage) to hide the cage, then press F4 so you can see the end result without edged faces.

6 On the Use NURMS panel, set iterations to 2 to further smooth out the helmet.


Helmet with middle seam and rim extrusions

In the next procedure, you will add more edges to create a less rounded extrusion to the rim and ridge.

On the ribbon $>$ Edit panel, click $\begin{array}{ll}\text { NURMS mode. }\end{array}$ (Use NURMS) to turn off
NURMS
8 Save your scene as my_helmet_02.max.

## Set up the scene:

1 Continue working on your scene, or open the scene helmet_02.max

2 If you opened the new file,

select the helmet, and make sure the


Modify panel is active.

## Refine the extrusions:

1 In the viewport, switch to a Left view. If the viewport is shaded, press F3 to turn off shading and see the helmet in Wireframe view.
Notice the slight wave to the extruded rim of the helmet.



region-select the row of vertices that is second from the bottom.


3 On the ribbon $>$ Align panel, click
(Align Z) to align all the vertices along their average orientation on the $Z$ axis.


4 Switch to a Top view and

region-select the vertices on one side of the ridge extrusion.


5 On the ribbon $>$ Align panel, click
Y (Align Y ) to align all the vertices along their average orientation on the Y axis.

6 Region-select the vertices on the opposite side of the ridge extrusion, and
click (Align Y) again.
Now the edges of the extruded ridge are also straight.


7 Change the viewport to a Perspective view once again.

8 On the ribbon $>$ Polygon Modeling panel, activate $<7$ (Edge).

9 On the Modify Selection panel, click to turn on $=5$ (Ring Mode).


10


Click to select one of the horizontal edges just on the near side of the ridge of the helmet.


Ring Mode selects all edges parallel to the one you clicked.

11 On the Loops panel, Shift+click
 (Connect).
3ds Max displays the caddy controls for the Connect tool.


12 Set the value of the third control, Slide, to 83 , so the new edge loop is very close to the base of the ridge, and then click $\square$ (OK).


Loop slides to the left

## E

 the helmet.

14 On the Edit panel, turn on
(Swift Loop).


15 Drag the mouse over the surface of the helmet. A green virtual loop appears as you drag the mouse. It lets you visualize where to place the loop.

Click to place a new, vertical edge loop on the near side of the helmet. Like the loop you placed on the opposite side, it should be close to the base of the extruded ridge.


SwiftLoop provides a fast way to create and position a loop on a model.


16 Use Swiftloop again to place a horizontal edge loop, this one just above the helmet's extruded rim.


Click to create the loop.


Adding these parallel edge loops reinforces the existing edges, so they won't be smoothed as much as you saw in the previous lesson.

17 Click $\begin{array}{r}\text { s. } \\ \hline \text { (Swift Loop) to turn it off. }\end{array}$
18 Click $<7$ (Edge) to exit the Edge sub-object level.

## View the helmet with smoothing:

1 On the ribbon $>$ Edit panel, click (Use NURMS) to turn it on, then press F4 to turn off edged faces and see how the added edge loops give the base of the extrusions a sharper angle.


Helmet showing sharper extrusions


## Save your work:

■ Save your scene file as my_helmet_03.

## Using Extrusions to Add Horns to the Helmet

This lesson shows you how to create a pair of twisting horns. It uses extrusions and transforms; it also demonstrates spline extrusion as a simple alternative to multiple extrusions.

Once again, apply a Symmetry modifier to mirror the edits you make to one half of the helmet.

## Set up the lesson:

1 Continue working from the previous lesson, or helmet_03.max.

2 If you opened the new file,
 select the helmet, and make sure


## Split the model in half and apply a Symmetry modifier:

1 On the ribbon $>$ Polygon Modeling panel, activate $\square$ (Polygon).


Select the polygons on the left half of the helmet (from your point of view), and then press Delete.

2 Apply a Symmetry Modifier, and adjust its settings as described in the previous lesson:

- Axis $=\mathrm{Y}$
- Flip = on

On the Modify panel, you can toggle

Hsure the helmet is mirrored correctly.

3 On the ribbon > Polygon Modeling panel, click
(Previous Modifier) to go to the Editable Poly level.

Adjust vertices at the base of the horn:

1 On the ribbon > Polygon Modeling panel, activate | $\square_{\square}$ | (Vertex). |
| :--- | :--- |

2 On the ribbon $>$ Edit panel $>$ Constraints group, activate
 (Constrain To Edge).


This ensures that the transform of any vertex will slide along the edges of the polygon to which it belongs.

3 Change the viewport to a Left view. If you need to, click 는 (Zoom Extents) to get a good view of the helmet.

4 On the main toolbar, activate
 (Select And Move), then select a vertex in the upper region of the helmet and move it as shown in the next illustration.


5 Select the vertex that is opposite the central vertex, and
 it as well. Also move the vertices above and below the central vertex. The goal is to create a symmetrical shape that is roughly circular.


6 On the ribbon > Edit panel, activate $\square$
(Constrain To None).

IMPORTANT When you forget that a constraint is on, surprising things can happen when you transform sub-objects. Because of this, it is a good idea to deactivate a constraint as soon as you have finished using it. Also, the buttons in this set behave like radio buttons. You can't turn a constraint off by clicking its button a second time: You must activate Constrain To None to deactivate the currently active constraint.

## Create the base of the horn:

1
Select the vertex at the center of the circular group of polygons.


2 On the ribbon > Polygon Modeling panel, Ctrl+click $\square$ (Polygon). This automatically selects all the polygons that share the vertex.


3 Switch the viewport back to a Perspective view, and E can see all of the base of the horn.


4 On the Polygons panel, Shift+click $\square$ (Inset).


5 On the Inset caddy, drag the Amount spinner (the second control) to a value of approximately 0.25 , and then click $(\mathrm{OK})$.


This creates an inset edge for the selected polygons.


## Use extrusion and bevel to create the socket for the horn:

1 On the Polygons panel, Shift+click $\square$ (Extrude).

2 On the first control of the caddy (extrusion type), choose Group from the drop-down menu.


3 Set Extrusion Height to approximately 3.0, and then click $\qquad$ (OK).


4 On the Polygons panel, Shift+click (Bevel).


5 On the Bevel tool caddy, set the Height value (second control) to $\mathbf{0 . 2 5}$ and the Outline value (third control) to - $\mathbf{0 . 5}$. Click



Helmet horn socket after first extrusion and bevel

6 On the Polygons panel, Shift+click $\square$ (Inset).
7 On the Inset tool caddy, set Amount (the second control) to 0.35, then click (OK).


8 On the Polygons panel, click $\square$ (Bevel).

9 Drag the selected polygons slightly toward the inside of the helmet, then release the mouse and drag slightly down to bevel the extrusion slightly in toward its center. Click once to end the operation.


Horn socket after second inset and bevel

10 Click (Extrude) again, and drag away from the helmet until the polygons extend slightly beyond the socket. Click to end the extrude operation.


Helmet horn ready for spline-based extrusion

At this point, you could continue to create the horn by using the Move, Rotate, and Scale tools, coupled with the Extrude, Bevel, and Inset polygon tools. Instead, you will guide the extrusion by means of a path.

Draw a spline for extruding the horn:

1 On the
Create panel, click

(Shapes), then on the Object Type rollout, click Line.

2 On the Creation Method rollout, choose Smooth for both Initial Type and Drag Type.


3 Press Alt +W to view all four viewports, and in the Top view draw a line extending from the horn socket. Click, drag, and click again, until you have created a line of four or five vertices. Right-click to end Line creation.


4 In the Front view,
 move the line along its Y axis until it is centered on the horn socket. Move it along the X axis too, if you need to.


5 Go to the


Modify panel
Selection rollout, and activate (Vertex).



Double-check and refine your Line edits in the other viewports.


Left view


## Extrude the horn:



2 Activate $\square$ (Polygon), then click $\because$ (Show End Result) to turn it on.

3 On the Polygons panel > drop-down panel, Shift+click Extrude On Spline.


The caddy controls for spline extrusion are more numerous than for most caddies.


4 Click the last of the controls, Pick Spline, and then click the spline you drew earlier.


After you click the spline, 3ds Max grows horns, but these have no taper, yet.

5 (Optional.) On the caddy, click Extrude Along Spline Align to turn it on.


3ds Max aligns the spline to the normals of the original faces, making the horns more perpendicular to the rest of the helmet. This might or might not be a good effect, depending on the spline you drew.

NOTE You can also try adjusting the values of Twist and Rotation (available only when Align is turned on).

6 Change the value of Taper Amount to about - $\mathbf{0 . 5}$, then click And Continue).
3ds Max extrudes the horns still further. This is easier to see in other viewports, but you can also navigate the Perspective view, as shown in this illustration.


7 Change the Taper Amount so the horns come to a point (for the illustrated helmet, the value was -0.955 ). Click

(OK) to finalize these changes and finish creating the horns.


By extruding the horns along a path, you saved yourself a great deal of back-and-forth between the transform and polygon modeling tools.

8 On the ribbon > Polygon Modeling panel, click $\square$ (Polygon) again to turn it off.

## Make the helmet a single object once again:

 smoothing needs to be off before you transform the helmet into an Editable Poly: Otherwise, you wind up with a model that has far too many faces.

2 In a viewport, right-click the helmet, choose Transform $>$ Convert To > Convert To Editable Poly, then press F4 to turn off edged faces.


The Symmetry modifier is removed and all the mirrored polygons are integrated into the model.

3 Press F4 again to turn edged faces back on.

## Save your work:

■ Save your scene as my_helmet_04.

## Using Freeform Tools to Add Spikes to the Helmet

In this lesson, you will use a variety of freeform tools to create a ridge of irregular spikes for the Viking helmet.

Set up the lesson:

1 Continue working from the previous lesson, or helmet_04.max.

2 If you opened the new file,
 select the helmet, and make sure the


Modify panel is active.

## Remove the middle seam from the helmet ridge:

1 On the ribbon
Polygon Modeling panel, activate $\qquad$ (Edge).
2 On the Modify Selection panel, click You will use this tool to remove the edge loop in the middle of the helmet ridge.

Click a vertical edge along the middle seam of the helmet ridge.


Loop mode selects the entire edge loop that forms the middle seam.


4 On the Edges panel, click
 (Remove).


Notice that while the loop edges have been deleted, their vertices remain. You want to remove the vertices as well.


Unwanted vertices left over from edge removal



Both edges and vertices removed

## Subdivide the ridge into rectangular faces:

$\square$
Click and Ctrl+click to select two of the longer vertical edges on either side of the helmet ridge, as shown in the next illustration.


2 On the Loops panel, Shift+click $\square$ (Connect).

3 On the caddy controls for Connect, make sure Segments is set to 1 and Pinch and Slide are set to $\mathbf{0}$, then click
 (OK).


These values ensure you are connecting the edges just once, with no offset.


Select the next pair of edges above the ones you just connected, and click
 (Connect) to add horizontal edge to the ridge.

5 Repeat the previous step for each pair of edges along the ridge, except for the shorter edges just above the rim of the helmet. Stop when you have connected edges on the rear side of the helmet as well as along the front.


Create irregular spikes using the Freeform tools:



3 Adjust the Perspective view to make sure you are looking at the helmet from an oblique angle.

NOTE If you start extruding the polygon while looking at the model head on, the extrusion will take on a 2D appearance.

4 On the ribbon, click the Freeform tab, and on the PolyDraw panel, click

(Branches).

| Graphite Modeling | Freeform | Selection Object Pain |
| :---: | :---: | :---: |
| $\begin{array}{cl} 5^{++} & \text {Step Build } \\ \text { Drag Extend } \\ & \text { 目 Optimize } \end{array}$ | OR: Grid Pick Offset: $0.0 \leqslant$ | Shapes <br> (18) Topology • <br> Splines Strips <br> Surface $\square$ <br> (2) Branchss |

5 Shift+drag the selected polygon outward, away from the helmet, then release the mouse.


Helmet after first Branch extrusion

6 Ctrl+click to select the polygon two above the one you just branched, then Shift+drag it to create another branch.

7 Continue extruding every second polygon until the entire ridge is complete.


As you progress along the helmet, make sure you maintain an oblique view of the polygons. If you don't like the shape of an extrusion, or you extrude the wrong polygon, press $C$ trl $+Z$ to undo the operation.

8 Click the ribbon $>$ Graphic Modeling Tools tab again.

9 On the ribbon $>$ Polygon Modeling panel, click $\square$ (Polygon) again to turn it off, then press F4 to turn off edged faces.

10 On the Edit panel, click

## 骂



The helmet geometry is smoothed out and ready to accept materials.

## Summary

Throughout this tutorial, you used a number of modeling tools on the Graphite Modeling Tools ribbon to create a Viking helmet. While these tools are also available from the Command panel, the ribbon gives you faster access, in context, as you need them.

This tutorial only scratched the surface of the many ways in which you can use the ribbon for editing mesh and polymesh objects. For a full description of the ribbon tools, consult the 3ds Max help. For more extensive exercises in polygon modeling, see Using Photos to Model Façades on page 148 and Modeling an Airplane on page 283.

## Using Photos to Model Façades

With a photo of a building, you can create a remarkably realistic model. This tutorial shows you how to do so.


Model of house fronts on a plaza
In this tutorial, you will model two house fronts, based on photos of buildings in the plaza of Monpazier, a 13th-century bastide (fortified town) in Dordogne. The illlustration shows these houses, along with two others (in the actual plaza, the houses occupy different positions).

You use each photo both to construct the façade and to texture it. In a way, you are "reverse engineering" the original architecture. Each house is constructed as an Editable Poly object: You will use various polygon-editing tools to give the façade depth so it can cast realistic shadows, and then use
the Unwrap UVW modifier to adjust the texture and improve the model's appearance.

TIP If you are not familiar with using the Material Editor and texture-mapping modifiers, you might want to go through the Materials And Mapping tutorials on page 1057 first, then return to this tutorial.

WARNING The techniques used in this tutorial are suitable for modeling architecture and other stationary objects. They aren't suitable for modeling organic meshes, especially ones that you want to animate by using a feature such as the Skin modifier or Physique. In this tutorial, we create irregular meshes that include multisided polygons. A deformable mesh, by contrast, should contain only square or triangular polygons of fairly uniform size (if you plan to turn the mesh into a subdivision surface by using the HSDS modifier, then it should contain only square polygons before you apply HSDS).

See Modeling an Airplane on page 283 for an example of mesh modeling with more-or-less regular polygons.

Skill level: Intermediate
Time to complete: 3 hours

## Some Pointers: Preparing a Photo Before You Use It to Build a Model

This section explains how to prepare photos for use in the kind of façade modeling the tutorial demonstrates. You might want to read it if you plan to take your own photos (or scans) to use in a similar way. Or you might want to skip this section, do the tutorial itself, and then read this material later.

In a photograph, as in the human eye, parallel lines appear to converge. But to create a façade in 3ds Max, horizontal lines should be horizontal, and vertical lines should be vertical. So you will almost always need to use a graphic editing program, such as Photoshop, to adjust the photo before you use it as a texture.

For example, here is the original photo used to create "Façade 4," the second building you construct in the tutorial:


Superimposing guidelines on the house, shows that the groundline is horizontal, and the left side is close to vertical, but that the right side needs adjusting:


Using a perspective-correction or "distortion" tool, lets you align the sides of the house to the guides:


NOTE Perspective-correction or "perspective-control" lenses are available to eliminate the vertical, or "third" vanishing point, and make the vertical sides of a building appear parallel. But such a lens is a specialized, expensive piece of equipment.

A view camera, which uses a bellows for the body, can be set to accomplish perspective correction, too. But view cameras are not in widespread use, these days.

A photo editor has other uses. In this example, we wanted to remove the little girl standing in the archway:

... Which is easy to do with most such programs:


The final step is to crop the image to the dimensions of the house itself:

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This final image becomes the bitmap used to construct and to texture the house in Modeling the Second House on page 233.

## Creating the First House

The first house, which we will call Facade1, is based on a single photograph, adjusted in the way described in Some Pointers: Preparing a Photo Before You

Use It to Build a Model on page 149. In this lesson, you take several steps to set up the scene and the modifier stack, so that modeling will go more easily when you add detail to the façade.

## Begin Building the Model

The house begins as a simple plane.
Set up the scene:

- On the Quick Access toolbar, click

(Open File), navigate to the $\backslash$ scenes $\backslash$ modeling $\backslash$ facades folder, and open facade_modeling_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene contains a plane to model the pavement, a Daylight system with a sky dome, and a few cameras that are hidden.

## Optimize bitmap display in viewports:

1 On the main toolbar, choose Customize > Preferences.
2 Go to the Viewports tab, then click Display Drivers $>$ Configure Driver. 3ds Max opens the configuration dialog for the graphics driver you are using (Software, OpenGL, or Direct3D).

3 Depending on the driver, there are either one or two check boxes labeled Match Bitmap Size As Closely As Possible. If there is one, turn it on. If there are two, turn on both of them.

## (9) Configure Direct3D

## $x$

Implementation-Specific Settings
Geometry
Display All Triangle EdgesUse Cached D3DXMeshes
$\square$ Use Wireframe FacesUse Triangle Strips
, For Wireframe Objects
Window Updates
Redraw Scene On Window ExposeRedraw In Maximized ViewportRedraw In UnMaximized Viewports
Use Incremental Scene Updates

Appearance Preferences
$\square$ Enable Antialiased Lines in Wireframe Views
Antialiasing
None
Background Texture Size

| 128 | 256 | 512 | 1024 |
| :--- | :--- | :--- | :--- |

Match Bitmap Size as Closely as Possible
Download Texture Size

\section*{| 64 | 128 | 256 | 512 |
| :--- | :--- | :--- | :--- |}

Match Bitmap Size as Closely as Possible

Texel Lookup
NearestLinearAnisotropic

MipMap Lookup
(O) NoneNearestLinear

## Configuration dialog for the Direct3D driver

4 Click OK to close the driver configuration dialog, and OK again to close the Preferences dialog.

5 If you had to turn on Match Bitmap Size As Closely As Possible, then exit 3ds Max. Restart 3ds Max before you continue with this tutorial.
Bitmap configuration changes do not take effect immediately: You always have to restart 3ds Max.

If you did not have to change the Match Bitmap Size setting, you can continue without restarting 3ds Max.

Make sure Use Real-World Texture Coordinates is turned off:
1 From the main toolbar, choose Customize $>$ Preferences.
2 On the Preference Settings dialog, go to the General tab.


3 In the Texture Coordinates group, make sure Use Real-World Texture Coordinates is off, then click OK.

## Texture Coordinates

 OK Cancel

The dimensions of the scene will actually be close to the real-world dimensions, but 3ds Max doesn't need to enforce that: This option would just add complications to your work.

## View the reference/texture bitmap, and note its dimensions:

1 On the main menu, choose Rendering > View Image File. In the View File dialog, navigate to the \sceneassets $\backslash i m a g e s$ folder, and highlight fac1.jpg.
In the lower-left corner of the View File dialog, a status line shows the dimensions of the image, which are $1200 \times 1533$ pixels. This will become the aspect ratio of the façade.

Devices...
Setup...
Info...
View

Gamma
Use image's own gamma

- Use system default gamma Override 1.0
$\square$ Sequence Preview


Statistics: $1200 \times 1533$, RGB Color 8 Bits/Channel - Single Image
Location: C:\Users\Default|Documents\3ds Max 2011 Tutorials\sceneass...\fac1.jpg

2 Click Open to view the image at full size.


3
$X$ Close the image window after you have looked at the photo.

## Construct the plane that will become the façade:

1 On the
Create panel, click

(Geometry) active, then on the Object Type rollout, click Plane.

2 Near the center of the Front viewport, drag to create a plane.
3 On the Parameters rollout, enter $\mathbf{8 . 7 m}$ for the Length (the height), and 6.8 m for the Width.

These dimensions roughly correspond to the aspect ratio of the photo: 1533:1200 pixels, or 0.78 .

4 Also on the Parameters rollout, change Length Segs and Width Segs to 1.
(After you convert the plane to an Editable Poly surface, you will subdivide it by using the polygon tools.)

5 Change the name of the plane to Facade1.

6 Go to the


Hierarchy panel. On the Adjust Pivot rollout, turn on Affect Pivot Only, then
 move the pivot vertically so it is at the base of the Facade1 plane.


Pivot moved to the base of the plane

7 Turn off Affect Pivot Only. With

(Select And Move) still active, on the status bar, right-click the $\mathrm{X}, \mathrm{Y}$, and Z spinner arrows so the pivot of the plane is now located at the origin $(0,0,0)$.
Setting the Z axis to 0.0 aligns the façade with the Ground object. Setting X and Y to 0.0 simply makes navigation easier, while you are editing the plane.

8 Right-click the Facade1 plane, and from the Transform (lower-right) quadrant of the quad menu, choose Convert To $>$ Convert To Editable Poly.

## Texture the plane:



Open the Slate Material Editor.

2 On the Material/Map Browser panel, locate Materials > mental ray, then drag the Arch \& Design entry to the active View (the large panel labeled View1 in the center of the Editor).


3ds Max displays the Arch \& Design material node in the active View.

3 Double-click the Arch \& Design material node to display the material parameters in the Parameter Editor panel on the right.

4 Name the material Facade 1.


5 On the Templates rollout, choose Matte Finish from the drop-down list of templates.


6 On the Material/Map Browser panel, locate Maps > Standard, and drag the Bitmap entry into the active View.
3ds Max opens a file dialog.
7 On the file dialog, choose fac1.jpg, turn off Sequence, and then click Open.

IMPORTANT In the Select Bitmap Image File dialog, be sure to turn off the Sequence toggle.

## fac1.jpg

## All Formats

## Gamma

(O) Use image's own gamma

Use system default gamma
Override

Sequence


When Sequence is on, 3ds Max attempts to create an IFL animation, and we want to open only the single image.

3ds Max adds a Bitmap node to the active View.
8 Drag from the Bitmap node's output socket (the small circle at the right). A wire appears in the View. Drop the end of the wire on the Arch \& Design material's Diffuse Color Map input socket (the small circle at the left).


9 Drag from the Bitmap node's output socket again, and this time connect the wire to the Arch \& Design material's Bump Map component.


10 Click the Facade 1 material node again to make it active, then on the Slate

(Assign Material To Selection), and
then turn on (Show Map In Viewport).

11


Close the Slate Material Editor.
12 Activate the Front viewport, and press F3 to turn on shading.


Shaded plane in Front viewport

## Save your work:

- Save the scene as facade1_begin.max.


## Set Up the Stack so 3ds Max Preserves the Photo Projection

You are almost ready to add detail to the façade. But first, you need to set up 3ds Max so it displays the façade texture consistently, without distortion, and so it clearly highlights selected polygons.

## Set up the scene:

- Continue working on your scene from the previous section, or open \modeling $\backslash$ facades $\backslash$ facade_modeling_01.max.

The goal of the steps in this section is to be able to edit the Facade1 poly surface without distorting the texture projected onto it. Editable Poly objects have a toggle, Edit Geometry rollout > Preserve UVs, that does a good job of preserving the projection in most cases.


Moving an edge while Preserve UVs is off


Moving an edge while Preserve UVs is on
The stack setup used in this section is an alternative method that works for surfaces other than Editable Poly.

## Add a UVW Map modifier:


Select Facade1, then go to the
2 From the Modifier List, choose UVW Map.


The UVW Map modifier has no visible effect: It merely provides more explicit mapping control than the implicit mapping provided by the Facade1 object's texture coordinates.

3 In the modifier stack controls, make sure that I| (Show End Result On/Off Toggle) is on.


## Add a Poly Select modifier:

1 In the modifier stack, go down one level to the Editable Poly object (Facade1).

2 From the Modifier List, choose Poly Select.


3 In the modifier stack controls, make sure that is on for Poly Select as well.


4 In the modifier stack, go to the Editable Poly level. Make sure that (Show End Result On/Off Toggle) is on for the Editable Poly object (Facade1) as well as for the modifiers.
Turning on Show End Result for all three levels of the stack causes the viewports to always display the full bitmap in its final placement, even while you edit the underlying geometry.

NOTE Depending on your 3ds Max configuration, when you go to the Editable Poly level, you might see this warning:

| Warning |  |  |  | $\underline{x}$ |
| :---: | :---: | :---: | :---: | :---: |
| A modifier exists in the stack that depends on topology. Changing parameters may have undesirable effects. <br> The dependent modifier is: Poly Select <br> Are you sure you want to continue? |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| $\square$ Do not show this message again | Hold/Yes | Yes | o |  |

For the edits you are doing in this tutorial, it is safe to click Yes and proceed with your work. You also have the choice of turning on Do Not Show This Message Again before you click Yes: That disables display of this warning, but it does so not only for this tutorial, but for all future 3ds Max sessions. The choice is up to you, but for the remainder of this tutorial, we won't mention the warning dialog again.

Now you have set up the stack so you can see the undistorted bitmap projection, even while you edit the geometry of Facade1.

| § + UVW Mapping | $\square$ |
| :--- | :--- |
| § + Poly Select | $\square$ |
| $\mp$ Editable Poly |  |

Stack setup for editing a poly surface with a bitmap

Show End Result must be on for all three levels.

One further adjustment corrects for the situation that highlighted polys are hard to see with the default color scheme.

## Change the color of selected faces:

1 On the
 Modify panel, with the Editable Poly level active in the stack, scroll down to the Subdivision Surface rollout, and open it if it isn't already open.

2 On the Subdivision Surface rollout, make sure Show Cage is on.
3 Click the second of the color swatches that follow Show Cage.

| Subdivision Surface | ヘ |
| :---: | :---: |
| $\checkmark$ Smooth Result |  |
| $\square$ Use NURMS Subdivision |  |
| $\checkmark$ Isoline Display |  |
| $\checkmark$ Show Cage..... $\square$ |  |
| Display |  |
| Iterations: 1 |  |

This color is the color of highlighted polygons.
4 On the Color Selector, choose a bright red as the highlight color, and then click OK.


In the next lesson, you will turn Facade1 into a three-dimensional façade.

## Save your work:

■ Save the scene as facade1_stack.max.

## Next

Begin Adding Detail to the Façade: Modeling the Windows on page 175

## Begin Adding Detail to the Façade: Modeling the Windows

Now that you have set up the stack and the color of selected polygons, you are ready to turn the plane of the façade into a three-dimensional model.

## Set up the lesson:

Continue working on your scene from the previous lesson, or $\backslash$ modeling $\backslash$ facades $\backslash$ facade_modeling_02.max. open
 panel, and make sure that (Show End Result) is on for all three levels of the stack.

- If you continue from the previous lesson, do the following:

1 Activate the Front viewport.

(Maximize Viewport Toggle) (or click Alt+W) to maximize the Front viewport.

3 Press F4 to make sure Edged Faces are displayed.

## Adjust the line of the eaves:

1 Go to the
Modify panel. In the modifier stack, click to activate the Editable Poly level.

TIP You will use the Graphite Modeling Tools ribbon, but the ribbon doesn't display all options unless the Modify panel is active, and the geometry is chosen in the stack.

2 If the Graphite Modeling Tools ribbon is not displayed, then on the main
toolbar, click (Graphite Modeling Tools (Open)). If you need to, click the ribbon's
 expand/collapse icon until the full-size ribbon panels display.

3 On the Graphite Modeling tools tab, click $\checkmark$ (Edge) to turn on the Edge sub-object level.

4 Select the top edge of Facade1, then
 move it downward to hide the roof.


You will restore the roof later, in a following lesson.

## Add edges for the windows:

1


Zoom the viewport so you have a good view of the three windows in the upper portion of the wall.

2 On the Graphite Modeling tools tab > Edit panel, click to turn on 8 (SwiftLoop).

The SwiftLoop tool adds edges to the Editable Poly surface by drawing a "loop" from one edge to another.

NOTE In this tutorial, you use only a handful of tools to create the façade geometry. The ribbon has many other options that aren't demonstrated here. See Modeling a Helmet Using the Ribbon on page 64 for further uses of the ribbon.

3 Drag over the façade near the top edge. 3ds Max constructs a vertical edge, which you can move.


4 Click to set a vertical loop at the left edge of the small window in the upper left of the façade.


5 Add additional vertical loops for the other window edges.


6 Add horizontal loops to define the tops and bottoms of the windows.


Add edges for the lintel beam and the doorways:

1
Pan down to get a good view of the doorway area.
2 Add loops to outline the lintel.


NOTE The lintel beam is not perfectly rectangular. You will adjust its outline in a later procedure.

3 Add a vertical loop for the edge of the right-hand doorway. (The other vertical door edges match edges you already created for the windows.)


4 Also add vertical loops to the left of each dark area, where the wall angles into the doorway.


Loop for the angle of the left doorway's left-hand doorjamb


Loop for the angle of the right doorway's left-hand doorjamb

5 Finally, add a horizontal loop to define the elevation of the doorstep.


6 Right-click to turn off the SwiftLoop tool.
Now you have most of the edges you need to add 3D detail to the façade.
Add depth to the top center window:


2 Drag the left edge of the ViewCube to get a view of the façade that shows some depth.


3 In the viewport,

click to select the Ground object in the background, then right-click and from the quad menu, choose Hide Selection.

4
 upper portion of the wall.


6 Go to the Editable Poly level.
TIP On the Graphic Modeling Tools ribbon, you can navigate the stack by
 These move to the geometry level as well as to modifiers.

7 On the ribbon, click $\square$ Polygon to go to the Polygon sub-object level.

8


Click and Ctrl+click to select the three faces of the top center window.


9 On the ribbon $>$ Polygons panel, click the drop-down arrow next to the
 Extrude button, and choose Extrude Settings.


3ds Max displays an interactive manipulator called a "caddy."
10 Drag the arrows by the Height control, and extrude the window back by about $\mathbf{- 0 . 0 5 m}$.


TIP You can also simply type -0.05 in the Height field, and then press Enter.

11 Click

(OK: the check-mark icon at the bottom of the caddy) to complete the extrusion.

## Add depth to the other two windows:



Click and Ctrl+click to select the two polygons of the small window at the upper left.


2 On the ribbon, Shift+click
$\mathrm{g}^{1}$ (Extrude).
Shift+click is a shortcut way to display the caddy for a modeling tool.


3 The caddy defaults to the previous value you used for Extrude Polygons,
so just click
 (OK) so the small window matches its larger neighbor.


Click and Ctrl+click to select the four polygons of the main window in the center of the wall.


5 On the ribbon, Shift+click (Extrude).
6 This window should have more depth than the smaller windows, so in the Height field, enter $\mathbf{- 0 . 1 m}$, then press Enter.


7 On the caddy, click (OK).

Now the windows for Facade1 are done.


This completes the modeling of the upper portion of the wall.

Next
Detailing the Doorways on page 190

## Detailing the Doorways

Modeling the lintel is a bit more complicated than modeling the windows. On the other hand, the doorways themselves are a simple extrusion as the windows are.

Set up the lesson:
■ Continue working from the previous lesson.

## Correct the outline of the lintel beam:

1 Click the Front face of the ViewCube to return to a Front view.


2


Pan and


Zoom to get a good view of the faces that show the lintel beam.


As you can see in the bitmap, the lintel has an irregular outline. You will edit the faces so they correspond to the outline of the wooden beam.

3 On the ribbon, click $\stackrel{\square_{\square}^{\square}}{\square}$ (Vertex) to go to the Vertex sub-object level.

4 At the left end of the lintel,
 move the three lower vertices so they follow the outline of the beam.


TIP To do these edits and the ones that follow, it might help to

zoom
in more closely, then
 pan as you work on other parts of the lintel.

5 Where the lintel passes over the central pillar between the two doorways,
click to turn on $\square$ (SwiftLoop), then add a new vertical loop where the stones of the pillar form an angle into the beam.


This new loop of edges is so you can add a vertex at the angle point without creating a free-standing vertex. Free-standing vertices are never a good idea.

6 Right-click to close the SwiftLoop tool.

7 On the ribbon > Edit panel, click to turn on
 (Cut).

8 Use the Cut tool to draw new edges that follow the top of the pillar and the bottom of the beam.


TIP The cursor for the Cut tool has three different forms:
 when the cursor is at a vertex
 when the cursor is on an edge
 when the cursor is on a face

To avoid creating free-standing vertices, do not click the mouse while the


9 Right-click to close the Cut tool.

10 At the right end of the lintel, click to turn on
$=-$
4 (SwiftLoop), then add two new vertical loops where the stones rise into the beam.


11 Right-click to close the SwiftLoop tool.

12 Click to turn on
 (Cut).

13 Cut new edges to follow the outline of the beam.


14 Right-click to close the Cut tool.

Move the two upper vertices at the right end of the beam, to better follow the beam contour.


16 Click to turn on

(Select Object) and turn off Move.

Now the faces over the lintel are a fair approximation of the shape of the beam.

## Add depth to the lintel:

1 If you zoomed in to perform the edits in the previous procedure,
 zoom out and
 pan so you can see the entire lintel.

2 On the ribbon, click $\square$ (Polygon) to go to the Polygon sub-object level.

3
Click and Ctrl+click to select all of the lintel faces.


4 Drag the left side of the ViewCube to get a view that shows some depth, again.


5 Do the extrusion interactively this time: On the ribbon, click
 (Extrude) to turn it on, then drag in the viewport so the lintel extends above the doorways.


6 Right-click, and from the quad menu, choose Scale.

7 Use the scale gizmo to scale the size of the front faces of the lintel down a bit along the X and Z axes.


NOTE In the original building, the lintel doesn't appear to extrude this far; but for our model, we want to have geometry that casts a decent shadow.

## Add depth to the doors:

1
 get a better view of the doorways.

2


Click and Ctrl+click to select the doorway faces. Include the portion with stone to the left of each door. (The left-hand doorway has an extra sliver of face that the right-hand doorway does not have.)


3 On the ribbon, Shift+click
 (Extrude), then use the caddy's Weight field to extrude the doorways inward by a value of $\mathbf{- 0 . 6 m}$.


4 Click (OK) to accept the extrusion.

5 * - Orbit (or use the ViewCube) to see the doorways from the other side.


6 On the ribbon, click $<7$ (Edge) to turn on the Edge sub-object level.


Click and Ctrl+click to select the four vertical edges that are part of the doorways, but whose faces show stonework.


8


Move these edges to the right along the X -axis until the faces show only the shadows beyond the door.


Incidentally, the perspective captured by the camera helps with the texture projection onto the left-hand doorjambs: These now look good. The right-hand doorjambs don't look as good. This is a problem that you will fix in a later lesson.

9 Click $\square$ (Edge) to exit the Edge sub-object level.

## Next

Completing the Façade: Detailing the Roof on page 202

## Completing the Façade: Detailing the Roof

The last step in modeling Facade1 is to add the roof.

## Set up the lesson:

- Continue working from the previous lesson.


## Begin to model the roof:

1 Click
2 On the ViewCube, click Front to return to a Front view.


3 On the ribbon, click
 (Edge) to turn on the Edge sub-object level once more.

4 On the ribbon $>$ Modify Selection panel, click $\quad 4$ (Loop Mode) to turn it on.

5 With
 (Select Object) active, click one of the edges along the top of the façade.
Loop Mode selects all edges along the top of the façade.


6 Drag the left edge of the ViewCube to see the façade in depth once more.


8
Shift+move the top of the façade forward a bit along the Y-axis.


Reminder: Holding down Shift while you move, clones the edges to create new edges.


Shift+move the top of the façade upward a bit along the Z-axis, until you can see the ends of the roofing tiles.


Before you finish the roof, you will add depth to the entire façade.
Add depth to the entire façade:

1 Click

(Select Object) to turn it on and turn off Move.
$2 \begin{aligned} & \text { On the ribbon, click } \\ & \text { level. }\end{aligned}$

3


Click an edge along the top of the façade. 3ds Max selects the entire border.



Now that the façade, including its roof area, has some depth to it, you can complete the roof.

## Finish the roof:

1 Click the Front portion of the ViewCube to return to a Front view.


2 Drag the top edge of the ViewCube to tilt the view a little, so you can see the rear edge of the roof.


3
5
Zoom to get a better view of the roof area.

4 On the ribbon, click $\square$ (Edge) to go to the Edge sub-object level, then
 drag a selection box to select all the edges at the rear of the roof.


5 Turn on (Select And Move).

6


Move the selected edges up along the Z-axis until you can see the peak of the roof.


If you ${ }^{2}$, orbit the view, you can see that raising the rear edge also gives a slope to the roof.


7 Return to a Front view.

 (Vertex) to turn on Vertex sub-object mode.

8 One at a time,
 move vertices at the rear roofline down vertically to match the bitmap of the roof.

TIP At the extreme left and right of the roof, you might also want to move the front roofline vertices slightly downward.


After moving all existing vertices, you can see there are two areas on either side of the peak, where the sagging of the medieval roof still shows some sky.


[^1]

10 Right-click to close SwiftLoop.

11


Move the new vertices at the rear roofline down vertically to hide the sky-blue (or cloudy) areas of the façade texture.
 (Vertex) to exit the Vertex sub-object level.

## Save your work:

■ Save the scene as facade1_modeled.max.

Now you've completed the modeling of the façade: You have a convincingly three-dimensional house front with a realistic texture.


The only flaw, is that there is a good deal of streaking on those faces that are perpendicular to the projection of fac1.jpg. The next lesson shows how to correct the texture in these portions of the model.

## Next

Correcting the Texture on page 212

## Correcting the Texture

To correct the texture on selected faces, you add additional mapping information for those faces. There are a number of ways to do this, but the Unwrap UVW modifier is the most versatile and interactive way: This lesson shows how to use Unwrap UVW.

Adding texture detail is a matter of how much time you want to spend, and how you plan to use the model. If the model will appear only in a long shot, you might be able to dispense with texture correction. If the model will appear in a medium shot or a close-up, you might have to go through these steps.
For the purposes of this lesson, we use the final rendering as a guide:


This is a medium shot. Facade1, on the left, is in shadow: But at another time of day, you would be able to see the right sides of the doorways. So we will show how to correct the sides of the doorway, and the doorstep.

The windows are too far away to see detail; the roof is seen only from below; and the sides of the house are obscured by other houses. So we won't go through the steps for correcting these details, but at the end of this lesson, we show how the details might be corrected. (The completed model, facade_modeling_completed.max, has many texture corrections that these lessons don't describe.)

## Set up the lesson:

1 Continue working on your scene from the previous lesson, or open \modeling \facades \facade_modeling_03.max.

2 If you open the file,
select the façade, go to the
Modify panel, and make sure that II (Show End Result) is on for all three levels of the stack.

## Add an Unwrap UVW modifier:

Select Facade1.

2 Go to the Modify panel. In the modifier stack, click the UVW Mapping entry to make this modifier active.

3 From the Modifier List, choose Unwrap UVW.


4 In the modifier stack, click
(the plus-sign icon) by the Unwrap UVW entry to expand the Unwrap UVW sub-levels, then click the Face sub-object level to make it active.

| Facade01 |  |
| :---: | :---: |
| Modifier List | - |
|  |  |
| § + UVW Mappings |  |
| § It Poly Select |  |
| $\pm$ Editable Poly |  |
| -m $11 \mid$ br 8 | 2 |

## Correct the texture on the left-hand doorjamb:

1
 viewport so you have a good view of the right side of the doorways.


The sides appear streaked, because they are at right angles to the texture projection of the UVW Map modifier.

Click and Ctrl+click to select both doorjamb faces.


NOTE You can adjust some settings for both doorjambs at once, because they are parallel to each other.

3 On the Modify panel Map Parameters rollout, click to turn on Planar, then click Align X.

| Planar | Pelt |
| :---: | :---: |
| Cylindrical | Spherical |
| Box | Spline |
| Align X | Align Y |
| Align Z | Best Align |
| Fit | Align To View |

Now the doorjambs are correctly aligned with the fac1.jpg texture.
However, they show the entire façade, which is not quite what we want.


4 Click Planar again to turn it off.
IMPORTANT If you forget to turn off Planar, later you won't be able to use controls in the Edit UVWs dialog.


3ds Max opens the Edit UVWs dialog.


7 On the Edit UVWs dialog toolbar, choose "Map \#11 (fac1.jpg)" from the background pattern drop-down list.


Now the main window of the dialog displays fac1.jpg.

8 On the lower toolbar, click to turn on
 (Filter Selected Faces). Now the geometry shown in the Edit UVWs dialog (the red mesh) represents only the left-hand doorjamb face.

9 On the Edit UVWs dialog toolbar, click to turn on (Freeform Mode).
The face mesh now shows handles at its edges and corners. With Freeform Mode, you can scale the face by dragging a corner handle, rotate the face by dragging a side handle, and move the face by dragging from the interior of the face.

10 Drag a corner to scale the face so it is roughly the size of a doorjamb in the bitmap.


TIP Move the Edit UVWs dialog so you can also see the left doorjamb in the viewport. That way, you can see your texture-mapping changes interactively, as you make changes in the dialog.

11 In the Edit UVWs dialog, drag the face to the right, so it covers the right side of the central pillar.


12 On the Edit UVWs dialog toolbar, click $\square$ In the viewport, you can see how the correction looks.


This is the pattern for using Unwrap UVW to correct textures on faces with poor texture projection: Essentially, you "fake" the texture by choosing some part of the original texture that looks well when applied to the surface that needs correcting.

## Correct the texture for the right-hand doorjamb:

1 With the Edit UVWs dialog still open,
 click to select the right-hand doorjamb.


2 On the Edit UVWs dialog lower toolbar, click to turn Filter Selected


IMPORTANT Toggling Filter Selected Faces ensures that the Edit UVWs dialog display is updated correctly.

3 On the Edit UVWs dialog toolbar, turn on (Freeform Mode), then drag the upper-right corner of the doorjamb face to scale it so it is roughly the size of a doorjamb in the bitmap.


4 Drag the face a bit to the right, so you can see the edge of the shrub.


5 On the Edit UVWs dialog toolbar, click Once again, you can see the correction in the viewport.


6 $\square$ Close the Edit UVWs dialog.

7 Deselecting the faces makes it easier to see the corrections you made.


## Correct the texture on the doorsteps:

The doorsteps are a little tricky, because the photo has no information about that portion of the building. To compensate, we use the lintel texture: Although the lintel is wood, when scaled up in size it can pass for stone.

1


Click and Ctrl+click to select the doorstep faces (there are four faces on the left, and three on the right).


2 On the


Modify panel
Map Parameters rollout, click to turn on Planar, then click Align Z.

| Planar | Pelt |
| :---: | :---: |
| Cylindrical | Spherical |
| Box | Spline |



Now the doorsteps are correctly aligned with the fac1.jpg texture.
3 Click Planar again to turn it off.

4 On the


Modify panel $>$ Parameters rollout, click Edit to open the Edit UVWs dialog.


5 In the Edit UVWs dialog, scale and move the doorstep faces so they are on top of the lintel beam in the bitmap.


6 $X$ Close the Edit UVWs dialog.

A close-up rendering of the doorways shows your texture corrections better than the viewport can.


## Save your work:

Save the scene as facade1_textured.max.

## Extra Credit: Mapping the Windowsills, Window Jambs, and Sides of the House

As we mentioned at the beginning of this lesson, it isn't necessary to correct the texture for the windows or the sides of the house. But if you want to try using Unwrap UVW to do so, or if you are simply curious how it was done for the completed model, here are the mappings used.

NOTE The completed model has some additional mapping corrections not shown here: the bottom of the lintel and the bottom of the eaves. You can investigate these, if you wish, by looking at facade_modeling_04.max or facade_modeling_completed.max.

## Windows



Mapping for the windowsills


Mapping for the window jambs
(The same texture is used for both sides of the windows.)

House Sides


Left side


Right side

## Next

Modeling the Second House on page 233

## Modeling the Second House

The second house front has a peaked roofline and an arched entry. We will concentrate on modeling these, as you already know how to model windows.

## Set up the lesson:

- Continue working on your scene from the previous lesson, or

open $\backslash$ modeling $\backslash$ facades $\backslash$ facade_modeling_04.max.


## View the bitmap for the second house, and note its dimensions:

1 On the main menu, choose Rendering > View Image File. In the View File dialog, navigate to the \sceneassets $\backslash i m a g e s$ folder, and highlight fac4.jpg.
In the lower-left corner of the View File dialog, a status line shows the dimensions of the image, which are $1200 \times 1740$ pixels.

## Devices...

Setup...
Info...

View

Gamma
Use image's own gamma
O Use system default gamma
Override 1.0

Sequence


Statistics: $1200 \times 1740$, RGB Color 8 Bits/Channel - Single Image Location: C:\Users\Default\Documents\3ds Max 2011 Tutorials\sceneass... \fac4.jpg

2 Click Open to view the image at full size.


3 $\square$ Close the image window after you have looked at the photo.

## Create the plane for the house:

1 Click
(Maximize Viewport Toggle) to display a four-viewport layout.

2 Change the upper-right viewport to a Front viewport, and activate it.

3


Select Facade1, and then click
 (Zoom Extents Selected).


Pan the viewport so Facade1 is at the left.

5 On the
Create panel, click
(Geometry), then on the Object Type rollout, click Plane.

6 In the Front viewport, drag to create a plane. Change the Length (height) value to $\mathbf{1 0 . 0} \mathbf{m}$ and the Width value to $\mathbf{6 . 8 m}$. Change Length Segs $=$ Width Segs $=1$.


NOTE The aspect ratio of the new house is 1200:1740, which equals 0.69 , so the dimensions of $10 \mathrm{~m} \times 6.8 \mathrm{~m}$ are close to the real-world dimensions. (Most of the houses in Monpazier are 6.8 m wide.)

7


Move the new plane so it is level with Facade1, then move it to the right so it is to the right of the previous house, with bit of distance between them.


8 Name the new plane Facade4.

9 Go to the


Hierarchy panel. On the Adjust Pivot rollout, turn on Affect Pivot Only, then
 move the pivot vertically so it is at the base of the Facade4 plane.

10 Right-click the Facade4 plane, and from the Transform (lower-right) quadrant of the quad menu, choose Convert To $>$ Convert To Editable Poly.

## Texture the plane:

1


Open the Slate Material Editor.

2 In the Material/Map Browser panel, locate Materials mental ray, and drag the Arch \& Design entry to the active View.

3 Double-click the Arch \& Design material node to display its parameters.
4 Name the material Facade 4.
5 On the Templates rollout, choose Matte Finish from the drop-down list of templates.

6 On the Material/Map Browser panel, locate Maps > Standard, and drag the Bitmap entry to the active View.

7 In the file dialog that opens, choose fac4.jpg as the bitmap, turn off Sequence, and then click Open.

IMPORTANT In the Select Bitmap Image File dialog, be sure to turn off the Sequence toggle.
fac4.jpg


When Sequence is on, 3ds Max attempts to create an IFL animation, and we want to open only the single image.

8 Wire the Bitmap to the Arch \& Design material's Diffuse Color Map and Bump Map components.


9 Click the Facade 4 material node to make it active, then turn on (Show Map In Viewport).

10 Drag from the Arch \& Design material node's output socket (the small circle on the right), and drop the material on the Facade 4 plane in a viewport.


Dragging and dropping is another way to apply a material.
NOTE You won't see the wire as it crosses the panel at the right of the Slate Material Editor, or in the viewport.


Shaded plane in Front viewport


Set up the stack and face-selection color:

1 Go to the


Modify panel.

2 From the Modifier List, add a UVW Map modifier. Click the Editable Poly entry again, then add a Poly Select modifier.

3 Make sure that $\mid$ (Show End Result) is on for all three levels of the stack (the two modifiers and the Editable Poly object itself).

4 Click the Editable Poly level again to make it active. Scroll down to the Subdivision Surface rollout, and open it if it isn't already open.

5 On the Subdivision Surface rollout, make sure Show Cage is on.
6 Click the second of the color swatches that follow Show Cage.


This color is the color of highlighted polygons.
7 On the Color Selector, choose a bright red as the highlight color, and then click OK.


## Adjust the roofline:

1 On the ribbon, click $<$ (Edge) to go to the Edge sub-object level.

On the Edit panel, click (SwiftLoop) to turn it on.
2 Make sure the viewport displays Edged Faces (F4).
3 Create a vertical edge that is centered on the peak of the roof.


4 On the ribbon, click | $\square_{\square}^{\square^{\prime}}$ | (Vertex) to go to the Vertex sub-object level. |
| :---: | :--- |



Move the upper-left and upper-right vertices down to match the roofline.


5 On the ribbon, click $\square$ (Edge) to go to the Edge sub-object level.


Click and Ctrl+click to select the two roof edges, then
 move them down vertically a bit to hide the cornice.


As you did for Facade1, you will add detail for the roof later in this tutorial.

## Add edges for the windows:

Although we won't go into detail about creating the windows, you will add their construction edges, as these can help you construct the arch.

## 1 On the ribbon $>$ Edit panel, click (SwiftLoop) to turn it on again.

2 Add vertical edges for the two windows.


3 Also add vertical cuts for the center dividers of the two windows.


As you work with SwiftLoop, you will notice that the "horizontal" loops are now chevron-shaped, because of the peaked roof. To get true horizontal edges, you need to use a different tool at first.


5 Position the cursor at the horizontal top of the upper window, then click the mouse once.
3ds Max creates a single horizontal slice.


6 Click the mouse a second time to "set" the quick slice. (If you drag the mouse, 3ds Max rotates the slice, which we don't need here.)

7 Use
 (QuickSlice) again to create the lower edge of the upper window.


8 Once you've used QuickSlice to finish creating horizontal edges for the
upper window, you can use
$\square$ horizontal edges for the lower window.


NOTE Although we don't go through the steps in this tutorial, we use three horizontal loops for the lower windowsill, because in the final model it has two levels of extrusion. You can see this in facade_modeling_completed.max.

Now you have some of the grid on which you will base the actual arch contour.
Next
Add Detail to the Arch on page 248

## Add Detail to the Arch

The arch is the distinctive feature of Facade4. It calls for more complex modeling than the doorways of the previous façade.

Set up the lesson:
■ Continue working from the previous lesson.

## Add edges for the arch:

The window edges give you a starting point, but to model the arch well, you need to add some further edges for reference and for making cuts.

Pan and
 zoom so you have a good view of the arch.

2 On the ribbon > Edit panel, turn on


3 Add a horizontal loop at the top of the arch.


4 Add a vertical loop at each side of the arch.


5 Subdivide the arch area with four horizontal loops. Make them a little closer together at the top, and more widely spaced toward the bottom.


6 Add one more horizontal loop for the doorstep or sidewalk.


7 Subdivide the arch area further with vertical loops: Add two on the left, and three on the right.


Outline the arch:
1 On the ribbon $>$ Edit panel, turn on (Cut).
2 Cut edges to define the archway.


Reminder: Don't click the mouse when the cursor shows it's
 a face. The cuts should always join edges or vertices.

3 Right-click to close the Cut tool.
 move the new vertices in X or Y (try not to deform the horizontal and vertical lines of the grid).

When the cuts for the archway are done, you're ready to extrude the arch.

## Extrude the arch:

1 On the ribbon, click $\square$ (Polygon) to go to the Polygon sub-object level.

2
Click and Ctrl+click to select the faces in the archway. Don't neglect the small triangular faces that you might have created along the upper edge of the arch.


3 Drag the left edge of the ViewCube so the view shows some depth.


4 On the ribbon $>$ Polygons panel, Shift+click (Extrude) to display the extrusion caddy.


You will extrude the arch in two stages: The first stage gives depth to the wall, and the second represents part of the interior of the arcade behind the arch.

5 In the caddy's Height field, enter $\mathbf{- 0 . 3 m}$ for the first extrusion (the width of the wall).


6 Instead of clicking OK, click (Apply And Continue).


3ds Max creates the extrusion and begins another.
7 In the Height field, enter $\mathbf{- 0 . 4}$ for the second extrusion (the arcade interior).


8 Click (OK) to accept the value and close the caddy.

## Next

Add Detail to the Cornice on page 257

## Add Detail to the Cornice

The cornice, with its peak, is slightly different from the roof for Facade1.

## Set up the lesson:

■ Continue working from the previous lesson.

## Model the cornice:



Pan so you can see the roofline.
2 On the ribbon, click $<7$ (Edge) to turn on the Edge sub-object level.
$\square$ Select the edges along the top of the façade.


TIP It can be hard to select the very small edges near the peak: Make sure the Window/Crossing toggle is set to

(Window), and drag a box around them. Ctrl+click to add the longer edges to the selection.

Shift+move the edges forward a bit along the Y-axis.


5


Shift+move the edges up a bit along the Z-axis.


6
Shift+move the edges forward along the Y-axis, and then Shift+move them up along the Z-axis once again, to complete the cornice.


7 Click $<7$ (Edge) to exit the Edge sub-object level.

At this point, if you wish, you can add depth to the windows and to the façade as a whole, as we did for Facade1. But that work has been done for you in the sample file for the next lesson. This completes the modeling work on Facade4. What remains is to correct the texture mapping with Unwrap UVW. Because the arch is curved, you will use a new method to map its inner faces.

## Save your work:

■ Save the scene as facade4_modeled.max.

## Next

Texturing the Arch on page 261

## Texturing the Arch

As for Facade1, you use Unwrap UVW to texture the entryway faces of Facade4. Because of the arrangement of these faces, you use different Unwrap UVW techniques.

Set up the lesson:

1 Continue working on your scene from the previous lesson, or open \modeling $\backslash$ facades $\backslash$ facade_modeling_05.max.
 panel, and make sure that II levels of the stack.

## Texture the pavement:

1


Select Facade4.
2 Make sure the viewport displays Edged Faces (F4).

3
 get a good view of the arch geometry.


4 Go to the


Modify panel. In the modifier stack, make sure UVW Mapping is the active level.

5 From the Modifier List, choose Unwrap UVW.

| Turn to Patch |
| :--- |
| Turn to Poly |
| Twist |
| Unwrap UVW |
| UVW Map |
| UVW Mapping Add |
| UVW Mapping Clear |

6 In the modifier stack, click
(the plus-sign icon) by the Unwrap UVW entry to expand the Unwrap UVW sub-levels, then click the Face sub-object level to make it active.


7

$\square$
Click and Ctrl+click to select the upper faces of the doorstep or sidewalk.


8 On the


Modify panel
Map Parameters rollout, click to turn on Planar, then click Align Z.

| Planar | Pelt |
| :---: | :---: |
| Cylindrical | Spherical |
| Box | Spline |
| Align X | Align Y |
| Align Z | Best Align |
| Fit | Align To View |

Now the pavement is correctly aligned with the fac4.jpg texture.


9 Click Planar again to turn it off.

10 On the
Modify panel > Parameters rollout, click Edit to open the Edit UVWs dialog.


11 On the Edit UVWs dialog, choose "Map \#13 (fac4.jpg)" from the background pattern drop-down list.


12 On the Edit UVWs dialog lower toolbar, click to turn on (Filter Selected Faces).
$i \pm!$
13 On the Edit UVWs dialog main toolbar, click to turn on (Freeform Mode).

14 Use the handles to move and scale the pavement faces so they are on top of the larger window's windowsill.


The idea is to map the pavement to a dark area of stone.

TIP Move the Edit UVWs dialog so you can also see the texture display in the viewport.


15 $\square$ Close the Edit UVWs dialog.

## Set up texturing for the wall portion of the arch:

1 Use the ViewCube to orbit the scene so you can see all the interior faces of the archway.


2
Click and Ctrl+click to select the outer faces along the inside of the archway: These are the faces that correspond to the width of the stone wall.


TIP You can press F2 to toggle the shading of selected faces. Turning on face shading makes it easier to see your selection.

3 Press Shift+Z to return to your previous view of the archway, looking at it from the side and slightly downward.

4 On the


Modify panel > Map Parameters rollout, click Cylindrical to turn it on, then click Align Y.

| Planar | Pelt |
| :---: | :---: |
| Cylindrical | Spherical |
| Box | Spline |
| Align X | Align Y |
| Align Z | Best Align |
| Fit | Align To View |

3ds Max displays a cylindrical gizmo for the Unwrap UVW projection.


Move the cylinder gizmo forward a bit, so you can see all of it, and it is not hidden by the wall.


TIP As the illustration shows, you might want to
 ViewCube) to see the wall and the cylinder gizmo more obliquely.

The cylinder gizmo has one height segment displayed in green. This indicates where the seam of the cylindrical mapping will be. At present, the green segment is near the right side of the arch.

6 Turn on
(Select And Rotate).

7


Rotate the cylinder gizmo about the Y-axis until the seam segment is at the bottom of the scene.


Since the arch isn't a full circle, putting the seam at the bottom ensures there won't be a seam on the façade geometry.

8 On the Map Parameters rollout, click Fit.

| Planar | Pelt |
| :---: | :---: |
| Cylindrical | Spherical |
| Box | Spline |
| Align X | Align Y |
| Align Z | Best Align |
| Fit | Align To View |
| Center | Reset |

3ds Max fits the cylinder gizmo to the geometry of the arch.


9 Click Cylindrical again to turn it off.

IMPORTANT Like the Planar button, the Cylindrical button enters a mode: If you forget to turn it off, later you won't be able to use controls in the Edit UVWs dialog.

Use the Edit UVWs dialog to position the wall texture:

1 On the Modify panel $>$ Parameters rollout, click Edit to display the Edit UVWs dialog.


2 If you need to, on the Edit UVWs dialog, choose "Map \#13 (fac4.jpg)" from the background pattern drop-down list, and on the lower toolbar, turn on
 (Filter Selected Faces).

3 On the Edit UVWs dialog main toolbar, turn on (Freeform Mode).

4 Use the handles to scale the wall faces so they cover a strip of stone above the arch. The placement doesn't matter much, as you will be changing it soon.


5 On the Edit UVWs dialog main toolbar, click
(Mirror Horizontal).
6 On the options panel below the main Edit UVWs dialog, click to turn on

(Vertex Sub-Object Mode).


7 On the Edit UVWs dialog menu bar, choose Tools $>$ Sketch Vertices. 3ds Max opens a Sketch Tool dialog.

8 On the Sketch Tool dialog, choose Free Form from the Align To drop-down list.


Also in the Sketch Tool dialog, click to turn on Interactive Mode, and then click OK.


After you have set up the Sketch Tool to use Free Form drawing, you work in a two-step manner: First, drag to select the vertices you want to reposition; Second, draw a freehand stroke to show Edit UVWs where to place the selected vertices.

9 In one continuous motion, drag to select vertices along the lower-left edge of the arch faces: Begin at the center of the lower edge, and move the cursor to the left.


NOTE If your grid of edges matches the grid shown in the previous lesson, there are 11 vertices on each side of the arch. 3ds Max numbers these from 0 to 10.

10 With the pencil cursor, sketch along the lower-left edge of the arch that the bitmap shows.
3ds Max moves the vertices you selected to follow the line as you draw.


You don't have to worry about being too precise: You can adjust your work later.

11 Repeat the previous two steps for the upper edge of the arch faces.


12 And then repeat the same steps for the right side of the arch.


Texturing the Arch | 277


13 After you have used Sketch Vertices to rough out the arch faces in this
way, on the Edit UVWs dialog toolbar, turn on
 move vertices to arrange them more regularly.


## Map the inner, arcade faces:

We'll let you decide whether you want to go through the steps for mapping the inner, arcade faces. The steps to follow are the just same as the steps you followed for the stone wall faces, with these changes:

- Select the inner faces instead of the outer ones.

■ Map the faces to the dark, arcade area of the bitmap. Avoid lighter areas of the bitmap (except the reflected lights, which will look OK); and of course, avoid the bicyclist.


A close-up rendering of the façade shows the result of mapping the arch.


## Save your work:

■ Save the scene as facade4_textured.max.

The completed scene is facade_modeling_completed.max. This scene contains two other façades. If you want to try modeling them, you should now know the tools you can use to do so.


Façade 2


Façade3

## Summary

With a photograph of a building's façade, you can create a convincing model of that façade. The overall steps are as follows:

1 Use a photo-editing program to correct the photograph's perspective, so that vertical and horizontal lines are parallel.

2 In 3ds Max, create a plane that has the same aspect ratio as the photograph, and the same dimensions as the original building.

3 Create a material that uses the photo as both a Diffuse and a Bump map, and apply it to the plane.

4 Make the plane an Editable Poly object.
5 Set up the stack with UVW Map and Poly Select, so you can see the end result while you edit the geometry.

6 Use Editable Poly tools to create edges that correspond to features of the façade.

7 Use the Extrude tool to make features three dimensional, having them recess or protude so the building will cast realistic shadows.

8 Use Unwrap UVW to correct the mapping of faces that aren't parallel to the main UVW Map projection.

## (3) Modeling an Airplane

In this tutorial, you explore Editable Poly surfaces further by building a model of a fighter airplane.


The aircraft is a Republic Aviation P-47 Thunderbolt, a heavy-duty fighter used extensively by the Allied forces in World War II. For information about the history and technical details of this aircraft, do a Web search for "P-47".

NOTE Unlike the irregular meshes used in the tutorial Using Photos to Model Façades on page 148, the mesh you create in this tutorial has consistent quadrangular faces. Although the airplane is not meant to be deformed, this is the kind of mesh you should create when you model a deformable character.

Skill level: Advanced
Time to complete: 5 to 6 hours

## Pointers on Setting Up a "Virtual Studio"

When you build a 3D model from scratch, often it helps to set up reference or "blueprint" images to use as a guide to the 3D geometry. Typically these images are plans that show the side, front, and top of the object to model.


Virtual studio for the P-47 model
You might find such plans on the Web, you might scan them from a book or the instructions for a scale model, or you might draw them yourself. Here are some pointers for how to set them up so you can use them in 3ds Max:

■ If you need to resize the images, resize them as a set, so the dimensions match in all three images.
Many image-processing programs have guidelines or rulers that can help you align the images to a common center, and make sure their dimensions match.

- Make the images square.

Square images are easier to align when you apply them to 3ds Max geometry.

- Use color for the images.

For this tutorial, we chose shades of blue: This nostalgically recalls paper blueprints, but more importantly, in 3ds Max it is impossible to see white selection boxes against a white background.

In 3ds Max itself, you can set up three planes in the virtual studio arrangement. For this tutorial, we used Generic units ( 1 generic unit equals 1 inch), and set the reference planes to the pixel dimensions of the blueprint images: 800 x 800.

Map the images to the planes, using these guidelines:
■ Set Self-Illumination to 100 percent.
If your scene uses lights, the blueprint images will always be visible.
■ Select all the planes, right-click, and choose Object Properties. On the Object Properties dialog, turn on Backface Cull.
This way, when you look at the model through one of the planes, the image doesn't get in the way.

- Also on the Object Properties dialog, turn off Show Frozen In Gray. Freezing the planes lets you work on the model without worrying about selecting the planes by accident. By default, frozen objects are gray: Turning off this option lets you freeze the planes and still see their blueprint images.
- Freeze the planes.

■ Set all four viewports to Smooth + Highlights display (F3).

Now you are ready to begin modeling.

## Creating the Fuselage

The fuselage begins as a geometric primitive. You modify the shape of the primitive, and then convert it to an Editable Poly object. For most of this section, and the remainder of the tutorial, you will use Edit Poly tools to shape the airplane.

## Model the Engine Cowl

You build the P-47 Thunderbolt from scratch, but use planes with "blueprint" images to guide your work. The airplane will consist of just two objects: The fuselage with its wings and other details, and the canopy that goes over the cockpit.

## Set up the scene:

- On the Quick Access toolbar, click
 (Open File), navigate to the \scenes $\backslash m o d e l i n g \backslash p 47$ folder, and open p47_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene contains three planes that show side, front, and top elevations of the airplane: a "virtual studio" as described in Pointers on Setting Up a "Virtual Studio" on page 284.

## Optimize bitmap display in viewports:

1 On the main toolbar, choose Customize $>$ Preferences.
2 Go to the Viewports tab, then click Display Drivers > Configure Driver. 3ds Max opens the configuration dialog for the graphics driver you are using (Software, OpenGL, or Direct3D).

3 Depending on the driver, there are either one or two check boxes labeled Match Bitmap Size As Closely As Possible (for the OpenGL driver, the label is Match Bitmap As Close As Possible). If there is one, turn it on. If there are two, turn on both of them.

## (G) Configure Direct3D

## 2

Implementation-Specific Settings
Geometry
Display All Triangle Edges
V Use Cached D3DXMeshes
$\square$ Use Wireframe FacesUse Triangle Strips
ป For Wireframe Objects
Window Updates
Redraw Scene On Window Expose
Redraw In Maximized Viewport
$\square$ Redraw In UnMaximized Viewports
Use Incremental Scene Updates

Appearance Preferences
Enable Antialiased Lines in Wireframe Views
Antialiasing
None -
Background Texture Size

| 128 | 256 | 512 |
| :--- | :--- | :--- |$\sqrt{1024}$

Match Bitmap Size as Closely as Possible
Download Texture Size

| 64 | 128 | 256 | 512 |
| :--- | :--- | :--- | :--- |

Match Bitmap Size as Closely as Possible

Texel Lookup

- Nearest
(O) Linear
- Anisotropic

MipMap Lookup
(0) None

Nearest

- Linear


## Configuration dialog for the Direct3D driver

4 Click OK to close the driver configuration dialog, and OK again to close the Preferences dialog.

5 If you had to turn on Match Bitmap Size As Closely As Possible, then exit 3ds Max. Restart 3ds Max before you continue with this tutorial.
Bitmap configuration changes do not take effect immediately: You always have to restart 3ds Max.

If you did not have to change the Match Bitmap Size setting, you can continue without restarting 3ds Max.

## Set up the viewports:

1 Click (Maximize Viewport Toggle) to display all four viewports.
2 For each of the orthographic viewports (Top, Front, and Left), turn on Smooth + Highlights (keyboard shortcut: F3), turn off grid display
(keyboard shortcut: G), and click
3 In the Left viewport, use
the front of the airplane.


## Create a cylinder to begin the engine cowl:

1 On the
Create panel, activate

(Geometry), then on the Object Type rollout, click Cylinder.

2 In the Left viewport, drag from the center of the propellor hub to create a cylinder that is about as wide as the airplane. Give it a height of about 60 (the exact value is not important). Set Height Segments to 1, Sides to 10, and turn off Smooth.


NOTE With 10 sides, the top and bottom segments are flat: This will come in handy when you add some details such as the tail.

3 Change the name of the cylinder to P-47.

4 Turn on

(Select And Move). In the Left viewport, move the cylinder so it is well centered on the image of the airplane. In the Top viewport, move it forward so its rear edge coincides with the rear edge of the engine cowl.


NOTE As you create the model, it can help to
 zoom and - 0 pan a particular viewport to get a better view of the geometry and the blueprint image. In general, we mention view changes when they are particularly important or useful, but you might want to change the view more often than we indicate. This is quite all right.

5 If you need to, reduce the height of the cylinder so its front edge matches the edge where the air-intake cover meets the cowl.


NOTE In this step, as in much of this tutorial, you are using the "blueprint" images as a guide, and the exact values don't matter much. Use your eye and your judgement.

6 Go to the Modify panel, and apply an FFD $3 \times 3 \times 3$ modifier to the cylinder.

FFD stands for "free-form deformation." This modifier lets you adjust the shape of the cylinder, using a $3 \times 3 \times 3$ array of control points.
$+$
7 On the modifier stack, click
(the plus-sign icon) to open the FFD $3 \times 3 \times 3$ modifier hierachy. Click Control Points to highlight that sub-object level.


8 In the Left viewport, drag to select the bottom row of FFD control points (this actually selects all nine control points at the bottom of the lattice),
then move them down so they coincide with the bottom of the fuselage. together.


9 Drag to select the upper row and plane of control points.
 them out a bit along the X axis, then
the Y axis.


You now have a good cross-section of the cowl at the front of the fuselage. In the next procedure, you refine its shape along the length of the airplane.

## Taper the profile of the cowl:

1 On the modifier stack, click the FFD $3 x 3 x 3$ entry to exit the Control Points level. Then choose Modifier List $>$ FFD 2x2x2.
You will use this additional free-form deformation modifier to give some taper to the nose of the airplane.
$\ddagger$
2 On the modifier stack, click
(the plus-sign icon) to open the FFD $2 \times 2 \times 2$ modifier hierachy. Click Control Points to highlight that sub-object level.


3 In the Front viewport, drag a selection box to select the row of control
points at the lower leading edge of the cowl, then
 move the points to follow the taper of the image. Do the same for the lower trailing edge of the cowl.


4 Do a similar adjustment for the upper profile of the cowl.


5 In the Top viewport, drag to select the leading plane of control points,
then $\square$ in that dimension as well. so it matches the blueprint image.


The changes you make in the Front and Top viewports also appear in the Left viewport.


## Extend the cowl forward:

1 Right-click the P-47 cylinder, then from the quad menu, choose Convert To > Convert To Editable Poly.
By converting the cylinder to an Editable Poly object, you lose the specific Cylinder and FFD modifier controls, but you gain access to the rich set of Editable Poly sub-object controls.

2 If the Graphite Modeling Tools ribbon is not displayed, then on the main toolbar, click
 (Graphite Modeling Tools (Open)).

3 If the ribbon is displayed but not fully expanded, click the expand/minimize icon until the full ribbon is visible.

4 On the ribbon $>$ Graphite Modeling Tools tab $>$ Polygon Modeling panel, click
 (Polygon) to go to the Polygon sub-object level.

5 In the Left viewport,
 click to select the large polygon at the front of the cowl.


6 Activate the Perspective viewport.

7 On the ribbon
Polygons panel, click $\square$ (Bevel).


The Bevel tool does two things: It extrudes a selection, and then lets you scale the size of the extrusion.

8 Do this step in the Perspective viewport, but watch your work in the Front viewport: Drag upward to extrude the selected polygon as far as the front of the airplane.


Release the mouse, then drag downward to scale the polygon so it tapers as the blueprint image shows.


The curve of the cowl is subtler than the model we have so far, but you will fix that later on.

## Next

Complete the Air Intake on page 303

## Complete the Air Intake

At the front of the cowl, the cover of the air intake is recessed, and has a rounded shape. You don't need to make the model as detailed as an actual airplane would be, but these steps give the general look of the front of the plane.

## Set up the lesson:

- Continue working from the previous lesson.


## Add detail to the air intake:

1 In each of the four viewports, press F4 to turn on Edged Faces.
This makes it easier to see the polygons with which you're working.
2 With the front polygon still selected, on the ribbon $>$ Polygons panel, click $\square$ (Inset). In the Perspective viewport, drag downward to reduce the size of the front polygon, and add polygons around it.


You can also see this change in the Left viewport.


3 On the ribbon Polygons panel, click viewport, drag downward to recess the central polygon.


Release the mouse, then drag it downward again a little bit, to taper the inside of the recess. This change is easier to see in the Left viewport.


As for most of the P-47 model, exact distances don't matter here: The important thing is the overall look.

4 Activate the Left viewport, and press Alt+X to turn on X-Ray (See-Through) display mode. Click away from the geometry to deselect the front face.
Even with X-Ray display, it is a little hard to see details of the blueprint image.


Here is the image without the geometry in front of it:

(If you like, you can also choose Rendering > View Image File, and then open \sceneassets $\backslash i m a g e s ~ \backslash p 47$ _front.jpg to see the full-size version of this image.)

As the blueprint image shows, there is a circular area within the recess: This is the intake for air to help cool the engine. The air intake for the engine's combustion is a pipe located below the circular area.

5 On the ribbon $>$ Polygon Modeling panel, click $\ll$ (Edge) to go to the Edge sub-object level.
 the bottom of the recess.



7


Scale the edge out a bit along the X axis so the outline of the intake becomes a bit rounder.


8 On the ribbon > Polygon Modeling panel, click | $\square^{\square}$ | (Vertex) to go |
| :---: | :--- | to the Vertex sub-object level. four vertices at the lower edge of the inner portion of the recess.



TIP If you select a vertex you don't want, Alt+click to deselect it.

9


Move the vertices up along the Y axis to make the cooling intake even more rounded.


If you activate the Perspective viewport and press Alt+X to turn off X-Ray display, you can get a better view of the work you've just done.


## Subdivide the intake faces:

The front of the airplane is nearly done, for the time being. But because of the way 3ds Max constructed the cylinder that was the origin of this model, the intake face is a 10 -sided polygon. As we mentioned earlier, it is best if the mesh consists of consistently quadrangular polygons: These work much better with smoothing and (if you are creating a character) with skin deformation. So to complete the air intake, you divide the large 10 -sided polygon into smaller quadrangular polygons.

1 Activate the Left viewport again.
 is easier to see.

2 Click and Ctrl+click to select the two vertices at either side of the intake polygon.


3 On the ribbon $>$ Loops panel, click $\square$ (Connect).

It is hard to see the connecting edge until you click elsewhere in the viewport to deselect the initial vertices.


4 Use the method from the previous two steps to add two more horizontal edges: one above the center edge, and one below it.


Now the original 10 -sided polygon is divided into four polygons, and each of the new polygons has only four sides.

## Next

Finish the Engine Cowl on page 319

## Finish the Engine Cowl

In this lesson, you add some detail to the rear of the cowl, and then adjust its shape to better fit the blueprint image.

## Set up the lesson:

■ Continue working from the previous lesson.

## Shape the rear of the cowl:

The engine cowl fits over the front of the main fuselage, a bit like a bottle cap on top of a glass bottle. So the rear of the cowl also has a recessed area, though not as pronounced as the air intake.

1 On the ribbon $>$ Polygon Modeling panel, click $\square$ (Polygon).

2 cowl. Orbit the Perspective viewport so you can see the back of the


Click to select the polygon at the rear of the cowl.


4 On the ribbon > Polygons panel, click $\square$ (Inset). In the Perspective viewport, drag the mouse down to inset the rear of the cowl.


5 On the ribbon $>$ Polygons panel, click $\square$ (Bevel). In the Perspective viewport, drag downward to create a shallow recess at the rear of the cowl.


Release the mouse, then drag it downward a bit more to reduce the size of the recessed polygon.


You can check your work by pressing Alt+X to turn on X-Ray display once again, and looking at the Front viewport.


## Adjust the curvature of the cowl:

The engine cowl is almost done: To complete it, you adjust its curvature to better match the blueprint.

1 Activate the Front viewport.
2 On the ribbon $>$ Polygon Modeling panel, click $\ll$ (Edge).

3


Click to select one of the longer edges along the length of the cowl.


[^2]

5 On the ribbon $>$ Loops panel, Shift+click
$\square$
Shift+clicking Connect displays the caddy controls for the Connect tool. These let you adjust the edge connection interactively.


6 On the caddy, drag the value of the lower spinner, Slide, to slide the new vertical edge to the left, so it is beneath the bulge in the cowl.


7 When the edge is in the right place, click (OK).
8


Scale the new edge up along the Y axis so the cowl has a bulge that better matches the blueprint image.


9 Click $\square$ (Edge) again to exit the Edge sub-object level.

Now the P-47 engine cowl is essentially complete, as far as polygon shapes go. (You will add some detail later, to improve the way 3ds Max smooths this part of the model.)

## Save your work:

Save the scene as p47_engine_cowl.max.

## Next

Add the Fuselage on page 330

## Add the Fuselage

The main fuselage is an extension of the cowl geometry.

## Set up the lesson:

- Continue working from the previous lesson.

Build the forward part of the fuselage from the rear of the cowl:

the Perspective viewport,

click the polygon at the rear of the cowl to select it.


2 On the ribbon > Polygons panel, click $\square$ (Inset). In the Perspective viewport, drag downward to create an inset with very narrow border polygons.


3 On the ribbon > Polygons panel, click

(Bevel). In the Perspective viewport, drag upward this time to extrude the polygon toward the rear of the airplane. Watch the Front viewport while youre doing so, and extrude the polygon just beyond the area of the cowl.


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## Front view

Release the mouse, then drag upward again to scale the bevel so it is almost the same diameter as the cowl itself. Again, watch the Front viewport while you work.


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## Front view

## Continue modeling the fuselage:

1 Use $\square$
(Bevel) again to extend the fuselage up to the leading edge of the rectangular panel in front of the cockpit, then scale it up so that in the Front view, it follows the contour of the blueprint image.


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Front view

This looks good, but if you look at the Top viewport, you can see that the new bevel is a bit too wide.

2 Activate the Top viewport, then scale the polygon down along the Y axis to align it with the blueprint image.


From here on, Extrude is the main tool for creating the fuselage. Along the way, you will use Scale and vertex adjustments to refine its shape.

3 If you need to, pan the Front viewport so you can see the cockpit.

NOTE We won't always mention when you need to pan the viewports, as this can vary depending on your 3ds Max window setup.

4 On the ribbon $>$ Polygons panel, click (Extrude). In the Perspective view, extrude the fuselage up to the leading edge of the cockpit. As usual, watch the Front viewport while you work.


Front view

5 On the ribbon > Polygon Modeling panel, click | $\square^{\square}$ | (Vertex). |
| :--- | :--- | :--- |

6 In the Front viewport,
drag a box to select the vertices at the
lower edge of the rear of the fuselage. Then
 move these vertices downward along the Y axis to match the lower contour of the airplane.


7 On the ribbon > Polygon Modeling panel, click
 (Polygon) to return to the Polygon sub-object level.

8 Activate the Top viewport, then $\square$ scale the polygon down very slightly along the Y axis.


9 On the ribbon > Polygons panel, click

(Extrude) once more.
Working in the Perspective viewport, but watching the Front viewport, extrude the fuselage as far as the seam at the rear of the cockpit.



Front view

TIP Sometimes the size of the 3ds Max window prevents you from extruding
as far as you want. If this happens, extrude as far as you can, then
 move the polygon horizontally to the desired location.

10 In the Front viewport,

move the polygon up a bit along the Y axis so the bottom is closer to the contour of the airplane.


11 Also in the Front viewport,
 scale the polygon down along the Y axis so it better matches the blueprint.


NOTE At this point, the match to the airplane contour is only approximate. Also, the polygons along the length of the fuselage are too long: In later procedures, you will add edge segments to refine the mesh, and move vertices to improve the contour of the fuselage.



After you adjust vertices, return to the $\square$ (Polygon) sub-object level.

12 In the Top viewport, $\square$ scale the polygon down some more along the Y axis, to match the blueprint image.


Complete the cylindrical part of the fuselage:

1 On the ribbon > Polygons panel, click

(Extrude) once more. Then extrude the fuselage as far as the leading edge of the tail.



## Front view

2 In the Top viewport,

scale the polygon down to match the contour of the airplane.


3 In the Front viewport, $\square$ scale the polygon down to the size of the contour.


4 Also in the Front viewport,

move the polygon to better match the blueprint image.


## Next

Complete the Lower Part of the Tail on page 349

## Complete the Lower Part of the Tail

The lower part of the tail extends the fuseelage, but it becomes much more narrow.

Set up the lesson:

- Continue working from the previous lesson.

Finish extruding the fuselage:
, el
Extrude the fuselage once more, this time to the very tip.


Front view

2 In the Top viewport,

scale the polygon down to match the blueprint image.


3 In the Front viewport,
 scale the polygon down to match the size of the blueprint image.


4 Also in the Front viewport,

move the polygon up to match the contour of the fuselage.


## Subdivide the rear polygon:

1 From the Orbit flyout, choose
 orbit,
 zoom the Perspective viewport to get a good view of the rear polygon.


2 On the ribbon > Polygon Modeling panel, click | $\square_{\square}^{口^{\prime}}$ | (Vertex). |
| :---: | :--- |

3 As you did for the large polygon in the air intake,
 Ctrl+click to select horizontal pairs of vertices, then click ribbon $>$ Loops panel >目 (Connect) to add three horizontal edges and subdivide the large polygon into four quadrangular polygons.


Creating the Fuselage | 355


## Begin modeling the tail:

1 On the ribbon > Polygon Modeling panel, click $\square$ (Polygon). If all four rear faces aren't selected when you switch to the Polygon
sub-object level, then

click and Ctrl+click to select them.
 Extrude the faces to the end of the tail.



Front view

3 In the Top viewport,
 bottom-rear portion of the tail.


Perspective view

4 On the ribbon >Polygon Modeling panel, click | $\square^{\square}$ | (Vertex). |
| :---: | :---: |

5 In the Front viewport, region-select vertices to be sure you are adjusting
both sides of the tail, then
 move the vertex pairs to follow the contour along the lower part of the tail.





## Save your work:

■ Save the scene as p47_fuselage.max.

## Next

Add the Vertical Stabilizer on page 363

## Add the Vertical Stabilizer

The portion of the tail that rises above the fuselage is technically known as the "vertical stabilizer."

Set up the lesson:

- Continue working from the previous lesson.


## Begin extruding the vertical stabilizer:

1 Go to the
 (Polygon) sub-object level.

2 In the Top viewport,
 click and Ctrl+click to select the two faces on the top of the fuselage, from which you will "grow" the upper part of the tail.


3
 Extrude these faces upward as far as the first hinge of the rudder.


Front view

Creating the Fuselage | 365

4 On the ribbon > Align panel, click $\quad$ (Align Y).
3ds Max aligns the two polygons so they are level.



Front view

NOTE The axis in which you need to align faces depends on how you created your geometry. In this case, the fuselage began as a cylinder built in the Left viewport, so aligning to the Y axis makes the faces horizontal. In a different model, you might have to experiment to find the axis that works.

5 In the Front viewport,

scale and

move the faces along the X axis to match the outline of the tail to the blueprint image.



6 On the ribbon $>$ Polygon Modeling panel, click | $\square_{\square}^{\square}$ | (Vertex). |
| :---: | :--- |

7 In the Front viewport,
leading edge of the top of the tail.


8 Activate the Top viewport, and then
 scale these two vertices along the Y axis to bring them closer together and narrow the width of the tail.


## Complete the vertical stabilizer:

1 In the Front viewport,

region-select the vertices at the center of the top edge of the tail, and
 move them along the X axis to align them with the leading edge of the rudder.


2 On the ribbon
Polygon Modeling panel, click $\square$ (Polygon). The two faces on top of the tail should become the active selection again.

If they don't, then in the Top or Perspective viewport,
 click and Ctrl+click to select them.

3 $\square$ Extrude the faces on the top of the tail as far as the top of the upper hinge of the rudder.



Front view

4 In the Front viewport,

move the faces in the X axis to fit the tail outline to the blueprint image.



[^3]


Front view

As you did for the bottom portion of the tail, you will move vertices to round the outline of the top of the tail. But to get enough vertices to model the curvature well, first you add another set of edges,

6 On the ribbon $>$ Polygon Modeling panel, click $<7$ (Edge).


In the Front viewport, click to select one of the horizontal edges on the forward, stationary portion of the tail.


8 On the ribbon $>$ Modify Selection panel, click $\rightleftharpoons$ (Ring).
3ds Max selects a ring of parallel edges around the forward part of the tail and the corresponding portion of the fuselage.


9 On the ribbon > Loops panel, Shift+click
 (Connect). 3ds Max displays the caddy for the Connect tool.

10 Use the third control, Slide, to position the new edges roughly in the middle of the forward, stationary part of the tail.


12 Go to the | $\square_{\square}^{\square}$ | (Vertex) sub-object level, then use region-select to |
| :---: | :--- |

 move them to follow the outline of the tail, as shown in the blueprint image. At this stage, you might also want to move the vertex pairs in the middle of the tail, to improve their alignment.




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13 Click (Vertex) again to exit the Vertex sub-object level.

## Save your work:

■ Save the scene as p47_fuselage_and_tail.max.

Next
Refine the Fuselage on page 387

## Refine the Fuselage

In this lesson, you add more edges to improve the regularity of the fuselage and refine its profile.

## Set up the lesson:

Continue working from the previous lesson.

## Add vertical edges to the fuselage:

1 Activate the Front viewport and click you can see all of the fuselage.


2 On the ribbon $>$ Polygon Modeling panel, click $<7$ (Edge).


Select one of the edges in the portion of the fuselage between the cockpit and the tail.


4 On the ribbon $>$ Modify Selection panel, click $\rightleftharpoons$ (Ring).
3ds Max selects all parallel edges around the circumference of the fuselage.


5 On the ribbon $>$ Loops rollout, Shift+click

(Connect).
3ds Max displays the caddy for the Connect tool. For the third setting, Slide, right-click the spinner arrows to reset the value to 0 . Then change
the first setting, Segments, to 2, and then click

(OK).
3ds Max adds two vertical sets of edges, evenly spaced, along the length of the rear of the fuselage. (Setting the Slide value to zero guarantees that the new edge loops are evenly spaced.)


NOTE For this step, since you aren't changing the Connect tool settings, you can just click the button.


Select one of the horizontal edges in the section of the fuselage in front of the cockpit. Click $\square$ (Ring) again, and then Shift+click
(Connect). Use the Connect tool caddy to reduce the number of Segments to 1, and then click (OK).
3ds Max adds a single set of vertical edges between the front of the cockpit and the rear of the engine cowl.


Adjust the curve of the lower part of the fuselage:

1 On the ribbon > Polygon Modeling panel, click | $\square_{\square}$ | (Vertex). |
| :---: | :--- |

2 Using region selection to select pairs of vertices along the bottom of the
fuselage,
 move them along the Y axis so the bottom outline of the fuselage better follows the curve that the blueprint image shows.


3 Click $\xlongequal[\square_{\square}^{\square}]{\square}$ (Vertex) again to exit the Vertex sub-object level.

## Save your work:

■ Save the scene as p47_fuselage_detailed.max.

Next
Completing the Tail on page 392

## Completing the Tail

To complete the tail, you add horizontal stabilizers on either side of the vertical stabilizer.

## Begin Adding the Horizontal Stabilizers

The horizontal stabilizers are shaped like small wings, and you use similar methods to model both these airplane parts. Because the horizontal stabilizers and the wings are symmetrical, it helps to split the model in half and use a Symmetry modifier to restore the mesh: This way, you have to model only one stabilizer and one wing; the modifier takes care of the other side of the airplane.

## Set up the lesson:

1 Continue working on your scene from the previous lesson, or open \modeling \p47\p47_01.max.

2 If you opened the file,
 select the $P-47$ fuselage and go to the


Modify panel.

## Split the model in half and add a Symmetry modifier:

1 Press Alt+X to turn off X-Ray display.
2 If you need to, adjust the Perspective view so you can see the P-47 fuselage from the front.

3


Select the fuselage. Then on the ribbon $>$ Polygon Modeling panel, click $\square$ (Edge).

4


Click to select one of the lateral edges at the very top of the fuselage.



6 On the ribbon > Loops panel, Shift+click $\rightarrow$ (Connect).
3ds Max displays the Connect tool caddy. On the caddy, be sure to set Slide (the third control) to $\mathbf{0}$ so the new set of edges is perfectly centered, and then click $(\mathrm{OK})$.


TIP You can right-click the spinner arrows to set the Slide value to zero.
Now you are ready to split the fuselage model.

7 On the ribbon
Polygon Modeling panel, click $\square$ (Polygon).

8 On the ribbon, go to the Selection tab.


9


Click the viewport at a distance from the fuselage, to make sure no polygons are selected.

10 On the ribbon $>$ Selection tab $>$ By Half panel, make sure that X is the chosen axis, and then click $\square$ (Select).


This selects the right half of the P-47 (from the airplane's point of view).


11 Press Delete.


12 On the ribbon, return to the Graphite Modeling Tools tab, and on the Polygon Modeling panel, click $\square$ (Polygon) to exit the Polygon sub-object level.

## Graphite Modeling Tools

$\square$

13 On the Modify panel $>$ Modifier List, choose Symmetry.


Now the model appears complete again. But the right side is generated by the Symmetry modifier, and changes you make to the left side will be reflected on the other side.

NOTE The symmetry must be about the X axis: This is the default for the Symmetry modifier.

Create the edges from which you will build the stabilizers:
1 Press Alt+X to turn on X-Ray display again.

2 Activate the Front viewport, and

zoom in to the region where the stabilizers will be.


3 On the ribbon > Polygon Modeling panel, click $\equiv$ (Previous Modifier), then click $\square$ (Polygon).

Also on the ribbon
Polygon Modeling panel, click to turn off
 (Show End Result). This makes it a bit easier to see the blueprint image.

4 On the
 Show Cage.


The cage display can be useful when you work with smoothing, but for the time being, it just makes it harder to see the plain geometry.

5 On the ribbon $>$ Edit panel, turn on
 (Cut).

6 Cut edges that follow the outline of the stabilizer that appears in the blueprint image. Right-click to exit the Cut tool.

TIP The cursor for the Cut tool has three different forms:

when the cursor is at a vertex

when the cursor is on an edge

when the cursor is on a face
In this step, you create free-standing vertices to round the leading and trailing edges of the stabilizer: In general, a model should not have free-standing vertices, and in a moment you will add edges to connect these vertices to other vertices.


TIP If the fuselage vertices overlap the stabilizer area, you can
 them so their locations are more like those shown in this illustration.

7 Right-click to close the Cut tool.

8 Use the $\square$ Cut tool again to create edges that join the free-standing vertices to the corner vertices of the neighboring faces. This ensures that the mesh still has all quadrangular faces.


## Begin to extrude the stabilizers:

Click and Ctrl+click to select the faces at the base of the stabilizer.


2 If you aren't already working with a four-viewport layout, click
 (Maximize Viewport Toggle) to display all four viewports.

3 On the ribbon > Polygons rollout, Shift+click (Extrude). Use the caddys Height control to extrude the faces by a value of about 20.0. Watch your work in the Perspective and Top viewports.



Top view

4 Click $(\mathrm{OK})$.
5 On the ribbon $>$ Align panel, click ${ }^{\prime 2}$ (Align X).


Top view

As you can see, there is a discrepancy between the side and top blueprint images. This is not unusual, especially when one of the drawings is foreshortened as the side image is. In the next couple of steps, you will adjust vertices to better match the top image, which is the more accurate one.

6 Go to the $\begin{gathered}\square_{\square} \\ \text { (Vertex) sub-object level. }\end{gathered}$
Select the three vertices where the trailing edge of the stabilizer joins the fuselage, and move them forward along the X axis to better match the top blueprint drawing. In the Top viewport, move them down along Y so they follow the fuselage contour (check this in the Perspective viewport).


Adjusting the trailing edge of the stabilizer
Front view


Adjusting the trailing edge of the stabilizer

## Top view

7 Do the same for the three vertices at the leading edge of the stabilizer (probably you won't have to move them very much in the Top viewport).


Adjusting the leading edge of the stabilizer

## Front view



Adjusting the leading edge of the stabilizer

Top view

8 Click $\square$ (Polygon) again.

9 In the Top viewport,

rotate the stabilizer faces on the Z axis to better follow the direction of the stabilizer. About 5 degrees is enough.


10 Activate
(Select And Move), then choose Local as the transform coordinate system (after you rotate the faces, you can't rely on View coordinates).


In the Top viewport, move the faces to better match the blueprint image.


11 Activate

(Select And Uniform Scale), choose Local as the coordinate system once more, then scale the faces up slightly in the Y axis so they match the blueprint image.


12 In the Front viewport,
 move the faces vertically in local Y axis to make them horizontal. Watch your work in the Left and Perspective viewports.


Left view


Perspective view

## Next

Complete the Horizontal Stabilizers on page 414

## Complete the Horizontal Stabilizers

To complete the horizontal stabilizers, you continue extruding and shaping them as you did the vertical stabilizer.

## Set up the lesson:

- Continue working from the previous lesson.


## Continue extruding the stabilizers:

1 Click $\square$ (Extrude), and then drag to extrude the stabilizer as far as the rectangular flap. Work in the Front viewport but watch the Top viewport.


2 In the Top viewport,
 scale the faces in their local Y axis so they match the blueprint image.


TIP This step is easiest if you switch the transform coordinate system back to View.


4 Go back to the $\square$ (Polygon) level, then E extrude the stabilizer again, this time almost to the tip.


5 On the ribbon $>$ Align panel, click ${ }^{\text {(Align X). }}$


6 In the Top viewport,
 local Y axis so they match the blueprint image.


7 To shape the tip of the stabilizer, you need a bit more detail in the geometry.

Go to the $\qquad$ (Edge) sub-object level.


Click to select one of the longitudinal edges in the widest faces of the stabilizer.



9 On the ribbon > Loops panel, click $\quad$ (Connect).


Now the tip of the stabilizer has seven pairs of vertices, which will help you give it shape.

## Complete the stabilizers:

1 In the Top viewport,
 zoom in on the tip and
 pan so you have a good view of both the geometry and the blueprint image.


2 Return to the $\square$ (Polygon) sub-object level, and $\square$ extrude the faces again, almost to the end of the stabilizer in the blueprint image.


3 Go to the $\stackrel{\text { (Vertex) sub-object level, then use region selection to }}{ }$

move vertices so they match the curve of the tip of the stabilizer.
TIP Move the closely spaced vertices at the leading and trailing edges as pairs (actually four vertices, counting top and bottom), then adjust them further in the next step.


4 For the closely spaced vertices at the leading and trailing edges of the
 rotate the vertex pairs so they follow the contour of the curve.



5 Click $\xlongequal{\square_{\square}^{\square}}$ (Vertex) again to exit the Vertex sub-object level.

## Save your work:

Save the scene as p47_stabilizers.max.

## Next

Check the Airplane Geometry on page 426

## Check the Airplane Geometry

In this lesson, you make one adjustment to correct an artifact that occurred when you created the horizontal stabilizers, and then you use NURMS smoothing to check the overall model.

## Set up the lesson:

- Continue working from the previous lesson.

Adjust the join between the stabilizers and the fuselage:
1 Press Alt+X to turn off X-Ray display.

2 On the ribbon > Polygon Modeling panel, click to turn on (Show End Result).

3 In the Perspective viewport,
 zoom in (and otherwise adjust the view as necessary) to get a good view of the area where the left-side stabilizer joins the fuselage. Press F4 to turn off Edged Faces display.


The horizontal stabilizers look good, but where they join the fuselage, there are two faces that are awkwardly narrow. You can fix this by moving a single vertex.

4 Go to the $\begin{gathered}\text { (Vertex) sub-object level. }\end{gathered}$

5 In the Perspective viewport,
 zoom in still further to get a good view of the vertices that surround the narrow faces.


6 On the ribbon $>$ Edit panel, activate (Constrain To Edge).

Turn on
(Select And Move), then select the forward vertex where the narrow faces join.


8 Move the vertex forward along the edge so the fuselage faces have more area.


The wider faces will smooth more easily.

9 On the ribbon > Edit panel, activate $\square$ (Constrain To None).

IMPORTANT When you forget that a constraint is on, surprising things can happen when you transform sub-objects. Because of this, it is a good idea to deactivate a constraint as soon as you have finished using it. Also, the buttons in this set behave like radio buttons. You can't turn a constraint off by clicking its button a second time: You must activate Constrain To None to deactivate the currently active constraint.


Use NURMS to check the appearance of the P-47:

1 In the Perspective view,
 the entire airplane again.


2 On the ribbon $>$ Edit panel, click $\xlongequal{\text { 胃 }}$ (Use NURMS)


The NURMS option (it stands for Non-Uniform Rational Mesh Smooth, an industry-standard method) is provided for smoothing editable polygon surfaces.

3 On the ribbon $>$ Use NURMS panel, increase the number of iterations to 2.


The airplane model, with its stabilizers, is looking good. Some faces, especially those at the air intake, are being smoothed more than they ought to be: You will fix this in a later lesson.

4 Click
 (Use NURMS) again to turn it off.


## Next

Adding the Wings on page 432

## Adding the Wings

The wings are shaped extrusions as are the horizontal stabilizers. Once more, the wing on the right side is provided by the Symmetry modifier.

## Begin Adding the Wings

To create the wings, first you make some adjustments to the contours of the fuselage.

> NOTE If you feel comfortable with the techniques shown in the previous lessons, and don't feel like going through all the steps to build a wing, you can skip ahead to Creating the Cockpit on page 468 .

## Set up the lesson:

1 Continue working on your scene from the previous lesson, or open \modeling $\backslash p 47 \backslash p 47$ _02.max,

2 If you open the file,

select the $P-47$. On the ribbon Polygon

Modeling panel, click Modify Mode, and then click
 (Previous Modifier) to go to the Editable Poly level of the stack.

3 On the ribbon > Polygon Modeling panel, click $\square$ (Show End Result) to turn it on.

## Create the "foundation" for the left-hand wing:

1 On the ribbon $>$ Edit panel, click $\quad$ (SwiftLoop).
2 In the Front viewport, use SwiftLoop to create a longitudinal loop of edges near the bottom of the fuselage.


3 Right-click to exit the SwiftLoop tool.

4 Go to the | $\square_{\square}^{\square}$ | (Vertex) sub-object level. |
| :--- | :--- |

5 On the ribbon > Edit panel, activate

(Constrain To Edge).

6 In the Front viewport, along the edge above the new edge loop,
 move vertices vertically to make a contour that will surround the wing faces.


7 On the ribbon
Edit panel, activate

(Constrain To None).

8 Click
ㅁ (Vertex) again to exit the Vertex sub-object level.

9 On the ribbon $>$ Edit panel, click
 (Cut).

10 In the Front viewport, use the Cut tool to creae edges around the outline of the wing. You can use some of the blueprint image to help locate these cuts, but for the forward part of the wing, use the contour above it and the following illustration.


11 Right-click to exit the Cut tool.

12 Turn on
 (Cut) once again, and as you did for the stabilizer, add edges from the free-standing vertices at the leading and trailing edges of the wing to the nearby corner vertices, to make sure all polygons are quadrangular.


13 Right-click to exit the Cut tool.

## Begin to extrude the wing:

1 Go to the $\square$ (Polygon) sub-object level.


Click and Ctrl+click to select the faces that make up the base of the wing.


3 On the ribbon $>$ Polygons panel, click extrude the faces a short distance.

TIP As you did for the stabilizer, drag in the Front viewport but watch your work in other viewports, especially the Top view.



Top view

4 On the ribbon > Align panel, click

(Align $X$ ).


Scale the faces along their X axis and

move them in both X and Y so the wing extrusion matches the blueprint image in the Top viewport.

TIP This step won't work if constraints are active: Make sure that
 (Constrain To None) is active.


6 In the Left view,

move the faces along their Y axis so the wing matches the blueprint image.


TIP At this point, if the upper surface of the wing seems too low, you can go to the | $\square_{\square}^{\square}$ | (Vertex) sub-object level, activate |
| :---: | :--- |
| (Constrain To |  | Edge), and

 move the vertices along the base of the wing's upper edge upward along the fuselage (it's easiest to select these vertices in the

Perspective viewport). Be sure to activate $\square$ (Constrain To None) when you're done.

7 At the
 (Polygon) sub-object level,
 extrude the wing as far as the seam at its middle.


Top view

8


Scale the faces along their X axis and

move them in both X and Y so the wing extrusion matches the blueprint image in the Top viewport.



Top view

9 Also
 scale and

move the wing in the Left viewport, so it matches the blueprint image.


Finish extruding and shaping the wings:


Extrude the wing as far as the last seam.


Top view

2 Once again,

move the faces so the wing matches the blueprint image in the Top viewport.



Top view

3 Do the same in the Left viewport.


4
E
Extrude the wing again, this time to the very tip.


Top view

Adding the Wings | 445

NOTE The long edge segments don't do justice to the curvature of the wings, especially at their trailing edges. In the next lesson, you will refine these the way you refined the curvature of the fuselage.

5 In the Left viewport,
 scale and
 move the faces to match the wing to the blueprint image.


7 In the Top viewport, use region selection to select pairs of vertices (top
and bottom), and
 move them so the curve of the wing tip matches the blueprint image.


Adding the Wings | 447



Adding the Wings $\mid 449$



Next
Complete the Wings on page 451

## Complete the Wings

To complete the wings, you adjust some details and improve the curvature of the trailing edges.

## Set up the lesson:

- Continue working from the previous lesson.


## Check your work:

1 In the Perspective viewport,

orbit around the model to make sure the wings are even.


If any vertices seem out of place, especially along the vertical axis, move


2 Activate

(Select Object) to turn off Orbit.
3 Press Shift $+Z$ to undo changes to the Perspective view.


4 In the Left viewport,
 scale them down a bit vertically.


5 Do the same for the vertices at the wingtip seam.


These adjustments are more intuitive than quantitative: Aim for a result that is visually pleasing to you.
 (Vertex) again to exit the Vertex sub-object level.

Refine the curvature of the wings:

1
 pan the Top viewport so you can see all of the left-hand wing.


2 On the ribbon $>$ Edit rollout, turn on (SwiftLoop). Then in the Top viewport, use SwiftLoop to add two new edge loops that subdivide the long faces on the wing.



3 Right-click to turn off the SwiftLoop tool.
$\square$
(Vertex) sub-object level again, region-select vertices
4 Go to the at the trailing edge of the wing, then
 move them to better match the curvature of the wing, as shown in the blueprint image.

 (Vertex) again to exit the Vertex sub-object level.

## Save your work:

■ Save the scene as p47_wings.max.

## Next

Correct the Air Intake on page 460

## Correct the Air Intake

As you will see, adding an edge loop for the wing geometry created a problem with the air intake. In this lesson, you correct that problem and further refine the shape of the intake.

## Set up the lesson:

■ Continue working from the previous lesson.

## Use NURMS again to check your work:

1 Press Alt+X to turn off X-Ray display, then on the ribbon $>$ Edit rollout,
turn on

(NURMS). On the Use NURMS panel, increase the number of iterations to $\mathbf{2}$.

2 Activate the Perspective viewport, and press F4 to turn off Edged Faces.


The smoothed model shows that the wings are successful.

3


Zoom and

pan the Left viewport so you have a good view of the air intake. Press F4 to turn off Edged Faces.


Two edges at the lower edge of the intake are sharper than they should be: These come from the additional contour you created with SwiftLoop when you were preparing to extrude the wings. You will correct these in the next procedure.

4 Click

(NURMS) again to turn it off.

## Correct the air-intake edges:

1 In the Front viewport, press F4 to turn on Edged Faces again.


2 Go to the $<7$ (Edge) sub-object level. On the very front of the engine cowl, viewport.


3 On the ribbon $>$ Edit rollout, activate $\square$ (Constrain To Edge), then

move the edge upward to about the center of the face it is on.


4 On the ribbon > Edit rollout, activate $\square$ (Constrain To None),

move the edge again, outward this time, so the intake portion of the engine cowl is a bit more rounded.


5 Select the center edge at the bottom of the front of the intake, and +
4
4 move it down along the Y axis.


6 Select the corresponding edge at the top of the intake, and

move it up slightly along the Y axis.


7 Deselect all edges.
8 Turn on (NURMS) again, and press F4 to turn off Edged Faces.


Now the intake portion of the cowl looks a good deal better.

## Save your work:

■ Save the scene as p47_wings_intake_fixed.max.

## Next

Creating the Cockpit on page 468

## Creating the Cockpit

The cockpit includes a canopy, which becomes a separate object. It also includes part of the hollow interior of the aircraft.

## Begin Modeling the Cockpit Canopy

To model the cockpit, you begin by shaping the fuselage in the cockpit region, then extruding polygons in that same region. This is the basis for the cockpit canopy, which becomes a separate object.

Set up the lesson:

1 Continue working on your scene from the previous lesson, or open \modeling $\backslash p 47 \backslash p 47$ _03.max,

2 If you open the file,

select the $P-47$. On the ribbon $>$ Polygon Modeling panel, click Modify Mode.

## Collapse the stack:

Now that you've created the horizontal stabilizers and the wings, the Symmetry modifier has done its work, so you can collapse the airplane model back into a unified object once again.

- Right-click the $P-47$, and from the Tools (lower-right) quadrant of the quad menu, choose Convert To $>$ Convert To Editable Poly.


## Outline the cockpit:

1 On the ribbon > Polygon Modeling panel, click | $\square_{\square}^{口^{\prime}}$ | (Vertex). |
| :---: | :--- |

2 Press Alt+X to turn on X-Ray display again.
3 In the Front viewport, region-select the top vertices just behind those at the front of the cockpit, and
 move them to match the cockpit outline in the blueprint image.


NOTE Now that the model is collapsed, when you region-select the top row, you are selecting three vertices: both sides and the middle of the fuselage.

4 Region-select the vertices immediately below these along the lateral edge,
 move them forward so the mesh is a bit more regular.


5 Region-select the top vertices behind the ones you moved in step 2, and $\xrightarrow[4]{4}+$ move them to match the blueprint outline as well.


6 Region-select the vertices immediately below these along the lateral edge,
 move them forward to adjust the mesh as you did for the more forward edge.


7 In the Top viewport,
 view of the cockpit area.


8 In the Front viewport, region-select the row of vertices at the leading
edge of the cockpit, and then in the Top viewport,
 scale them along the Y axis so they match the shape of the cockpit (the dark-blue area) in the blueprint image.


9 Repeat the preceding step for the other three rows that define the area of the cockpit. Use the Front viewport to region-select the vertices, and then use the Top viewport to watch how you scale them.



## Extrude the cockpit canopy:

1 On the ribbon $>$ Polygon Modeling panel, click $\square$ (Polygon).

2 On the
Modify panel > Selection rollout, turn on Ignore Backfacing.

3 In the Top viewport,

click and Ctrl+click to select the polygons that make up the cockpit area.


4 On the ribbon $>$ Polygons panel, click (Extrude). In the Perspective viewport, extrude the polygons: Watch your work in the Front viewport, so you can make the extrusion about the height of the cockpit canopy in the blueprint image.



Front view

5 On the ribbon $>$ Align panel, click

## Y

 (Align Y).


Front view

If you need to,
 move the polygons so that in the Front viewport, they are the same height as the canopy in the blueprint image.

6 On the


Modify panel $>$ Selection rollout, turn off Ignore Backfacing.

## Next

Block Out the Shape of the Canopy on page 479

## Block Out the Shape of the Canopy

Now you give the cockpit canopy its overall shape. You will add more detail to the geometry in a later lesson.

Set up the lesson:
■ Continue working from the previous lesson.

Block out the shape of the canopy:

1 On the ribbon > Polygon Modeling panel, click | $\square_{\square}$ |  |
| :---: | :--- |
|  | (Vertex). |

2 As you did for the top of the cockpit (which is now the bottom of the canopy), in the Front viewport region-select vertex groups, and
 move them to follow the shape of the canopy in the blueprint image.


3 In the Front viewport, region-select the leading edge of vertices in the glass part of the canopy (the upper part, above the fuselage), then in the

Top viewport,
 scale the vertices along the Y axis. This time, use the Left viewport to monitor your work and match the model to the blueprint image.


Left view

4 Repeat the preceding step for the row of vertices immediately behind the row you just scaled.

NOTE For this row and the next one, you won't be able to duplicate the extreme round shape shown in the Left viewport's blueprint image. This isn't a problem: Later on, you will increase the curvature. For this step, approximate the metal struts of the canopy, which in the blueprint image are shown in the lighter color.



Left view

5 And repeat the step once more for the third row of vertices, at the top of the canopy before it narrows again.
For this step, approximate the outer edge of the canopy, shown in dark blue.


6 In the Top viewport,
click and Ctrl+click to select the three vertices along the "ridgeline" of the canopy.


TIP If you select a vertex you don't want to move, use Alt+click to deselect it.

7 In the Front viewport,
 move these vertices up along the Y axis while watching the outcome in the Left viewport.



8 In the Front viewport, click to select only the most forward of the three vertices you just moved.


9

| 4 |
| :---: |
| $40+$ |

Move the vertex down a bit in the Y axis to make the outline of the canopy look smoother.



## Detach the canopy and hide it:

The canopy will become a separate object from the fuselage. In this procedure, first you detach the canopy from the fuselage, and then hide it: The next lesson will concentrate on modeling the interior of the cockpit.

You finish adding detail to the canopy object in a lesson that follows.

1 On the ribbon $>$ Polygon Modeling panel, click $\square$ (Polygon).
2 On the main toolbar, make sure the Window/Crossing toggle is in its


Crossing state; on the


Selection rollout,
make sure that Ignore Backfacing is turned off; then in the Front viewport,

drag a selection box to select all the polygons in the canopy.


3 On the ribbon $>$ Geometry (All) rollout, click

(Detach).
4 On the Detach dialog, name the new object Canopy. Make sure both options are turned off (they should be off by default), and then click OK.


5 On the ribbon > Polygon Modeling panel, click $\square$ (Polygon) again to exit the Polygon sub-object level.

6


Click to select the new Canopy object.


7 Right-click, and from the Display (upper-right) quadrant of the quad menu, choose Hide Selection.
You will unhide the cockpit, and finish it, after you finish modeling the fuselage.

## Save your work:

■ Save the scene as p47_cockpit_and_canopy.max.

## Next

Create the Cockpit Interior on page 492

## Create the Cockpit Interior

The cockpit interior doesn't require extensive detail, but adding it restores the fuselage model to being a single continuous surface.

## Set up the lesson:

■ Continue working from the previous lesson.

## Begin modeling the interior of the cockpit:

1 Select the $P$-47 fuselage.
2 Press Alt+X to turn off X-Ray display.

3 In the Perspective viewport,
 zoom and

pan to get a better view of the top of the cockpit.


The $P-47$ fuselage now has a cockpit-shaped hole in it. To make the model a continuous surface again, you will add faces to form the interior of the hole.

4 On the ribbon $>$ Polygon Modeling panel, click $\bigcirc$ (Border).


6


Shift+move the border downward to clone it and create a rim for the cockpit.


7 Press Alt+X to turn on X-Ray display again.

8 In the Top viewport,


Shift+scale the new border uniformly, to make the cockpit interior wider than its rim.
Watch all four viewports when you do this step: You don't want the sides of the cockpit interior to extend beyond the outside of the fuselage!


9 In the Front viewport,
 Shift+move the cockpit border down, until the new border is just above the level of the wings.


10 On the ribbon > Align panel, click Y border horizontal.


## Add a floor to the cockpit:

1 Press Alt+X to turn off X-Ray display.

2 In the Perspective viewport,
 pan so you can see most of the opening at the bottom of the cockpit.


The bottom of the cockpit is still an open hole.

3 On the ribbon $>$ Geometry (All) panel, click

(Cap Poly). 3ds Max creates a polygon to cap the open border.


The polygon you just created is large and multisided, so you need to subdivide it into quadrangular polygons.

5 On the ribbon > Polygon Modeling panel, click | $\square_{\square}{ }^{\circ}$ | (Vertex). |
| :---: | :--- |

6 Two lateral edge loops were interrupted by the cockpit hole, and now they are interrupted by the large polygon that forms the cockpit floor.

To fix this,

click and Ctrl+click to select the two vertices where the forward edge loop stops at the cockpit floor, then on the ribbon

Loops rollout, click

(Connect).


7 Do the same for the trailing pair of edge loop vertices.



NOTE Even if the two edges are selected by default when you switch to the Edge sub-object level, deselect them and then select them explicitly: Otherwise, the default edges created in the next step, when you click Connect, will form too complex a web of edges.

10 On the ribbon $>$ Loops rollout, click

(Connect).


11 To complete the "quadrification" of the cockpit floor, use the ribbon

Edit panel
$\square$ (Cut) tool to connect the vertex at the front floor level of the cockpit to the one at the middle of the leading floor-level loop. Use the Cut tool again to connect the vertex at the middle of the trailing flor-level loop to the one in the middle of the back floor level of the cockpit.


Now the polygons that form the interior of the cockpit are all quadrangular, and follow the overall pattern of the polygons that form the exterior of the fuselage.

## Add leg room to the cockpit:

1
 you have a more edge-on view of the cockpit.

2


Click to select one of the vertical edges along the side of the cockpit interior.


3 On the ribbon $>$ Modify Selection panel, click $\Longrightarrow$ (Ring).
3ds Max selects all the vertical edges, in a ring around the inside of the cockpit.


4 On the ribbon $>$ Loops panel, click
 (Connect).
3ds Max connects the edges with a new horizontal loop of edges.


5 On the ribbon $>$ Edit panel, activate $\square$ (Constrain To Edge).

6


Move the new edge loop up a bit.
TIP Change the coordinate system to Local before you move the edge loop.


7 On the ribbon $>$ Edit panel, activate $\square$ (Constrain To None).

8
 the polygons at the front of the cockpit interior.
9 Go to the $\square$ (Polygon) sub-object level.


Click and Ctrl+click to select the two polygons at the bottom of the front wall of the cockpit interior.


11 On the ribbon > Polygons panel, turn on (Extrude). Drag to extrude the polygons forward, providing leg room for a pilot. (The two polygons above the leg room but below the cockpit rim would be the location of the instrument panel.)


12 Exit the $\square$ (Polygon) sub-object level.

## Next

Refine the Cockpit on page 507

## Refine the Cockpit

Although the cockpit is essentially done, you need to add edges and adjust their position so the cockpit still looks good when you smooth the model.

## Set up the lesson:

■ Continue working from the previous lesson.

Use smoothing to preview the model and help you refine the geometry:

1


Zoom,

pan, and
 - orbit the Perspective viewport so you have a more conventional view of the whole airplane, or most of it. Angle the view so you are looking down on the cockpit area.


2 On the ribbon > Edit panel, turn on (NURMS), and then on the ribbon > Use NURMS panel, increase the number of iterations to the usual value (for the P-47) of 2.

The model is smoothed nicely, and the cockpit is smoothed all the way around. This is easiest to see in the Top viewport.


However, the blueprint image shows that the leading edge of the cockpit should be straight. You can fix this by adding some edges (as you saw when you refined the air-intake portion of the engine cowl, placing edges close together reduces the effect of NURMS smoothing).

3 Turn off
 (NURMS).

4 Go to the $\square$ (Edge) sub-object level.

5 On the ribbon $>$ Edit panel, turn on
 (SwiftLoop). Add a new lateral loop of edges, about halfway between the leading edge of the cockpit and the loop of edges that is now in front of it.

TIP For this step and the ones that follow, you might want to use the

Perspective viewport and $\qquad$ zoom in before you make the changes.


6 Right-click to turn off SwiftLoop.

7


Click and Ctrl+click to select the two edges on top of the fuselage, in the new loop you just created.


8 On the ribbon $>$ Edit panel, activate (Constrain To Edge).

9 | 4 |
| :---: |
| $4+8$ |
| 4 |

Move the two edges so they are close to the leading edge of the cockpit.


10 Turn on (SwiftLoop) again, and add another lateral loop of edges behind the leading edge of the cockpit, about halfway to the edges that trail it.


11 Right-click to turn off SwiftLoop.


Click and Ctrl+click to select the two small edges along the rim of the cockpit, in the new loop you just created.

To select both edges, you have to ? orbit the Perspective view.


$\underset{4}{4}+$
Move the two rim edges forward so they too are close to the leading edge of the cockpit.


14 On the ribbon $>$ Edit panel, activate

(Constrain To None).

15 Click

(Select Object) to exit Move.
16 Press Shift+Z several times to undo Perspective view changes, and return to an overhead view of the P-47.


17 On the ribbon > Edit panel, turn on
The leading edge of the cockpit is now straight, as it is in the blueprint images.


18 Turn off $\underset{\sim}{\text { 品品 }}$ (NURMS).

## Next

Refining the Aircraft on page 516

## Refining the Aircraft

To complete the aircraft, you make various adjustments to both the fuselage and the cockpit canopy.

## Refine the Curvature of the Nose

The nose of the fuselage is flat on top. Making it a bit more rounded improves the airplane's appearance.

## Set up the lesson:

■ Continue working from the previous lesson.

## Improve the curvature of the top front portion of the fuselage:

1


Click and Ctrl+click to select the three ridgeline edges in front of the cockpit, and the ridgeline edge immediately behind it.

TIP Use region selection for the small edge where you reinforced the front of the cockpit. If you select an edge by mistake, use Alt+click to deselect it.


Move these edges up vertically a bit, to make the fuselage more rounded.


Front view

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Increase the curvature at the top of the engine cowl:


2


Click and Ctrl+click to select the three vertices along the top of the engine cowl.


3


Move these vertices up a bit, as well.


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Front view
 (Vertex) to turn it off and exit the Vertex sub-object level.

5 In the Perspective viewport,
 zoom out and press F4 to turn off Edged Faces.

6 On the ribbon $>$ Edit panel, turn on
Now the fuselage is convincingly rounded.


7 Turn off $\xrightarrow{\text { 品 }}$ (NURMS).

## Save your work:

■ Save the scene as p47_fuselage_finished.max.

## Next

Set Up Smoothing for the Fuselage on page 522

## Set Up Smoothing for the Fuselage

NURMS smoothing does its job a little too well. There should be clear joins between some parts of the airplane; for example, between the wings and the fuselage. You can fix this by using smoothing groups. Smoothing groups change the appearance of the model without changing its geometry. Unlike NURMS, smoothing groups don't increase the face count: This can be an important consideration if you are preparing your model for use in a game.

## Set up the lesson:

■ Continue working from the previous lesson.

## Set up the viewports:

1 With the P-47 selected, choose
 (Zoom Extents All Selected).

2 Activate the Left viewport, and

region zoom to get a good view of the air intake.


Smooth the engine cowl:

1 Go to the
 (Polygon) sub-object level.

2 Press Ctrl+A to select all polygons in the airplane.


3 On the ribbon $>$ Properties panel $>$ drop－down portion，click $\begin{array}{r}\text { \＃囲 } \\ \text { 日品二 } \\ \hline\end{array}$ （SmGroups）．
3ds Max opens the Smoothing Groups dialog．


4 On the Smoothing Groups dialog，click Clear All．


This removes any default smoothing-group values that the faces might have.

Leave the Smoothing Groups dialog open: You will be using it throughout this lesson.

5 On the main toolbar, make sure the Window/Crossing toggle is in its


Crossing state, then in the Front viewport,

drag a region to select the faces at the very front of the engine cowl.


6 On the ribbon > Modify Selection panel, click

(Grow) a couple of times, until all of the engine cowl is selected.


7 On the Smoothing Groups dialog, turn on 32.


3ds Max smooths the faces of the engine cowl.
The basic idea of the smoothing-group values is simple: If two faces share the same value, 3ds Max smooths between them. If they have distinct values, there is no smoothing. (A face can have more than one smoothing-group value, which complicates matters, but we won't use that feature in this tutorial.)

## Remove smoothing from the air intake:

In this procedure, you don't really remove smoothing from these faces: You just assign them to a different group from the rest of the cowl.

1 In the Left viewport, $\square$ click and Ctrl+click to select the faces of the air intake.


2 On the Smoothing Groups dialog, click to turn off 32, then turn on 31.


Now the air-intake faces look flat.


## Smooth the wings:

1 In the Top viewport,
 drag and Ctrl+drag to select the tips of the wings.


2 On the ribbon $>$ Modify Selection panel, click $\square^{\text {a }}$ (Grow) several times, until all of the wings are selected.



Perspective view

3 On the Smoothing Groups dialog, turn on 24.


## Smooth the horizontal stabilizers:

The steps for the horizontal stabilizers are almost the same as those for the wings.

1 In the Top viewport, stabilizers.


2 On the ribbon > Modify Selection panel, click (Grow) a few times, until all of the stabilizers are selected.


3 On the Smoothing Groups dialog, turn on 23.


## Smooth the remainder of the fuselage:

Now all of the model is smoothed correctly, except for the main fuselage. You can use the smoothing groups you've already created to help select it.

1 On the Smoothing Groups dialog, click Select By SG.


3ds Max opens a Select By Smooth Groups dialog. The buttons show only those smoothing groups that you've assigned so far.


2 On the Select By Smooth Groups dialog, turn on all four buttons, then click OK.


3ds Max selects those faces that already have a smoothing-group value assigned.


3 Press Ctrl+l to invert the selection.
Now only the fuselage and tail are selected.


4 On the Smoothing Groups dialog, turn on 16.


Smoothing the fuselage has an unexpeted effect: The faces around the cockpit are indented too deeply. You can use the Smoothing Groups dialog to fix this.


Unwanted indentation around the cockpit
(This is easier to see when the polygons are not selected, but you don't need to deselect the polygons in your scene.)

5 Make sure the fuselage polygons (smoothing group 16) are selected, then on the Smoothing Groups dialog, change the Auto Smooth threshold value to 80.0, and then click Auto Smooth.


3ds Max corrects the indentation around the cockpit.


Increasing the threshold value increases the chance of two faces to be smoothed together.

NOTE Auto Smooth changes the smoothing value (16) that you originally assigned to these faces. After you click AutoSmooth, the faces share values of 1,2 , and 3 .

Use smoothing groups with NURMS smoothing:

1 Exit the
 (Polygon) sub-object level.

2 On the ribbon > Edit panel, turn on
3 On the ribbon > Use NURMS panel, increase the number of iterations to 2.

The default NURMS smoothing ignores the smoothing groups, and blends all faces of the P-47 together.


4 On the ribbon $>$ Use NURMS panel $>$ drop-down portion, open the Separate By drop-down list, and turn on Smoothing Groups.


With smoothing groups taken into account, NURMS correctly shows seams between the air intake and the rest of the engine cowl, and between the wings and stabilizers and the main fuselage.



Although the smoothing provided by smoothing groups alone is not as good as NURMS smoothing, it could work for a low-polygon environment such as a game engine, or for viewing the model in a medium or long shot.


## Save your work:

- Save the scene as p47_smoothed.max.


## Next

Add Detail to the Cockpit Canopy on page 541

## Add Detail to the Cockpit Canopy

The cockpit canopy in this particular model is a bubble canopy, one of the canopy options for the P-47. The pilot sits in a glass bubble. The forward windshield is flanked by two side windshields, and the three windshields are backed by a metal strut like a rollbar.


NOTE On the Web you can find good photos of P-47s with the bubble canopy, as well as with an earlier style of canopy that featured more metal.

## Set up the lesson:

1 Continue working on your scene from the previous lesson, or
 open \modeling $\backslash p 47 \backslash p 47$ _04.max,

2 If you open the file,
 select the $P-47$. On the ribbon Polygon Modeling panel, click Modify Mode.

3 On the ribbon $>$ Edit panel, turn off | 品 |
| :---: | :---: | :---: | :---: |
| (NURMS) |

## Adjust the shape of the front windshield:

1 Right-click a viewport and from the quad menu, choose Unhide All. Now you can see the canopy again.

get a closer view of the canopy.


3
Select the canopy and if you need to, press F4 to display Edged Faces.


4 Go to the | $\square_{\square}^{口_{0}}$ |
| :---: |
| (Vertex) sub-object level. | the top center of the front windshield.



5 On the ribbon $>$ Edit panel, activate $\square$ (Constrain To Edge). Then

move the vertex upward to give the front windshield more of a peak.


6 Activate

(Select Object) to deactivate Move.


Add edges to reinforce the metal parts:

1 On the ribbon $>$ Edit panel, turn on $\quad$ (SwiftLoop).
2 Add edge loops to reinforce the metal parts of the canopy, as follows:
■ Horizontally, at the base of the canopy.
TIP Use the Front viewport for this one, so you can match the loop to the blueprint image.


■ Vertically, just behind the edges that define the front windshield.


■ Vertically, just in front of the edges that define the "rollbar" strut.


3 Right-click to exit the SwiftLoop tool.
4 Go to the $<$ (Edge) sub-object level.

5


Click and Ctrl+click to select the two edges at the top front of the "rollbar" strut.


6 On the ribbon $>$ Edit panel, activate

(Constrain To Edge). Then
$\square$ move the edges forward a bit to give the strut a more even width.


7 Make a similar adjustment to the two top edges that define the rear of
the windshield frame,

moving them back slightly so the width of the frame is more even.


8 Activate (Select Object) to deactivate Move.
9 On the ribbon > Edit panel, activate $\square$ (Constrain To None).

Add width to the metal parts:

1 Go to the $\square$ (Polygon) sub-object level.

2 Click (Zoom Extents All Selected).


NOTE When you change to the Polygon sub-object level, you might see all the polygons selected, as the illustration shows.

3


Click away from the canopy to deselect all polygons. Then click and Ctrl+click the polygons that correspond to the glass parts of the canopy. You will need to use the Top viewport to select polygons that aren't visible in the Perspective view.


Perspective view

4 Press Ctrl+I to invert the selection.


5 On the ribbon > Polygons panel, Shift+click
 (Extrude). 3ds Max displays the Extrude Polygons caddy.

6 Click the first control in the caddy, then from the drop-down list, choose Local Normal.


7 Use the second control on the caddy to extrude the polygons by about 1.7 units.


$\bigcirc$(OK) to accept the extrusion.
8 Click

9 On the ribbon $>$ Modify Selection panel, click $\square$ (Grow).
This selects the side faces that were created when you extruded the metal parts. These faces should be metal, too.


IMPORTANT You will use this selection in the following lesson.

## Next

Use Smoothing Groups to Distinguish the Glass and Metal Canopy Parts on page 556

## Use Smoothing Groups to Distinguish the Glass and Metal Canopy Parts

Just as you used smoothing groups to distinguish different parts of the fuselage, you can use smoothing groups to distinguish the different materials in the canopy.

## Set up the lesson:

- Continue working from the previous lesson.

Use smoothing groups to distinguish the metal parts from the glass parts:

1 On the ribbon > Properties panel $>$ drop-down portion, click (SmGroups).
3ds Max opens the Smoothing Groups dialog.
2 In the Smoothing Groups dialog, assign the metal polygons a value of 32.


NOTE You used this value for the engine cowl as well, but remember that the $P-47$ fuselage and the Canopy are two different objects, so the smoothing-group values don't overlap.

(8)


3 Press Ctrl+l to invert the selection again, and then assign the glass faces a smoothing-group value of 24 .


4

## 3

Close the Smoothing Groups dialog.

Use NURMS smoothing to preview the canopy:

1 Exit the
 (Polygon) sub-object level.

2 Press Alt+X to turn off X-Ray display.


3 On the ribbon $>$ Edit panel, turn on (NURMS). On the ribbon
$>$ Use NURMS panel, increase the value of Iterations to 2.


This is far too much smoothing. As with the fuselage, you now need to take smoothing groups into account.

4 On the ribbon $>$ Use NURMS panel $>$ drop-down portion $>$ Separate By drop-down list, turn on Smoothing Groups.


Now the metal and glass portions of the canopy appear more distinct.


With smoothing groups taken into account, there are well-defined edges between the glass and the metal parts of the canopy. On the other hand, the shape of the windshields is far too rounded. You will fix that in the next procedure.

## Next

Refine the Canopy on page 560

## Refine the Canopy

As with the air intake or the front edge of the cockpit interior, the way to reduce the amount of NURMS smoothing is to reinforce an edge by adding nearby edge loops. You will do this to the front windshields of the cockpit canopy.

## Set up the lesson:

- Continue working from the previous lesson.


## Fine-tune the bubble canopy:

1 On the ribbon $>$ Edit panel, turn on
2 (SwiftLoop).

2 Add edge loops to reinforce the windshields, as follows:
■ Near the front of the side windshields, just behind the metal strut.


- On the front windshield, just on the other side of the left-hand strut.

- Also on the front windshield, but on the right side, opposite the previous loop.

TIP This one is easiest to do in the Top viewport.


Immediately in front of the "rollbar" strut.


- And immediately behind the "rollbar" strut, as well.

- Finally, add an edge loop just above the rim of the cockpit canopy.


3 Right-click to exit the SwiftLoop tool.

## Check the smoothing once again:

On the ribbon > Edit panel, turn on
off Edged Faces.
Now the windshields have their proper shape, and the edges between the metal and glass parts are crisp.



## Next

Refine the Shape of the Bubble on page 565

## Refine the Shape of the Bubble

The final step in modeling the P-47 is to improve the curvature of the glass bubble.

## Set up the lesson:

■ Continue working from the previous lesson.

Refine the shape of the bubble:
1 Press F4 to turn Edged Faces back on.

2 Turn on
 loop that is already present, midway along the bubble portion of the canopy.


3 Right-click to exit the SwiftLoop tool.
4 Go to the $<$ (Edge) sub-object level.

5 In the Top viewport, at the top of the original bubble loop.


Perspective view then in the Front viewport,
 move the edges back, toward the tail of the airplane.


7 With Move still active, in the Top viewport, click and Ctrl+click to select the two edges just above the sides of the middle of the bubble.


8 In the Front viewport move these edges down to the middle of the side of the bubble.



10 On the ribbon > Edit panel, activate
 (Constrain To Face).

11 With Move still active, in the Top viewport, click and Ctrl+click to select the two vertices where the side of the bubble meets the top, behind the vertical loops.


12 In the Front viewport,
 move these vertices down and forward so the bubble has a smoother contour.


13 On the ribbon $>$ Edit panel, activate

## Expand the width of the bubble:

The last step in finishing the canopy, is to refine the bubble so the glass bulges a bit more, as shown in the blueprint images.

1 In the Front viewport,
 Ctrl+drag to select the vertices you just moved, as well as the vertices immediately above them on the same segment.


Look at the Top view to make sure you have selected four vertices: two on each side of the bubble.



3 In the Top viewport,

scale the vertices out along the Y axis to give the rear part of the bubble more of a bulge.


4 In the Front viewport,

region-select the four vertices that are in front of the ones you just scaled, at the sides of the bubble along the contour.


5 In the Top viewport, $\square$ as you did for the rear vertices.


## Observe your work:



NOTE Use NURMS > drop-down portion > Separate By > Smoothing Groups should be turned on for the fuselage as well as for the canopy. You might want to verify this.

4 In the Perspective viewport, press F4 to turn off Edged Faces, and then

zoom out so you can see the entire airplane.


## Save your work:

■ Save the scene as p47_canopy_finished.max.
To see a finished version of the P-47 model, you can open p47_completed_no_texture.max. This version of the model includes some additional geometry adjustments that didn't seem important enough to include in this tutorial.
You can also see a finished and textured version of the P-47 model by opening p47_completed_textured.max..

## Summary

The P-47 Thunderbolt model contains only two objects, but each object has a lot of subtle detailing. Among the features and methods covered in this tutorial were:

■ Setting up a "virtual studio" with "blueprint images" to use as references.
■ Turning on See-Through ("X-Ray") display to use the reference images more easily.

■ Using free-form deformation (FFD) modifiers to change the shape of a primitive object.

■ Turning a geometry primitive into an Editable Poly surface so you can change it into a streamlined or organic shape.

■ Using the Symmetry modifier to ensure that a model is symmetrical.

- Using the Extrude, Inset, and Bevel tools to add polygonal faces.

■ Using the Align buttons to align polygon sub-objects.

- Using the SwiftLoop, Connect, and Cut tools to add edges or loops of edges.
- Using the Ring tool to select a ring of edges.

■ Using transforms, especially Move and Scale, to adjust the shape of the model by changing the position of sub-objects, especially vertices and edges.

■ Using the Constrain tools to limit sub-object movement.
■ Using the Border sub-object level to select the edge of a hole in the surface, and the Cap Poly tool to cover that hole.

■ Using NURMS to smooth the model and increase the detail of its geometry.
■ Adding edge loops to "reinforce" edges and reduce the amount of smoothing.

- Assigning smoothing groups to differentiate components of the model, and to provide fairly good smoothing even when the model has a low polygon count.


## (S) Learning to Use Containers

This tutorial introduces methods for working with the Container feature. The container provides various project-management functions, including organizing scene components and sharing tasks among team members, along with locking files and restricting access to specific scene components.


Use containers to organize scene contents and build scenes.
In this tutorial, you will learn how to:

- Use containers to organize and share scene contents.

■ Inherit a container.

- Restrict access to specific object parameters from other users.

■ Use the locking feature so that only one person can edit a container's contents at a time.

■ Build a complex scene using nested containers.

Skill level: Beginner
Time to complete: 2 to 3 hours

## Getting Started

Set up the scene:

- On the Quick Access toolbar, click

(Open File), navigate to the


NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene contains a table, a chair, and two place settings: one for eating a meal and another for attending a meeting at work.


## Get acquainted with container tools:

1 Each scene component has a named selection set. From the Named Selection Sets drop-down list on the main toolbar, choose the dinner setting item.

This selects all the objects in the dinnerware set.
2 Right-click in the active viewport, choose Hide Unselected, and then click


- (Zoom Extents All).

The dinnerware set is maximized in all viewports.


3ds Max provides various ways of accessing container-related commands, but one of the handiest is the Containers toolbar.

3 Right-click an empty area on the main toolbar and, from the context menu that opens, choose Containers. Then right-click the Containers toolbar title bar, and choose Dock > Right.
The toolbar docks on the right side of the interface, next to the command panel.

4 On the toolbar, click
 (Create Container From Selection). This command adds a new container to the scene and then places the selected objects in the container. The container appears in the viewports as a wireframe box with the lid flaps open. The box's position is calculated from the average of the selected objects' locations.


Alternatively, you could create a new container and then add objects to it, but if you already know which objects you want in the container, using Create Container From Selection is the easiest method.

NOTE The container is a helper object, and as such does not render.
Because the container starts out in an open state, you can manipulate it and its contents freely.

Move the container and note that its contents move along with it. Then move some of the contained items and note that their movement doesn't affect other objects.
In effect, the objects in the container are children of the container. But there's much more to the Container feature than a simple hierarchical relationship.

6 Undo any movements from the previous step, and then select the container.

7 Go to the


Modify panel and on the Manage Container rollout, click the Close button.

A file dialog titled Container Definition File opens, with the default file name container_start_Container001, based on the scene-file name and the container name. The file name extension .maxc is added when you save the file.

NOTE .maxc stands for "Max container," and is actually a standard 3ds Max scene file with a special file name extension. If you ever have problems opening a container file, you can load it as a regular scene by changing the extension to .max.

8 Navigate to the \scenes $\backslash$ modeling $\backslash$ container folder and click Save to store a copy on disk using the default name.
After you close the container, its appearance in the viewport changes to indicate that it's now closed.


9 Move the container and then try to select an object within it.
Moving the container works as before, but you can no longer select the contents. This behavior mimics the real world; if you put stuff in a box or other container and then close it, the contents are no longer directly accessible.

10 On the Manage Container rollout, click Open.
The box returns to its previous status, with one difference: On the Local Content rollout, the Saved Local Definition field contains the name of
the saved container. When a container has a local definition, that effectively means you're the container's owner, although it doesn't necessarily mean you have full control of its contents; this will become clearer later in the tutorial.


TIP The entire path and file name probably don't fit in the Saved Local Definition field, but you can see them, along with a tooltip, by positioning the mouse cursor over the field. In fact, most controls on the container rollouts offer helpful tooltips.

## Share the container with yourself:

Henceforth this tutorial will refer to Session 1 and Session 2 of 3ds Max. The best way to learn how the Container feature works without getting mixed up is by working in two different sessions of the program. In effect, you're simulating two users: one who originates a container in Session 1, and another who inherits it in Session 2. When you inherit a container, you can still use it, but only within the limits set by the originator.

One way to work in two different sessions of 3ds Max is by saving your work, resetting the program, and then reloading your work from the other session. As you can imagine, however, going back and forth this way is slow and cumbersome. Much better is to run 3ds Max twice, thus having two different sessions running concurrently on the same machine. We recommend this method if your machine has at least 2GB of system memory and 512 MB or more of graphics memory. If you're not sure whether you have enough memory, the best way to tell is just to try it.

Or, if you have two networked machines, run 3ds Max on both and switch back and forth. This latter method is closer to a typical studio setup with
multiple users on the same team sharing data, but the single-machine approach works fine as well.

1 Save Session 1 as my_container1.max.
2 In Session 2, add the Containers toolbar as before, if necessary, and then
click

(Inherit Container). Using the Inherit Container file dialog, navigate to the folder in which you saved the container file (container_start_Container001) in the previous section, and then open the file.

The container and its contents appear in the viewports, in the same location from which you saved them. The container is closed and selected.


3 Move the container and then try to open it.
You can move the container, but you cannot open it because the Open button on the Manage Container rollout is unavailable. Also note that the Edit In Place button is unavailable. To see one reason for this, return to Session 1.

4 In Session 1, take a look at the Rules rollout.
The When Inherited, Allow option is set to No Access (Closed), which means that the inheritor can work with the container, but not its contents. This capability is useful for a team in which one member creates the content and another simply arranges that content to set up a scene, such as a game level.

## Next

Using Rules on page 585

## Using Rules

## Change the rules:

Besides No Access, the container provides three other rules that allow various levels of access to other users. In this procedure you'll look at Only Edit In Place.

1 In Session 1, on the Rules rollout, choose Only Edit In Place and then close the container.

| Rules |  |
| :---: | :---: |
| When Inherited, Allow: |  |
| O No Access (closed) |  |
| (O) Only Edit In Place |  |
| Only Add New Objects |  |
| Anything Unlocked: |  |
|  | Edit |

This resaves the container with the rule change applied.
2 Return to Session 2.

On the Manage Container rollout, a icon appears next to the Update button. This indicates that an update is needed to keep in sync with the source container; the one created by the originator.


3 Click the Update button.

The container looks the same, but now the + icon appears next to the Update button, indicating that the container definition is current. Also, while the Open button is still unavailable, the Edit In Place button is available.

4 Click Edit In Place.
The inherited container opens in Edit In Place mode. Edit In Place is a mode that you enter and exit by clicking this toggle button.

5 In Session 1, try to open the container.
The Open button is available, but when you try to use it you get a message that the container's definition is currently being edited by you in another instance of 3ds Max.

This demonstrates two important Container features:

- When a container is set to Only Edit In Place, it can be edited by only one person at a time. This is thanks to a locking mechanism in the form of a file with the same name as the container, appended with .lock, which 3ds Max creates when Edit In Place is active. If you ever have trouble accessing a container, it might be due to the presence of this file, possibly as a result of exiting or resetting 3ds Max while Edit In Place is active. A warning is displayed when you attempt to do so, but you can ignore it if you choose. If this happens, simply delete the .lock file.
- When someone else is editing a container, 3ds Max can determine that person's user name and tell you what that is.

6 In Session 2, select the wine glass and move it upward a short distance. Then select the container and click Edit In Place.

This exits Edit In Place mode, saving any changes to the container contents and unlocking the container file.

7 In Session 1, open the container.
The wine glass changes position, reflecting the edit from Session 2.
NOTE At no time does the Update button become available in Session 1, because the container is local to Session 1 and the Update function applies to inherited containers only.

8 Still in Session 1, close the container without changing its contents.

9 In Session 2, the icon is again visible next to the Update button, even though the container definition hasn't changed.
The Update function doesn't look at the container definition; it simply compares the date and time stamp on the file with the version you inherited, and if it's newer, advises you to update.

## Lock an object's transforms:

Say the originator is now happy with the wine glass's position and doesn't want it change any more. The ability to lock specific parameters of a container definition is an important Container feature.

1 In Session 1, open the container, then, on the Rules rollout, click the Edit button.
Track View opens showing the container hierarchy.
2 Scroll down to the wineglass item and click the Transform entry to highlight it.

TIP As long as

(Filter - Selected Objects Toggle) is on in Track View, you can find the object faster in the list by selecting it.

3 Right-click the Transform entry, and from the quad menu $>$ top-left quadrant, choose Lock.

The Transform entry and all its children (branches and leaves) now show "(Locked)" after their names in the Track View hierarchy.


4
 Exit Track View and then close the container.

5 In Session 2, click Update and then click Edit In Place to open the container.

6 Move the objects in the container, including the wine glass.
You can move everything except the wine glass.
7 Undo any changes from the previous step, and then select the container and click Edit on the Rules rollout.

8 In Track View, find the wine glass item and then its Transform track. Click the Transform track to highlight it.

9 Right-click the Transform track and choose Unlock. The Transform track is no longer locked, but its child tracks still are. Lock affects child tracks, but Unlock affects only highlighted tracks.
（7）wineglass
煺 Transform
谆倖Position（Locked）
WX Position（Locked）
YY Position（Locked）
Z Position（Locked）
［C］Rotation（Locked）
EX Rotation（Locked）

10 Undo（Ctrl＋Z）to restore the the Transform track to Locked status．
11 Right－click the Transform track and choose Unlock Leaves．
This unlocks the Transform track as well as all of its child tracks．Now you can transform the wine glass if you want．

12 Undo the Unlock Leaves command and any other changes from the previous step，then select the container and click Edit In Place to close it．

## Change the rules again：

As you＇ve seen，you can lock specific tracks for objects in a container，but if you use the Only Edit In Place rule，the inheritor can easily defeat your locks． If you use a different rule，however，the inheritor must abide by your locks unless you revise them．

1 In Session 1，open the container and on the Rules rollout，choose Anything Unlocked．

| Rules＾ |  |
| :---: | :---: |
| When Inherited，Allow： |  |
| O No Access（closed） |  |
| Only Edit In Place |  |
| Only Add New Objects |  |
| （0）Anything Unlocked： |  |
|  | Edit |

With Anything Unlocked enabled, you can use the four icon buttons at the bottom of the Rules rollout to quickly lock all modifiers, materials, transforms, and objects, and you can also use the Edit button to lock specific tracks, as before. For the sake of convenience, in this exercise you'll just use the existing locked transform tracks for the wine glass.

2 Close the container, then go to Session 2 and click Update.
This time something different happens: The container opens, and Edit In Place is unavailable.

3 Go to Session 1 and open the container.
No problem opening it this time. Edit In Place is the best rule for passing a single container back and forth between team members while preventing accidental overwriting; the remaining rules are better suited for one-way transfer of containers, as you'll see in the following steps.

4 Return to Session 2 and click the Close button.
Instead of simply closing the container, 3ds Max prompts you for a file name.

5 Enter the name DinnerSetting and click Save.
This saves a local definition of the container, although it still has a connection to the source definition, as indicated by the source file name under Source Definition on the Inherited Content rollout.

NOTE When any user has this local container open, it is locked, just like an Edit In Place container.

6 Open the container again.
Now you can see the name of the container file you saved under Saved Local Definition on the Local Content rollout.

Depending on whether the inherited container is open or closed, the Modify panel shows either the Local Content or Inherited Content rollout; never both.

7 If Track View isn't open, click Edit on the Rules rollout and find the Transform section of the wineglass hierarchy.
Now the "(Locked)" text is in italics, indicating that you, as the inheritor of this data, cannot unlock those tracks. Try to unlock them; you can't, even if you change the rule. You're limited by the rules set in the container you inherited.

8 Return to Session 1 and try to move the wine glass; you can't because its

Transform tracks are locked. On the Containers toolbar, click
 (Override All Locks).
The toggle button stays highlighted to indicate that this condition is active.

9 Move the wine glass and then close the container.
10 In Session 2, select the container and then update it. The glass moves to reflect its new position from the source container.

11 Check the glass's Transform tracks in Session 2; they're still irrevocably locked.

The overridden transforms are inherited in Session 2, but the overrides themselves are not. Thus, using the Anything Unlocked rule, the originator of the container can keep a firm grasp on which changes the inheritor can make, but can override her own rules at will.

12 Create a sphere or any other object primitive in Session 2. On the

(Add Selected To Container). Use the Select dialog that opens to highlight the container and then click the Add button.

NOTE You can add objects only to open containers.
13 Close the container in Session 2 and then return to Session 1 and close and reopen the container.
The new object from Session 2 doesn't appear. Source containers set to Anything Unlocked (or Only Add New Objects) move data in one direction only: from the originator to the inheritor. If you like, add an object in Session 1, close the container, and then update in Session 2; the object is added to that container, even though it has a local definition. In a sense, the container in Session 2 is a hybrid of of a source and local container.

14 In both sessions, close the containers and then reset 3ds Max.

## Next

Assembling Containers on page 592

## Assembling Containers

As mentioned, the Container feature is intended primarily for use by teams working together on projects. In this last exercise, you'll simulate a team of three: one person creating content, another one using a subset of that content to assemble a dinner-table scene, and a third using a different subset to put together a conference-room scene at an office or convention. You'll do so using the remaining rule: Only Add New Objects.

## Use the Only Add rule:

1 In Session 1, open container_start.max.
2 From the Named Selection Sets drop-down list on the main toolbar,
choose each named selection set in turn and use (Create Container From Selection) to add the objects to containers. After you create each container, rename it to reflect its contents: dinner_setting, office_setting, table, and chair.
You should end up with four containers, each set to the default No Access rule.

3 Close the two table-settings containers and give them the file names dinner_setting and office_setting (3ds Max automatically adds the .maxc extension).

4 Select the container with the table, set its rule to Only Add New Objects, close it and save it as table. Do the same with the chair container, saving it as chair.


5 In Session 2, 4 inherit the chair.maxc container file; it comes in open. Also inherit the dinner_setting.maxc container file, which comes in closed and can't be opened or edited.

6 Try to select the chair object; you can't.
That's because the object is locked as a consequence of using the Only Add New Objects rule. When an object is locked, you can't select it, so of course you can't transform it directly. However, you can transform it via its container.

7 Select the dinner_setting container, then click
 (Add Selected To Container). Use the Select dialog that opens to highlight the chair container and then click the Add button.
You now have a nested container setup: The chair container contains the chair object as well as the dinner_setting container and its contents.

8 Inherit the table.maxc container; like the chair container, it comes in open, but with the contents locked.

9 Select the chair container and use Shift+Move to create three copies. Cloning the chair container also clones its contents; the chair object and the dinner_setting container and contents.

10 Position the copies around the table in any arrangement you like. As long as you move them horizontally only, the chairs and place settings remain at the correct heights for the table.


You now have a basic setup for four people eating dinner at a table. You could then add other objects such as wine bottles, flowers, and so on.

11 Select all four chair containers and then
 add them to the table container.
Now when you move the table container, all four place settings and chairs move along with it.

12 Close the table container and give it the file name dinner_table.
Because you're prompted to create a new local container definition when closing an inherited container set to Only Add New Objects, this helps prevent inadvertently overwriting the original container definition.

NOTE When any user has this local container open, it is locked, just like an Edit In Place container.

13 Make a few copies of the table container and arrange them to create a restaurant dining-room setup.


14 Save the scene as my_dining_room.max.

## Set up the conference table:

1 Reset 3ds Max, then inherit the chair, table, and office_setting containers. Because the office setting is offset from the chair, you need to position them closer together.

2 Select the office_setting container, then move it horizontally and rotate it a half-turn so it's positioned correctly with respect to the chair.


3 As before, add the office_setting container to the chair container.
4 Make three copies of the chair container, and then add all four chair containers to the table container.


5 Close the table container and give it the file name conference_table.
6 Make some copies of the table to populate a conference room. Position and rotate each conference table to create a natural-looking arrangement.

## Summary

In this tutorial you learned how to create containers from selected objects, how to save and inherit containers, and how to restrict access to certain parameters from other users. You also learned how to combine containers for easy setup of complex scenes containing repetitive elements.
There's much more to the Container feature than we've shown here; for example, you can merge contained elements into your scene and use low-resolution proxies to set up complex geometry quickly. To learn more, consult the Container section of the 3ds Max Help.

## Animation Tutorials

## 4

The tutorials in this chapter show you the fundamentals of creating animation with 3ds Max.


Different kinds of balls have different bounces.

## Features Covered in This Chapter

- Auto Key animation
- Set Key animation
- Ghosting and trajectories

■ Track View: The Curve Editor
■ Rigging a model with hierarchies and paramenter wiring

- Sound effects


## (3) Animating with Auto Key: Bouncing Balls

A bouncing ball is a common first project for new animators. This classic example is an excellent tool for explaining basic animation methods in 3ds Max.


Different kinds of balls have different bounces.

Skill level: Beginner
Time to complete: 1 1/2 hours

## Bouncing a Ball

To create a bouncing ball, first you use Auto Key to block out the motion, and then use the Curve Editor and other tools to make the motion more realistic. (This is a very typical workflow for animators.)


Open the starting scene and set the start frame to frame 0 :

1 On the Quick Access toolbar, click
$\square$ Iscenes\animation\auto_key folder, and open bouncing_ball_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene contains a basketball and a plane that will act as the floor. It isn't animated yet.


2 Look at the start frame, at the left of the time bar and time slider.


If the first frame shows frame 1 instead of frame 0 , click
 (Time Configuration), among the animation controls near the lower right of the 3ds Max window, then in the Time Configuration dialog, change the Start Time value to 0 .
Animation
Start Time: 0
End Time: $\sqrt{100}$ Re-scale Time Cur

Make sure the Length of the animation is 100 frames, then click OK.
For some purposes, frame 1 is a useful start frame (for example, a character animator might want to reserve frame 0 for a "reference pose"), but the exercises in this tutorial will start at frame 0 .

## Use Auto Key to Block Out the Bounce

Auto Key provides an easy way to block initial animation.
A simple diagram illustrates the path of a bouncing ball.


The shape of the curve that the ball follows, its trajectory, affects the realism of the animation. So does the shape of the ball itself, which we'll get to later in this lesson.

The default frame rate for 3ds Max is the NTSC (National Television System Committee) standard of 30 frames per second. If we want a single bounce of
the ball to last one second, then it will fall for the first 15 frames, and rebound for the next 15 frames.

## Set up the scene:

- Continue from the previous lesson.


## Use Auto Key to animate the ball falling:

1 Click
Auto Key (Auto Key) to turn it on.
The Auto Key button turns red to show that you are now animating.

## Auto Key

The time slider background and the border of the active viewport also turn red. Now when you move, rotate, or scale an object, 3ds Max creates keyframes that control the object's motion.


The time slider background and active viewport border turn red while you are animating.

2 Make sure that
(Select Object) is turned on, then click the basketball to select it.

3 Drag the time slider to frame 15.


4 In the Perspective viewport, right-click the basketball. Choose Move from the quad menu.

5 Move the basketball vertically so it touches the floor, and even drops a little bit through the floor.


The ball touches the floor at frame 15.
(You will correct the intesection with the floor in a later procedure.)
If you drag the time slider between frame 0 and frame 15 , you will see that 3ds Max has animated the fall of the basketball. Red boxes appear on the timeline at both frame 0 and frame 15: these represent keys that 3ds Max created when you moved the ball.


Keys appear on the timeline at frame 0 and frame 15.

## Clone a key to complete the bounce:

You could drag the time slider to frame 30, and then move the ball upward so it approximately returns to its original position, but 3ds Max lets you position the ball more accurately than that.

1 On the timeline, click the key at frame 0 to select it.
The key turns white.


2 Hold down the Shift key, then drag the key from frame 0 to frame 30.


Shift+drag is a general method for cloning keys on the timeline. (Dragging a key without holding down Shift simply moves the key.) Now at frame 30 , the ball is in precisely the position it was in at frame 0 .

3 Click Auto Key
(Auto Key) to turn it off.
4 Drag the time slider to see the complete animated bounce.

In the animation you've just created, the ball moves down and then up, but the motion isn't very bouncy: It looks stiff and computer generated. In the next section, you adjust key timing to make the bounce more realistic.

## Next

Use the Curve Editor to Improve the Motion on page 607

## Use the Curve Editor to Improve the Motion

The Curve Editor is part of the Track View feature, which is a general-purpose tool for managing and adjusting animation.

## Set up the scene:

- Continue from the previous lesson.


## Open the Curve Editor:

- Right-click the basketball, and choose Curve Editor from the quad menu. 3ds Max opens the Curve editor. The tracks you just created for the ball should be visible on the left, and the curves themselves should appear in the curve window to the right.


TIP If the tracks and curves don't appear when the Curve Editor opens, pan in the controller window at the left until you see the position tracks, then click and $\mathrm{Ctrl}+\mathrm{click}$ to highlight them.

The Z track, in blue, clearly shows the up-and-down movement of the ball. The X and Y tracks are both flat, which indicates no change in these dimensions. In fact, the ball should travel along the X-axis, as if it were given some forward momentum when it was dropped.

NOTE The track curves are color-coded like the axes on transform gizmos: X is red, Y is green, and Z is blue.

## Add movement along the X -axis:

1 Drag the time slider to frame 30. Turn on Auto Key (Auto Key) once again, then in the Left viewport, move the ball to the right along its X -axis.


The curves in the Curve Editor also update to show the change you made.


That doesn't look quite right: As you can see if you scrub the time slider, the ball drops vertically, and then travels forward. Instead, the effect we want is a smooth forward motion, as in the diagram at the beginning of this lesson. The culprit is the Y Position key at frame 15 , which pins the ball to the same Y position it has at frame 0 .

2 Turn off
Auto Key
(Auto Key).
3 In the Curve Editor, click the Y Position key, along the green curve, to select it.


The key turns white when you select it. It also shows some tangent handles.

4 Press Delete to delete the Y Position key at frame 15.


Now the basketball moves forward from frame 0 to frame 30, as you can see if you scrub the time slider. The animation still looks too mechanical, but you'll improve that soon.

NOTE The X Position track is still flat, indicating no change along that axis. You could delete all the keys in the $X$ track without affecting the animation.

Add a trajectory and ghosting to improve animation display in the viewports:
You can display the trajectory of an object in viewports, and also "ghost" images of the moving object. Both these options help you visualize your animation.

1 In a viewport, right-click the basketball, and choose Object Properties from the quad menu.
3ds Max opens the Object Properties dialog.
2 In the Object Properties dialog > Display Properties group, click Trajectory to turn it on, and then click OK.

General Adv. Lighting mental ray User Defined

Object Information
Name: Basketball
Dimensions: $\mathrm{X}: 63.451$ Material Name: Material \#35
Y: 63.036 Layer: 0 (default)
Z: 63.021
Vertices: 3584 Parent: Scene Root
Faces: 3560 Num. Children: 0
$0 \quad$ In Group/Assembly: None

## Interactivity

$\square$ HideFreeze
Display PropertiesSee-Through
Display as BoxBackface Cull
V Edges OnlyVertex Ticks
 Trajectory hignore Extents
$\square$ Show Frozen in GrayNever Degrade
Vertex Channel Display
Vertex Color $\rightarrow$ Shaded
Map Channel: 11 |

Rendering Control
Visibility: 1.0 By Object
V Renderable
V Inherit Visibility
$\checkmark$ Visible to Camera
V Visible to Reflection/Refraction
( Receive Shadows
V Cast Shadows
$\checkmark$ Apply Atmospherics
$\square$ Render Occluded Objects
G-Buffer

Motion Blur
Multiplier: 1.0 | $\stackrel{\Delta}{v}$ By Object
V Enabled
(O) None Object $\bigcirc$ Image

Now viewports show a trajectory for the basketball, in red, with white tick marks along its length. Each tick represents a frame.


## Basketball trajectory in a viewport

The ticks are more closely spaced at the beginning and end of the trajectory (this is easiest to see in the Left viewport). This is a timing effect known as "ease in, ease out" (or "slow in and slow out"). However, the ticks are evenly spaced around frame 15 , where the ball bounces off the floor. This is one reason the bounce doesn't appear realistic, yet.

3 From the menu bar, choose Views $>$ Show Ghosting to turn it on.
Now when you drag the time slider, viewports show ghost images of where the ball has traveled.


The default ghosts are closely spaced, and a little hard to read. You can improve this by changing the default settings.

4 From the menu bar, choose Customize > Preferences. Go to the Viewports tab.


5 In the Ghosting group, change the value of Ghosting Frames to 4, and change the value of Every Nth Frame to 2. Click OK.
Now when you scrub the time slider, you see fewer ghosts, spaced two frames apart. This makes it a bit easier to see how the animation is progressing.


## Adjust the timing of the bounce, in the $\mathbf{Z}$ dimension:

1 In the Curve Editor Controller window (the list of objects and tracks at the left), click the Z Position track to display the curve for just that track.


2 Click the "floor" key at frame 15 to select it (you also can select the key by dragging a box around it).


3 On the Track View - Curve Editor toolbar, click
 To Fast).


4 Scrub the time slider.
NOTE As you might notice, the trajectory display in viewports doesn't update until you move the time slider.

Now the bounce has a snap to it that makes it look more like a real bounce.


## Adjust the basketball's forward motion:

As it did for the ball's up-and-down motion, Auto Key applied ease in, ease out to the ball's forward motion. But this isn't necessary, and in fact would give strange results when you repeat the bounce, as you do in the next section.

1 In the Curve Editor $>$ Controller window, click the Y Position track to display the curve for that track.


2 Drag to select both the starting and the ending key in this track.


3 On the Track View - Curve Editor toolbar, click
 To Linear).

3ds Max removes the ease curves from this track, making the forward movement uniform.


Save your work:
■ Save the scene as my_bouncing_basketball_adjusted.max.

## Next

Repeat the Bounce on page 618

## Repeat the Bounce

Typically, a bouncing ball does not bounce once. The Curve Editor gives you the means of repeating the initial bounce.

## Set up the scene:

- Continue from the previous lesson.


## Remove the X Position keys:

The X Position track has keys that don't change, so you can safely delete them.
1 In the Curve Editor $>$ Controller window, click the X Position track to display the curve for that track.


2 Drag to select all the keys in this curve.


Dragging to select the X Position keys


All X Position Keys selected

3 Press Delete to delete the X Position keys.

## Repeat the animation:

1 In the Curve Editor > Controller window, click the Z Position track, then hold down Ctrl and click the Y Position track so both curves are visible.


2 On the Track View - Curve Editor toolbar, click

(Parameter Curve Out-Of-Range Types).
3ds Max opens the Param Curve Out-Of-Range Types dialog.

Param Curve Out-of-Range Types


This dialog presents various options for how to continue a portion of animation outside the range of the keys you've created. Each option is represented by a graphic button. In the graphic, the original animation is represented by a solid trace, and the effect of continuing the animation is represented by dotted traces.

NOTE You don't need to select keys before you open this dialog: Parameter Curve Out-Of-Range Types operates on whatever keys are present in the tracks you select.

You can click a graphic button to choose the same type for both incoming and outgoing animation, or use the smaller buttons to choose incoming and outgoing types individually.

At first glance, Loop seems the obvious choice, but while this option successfully loops the bounce, it also loops the forward motion of the basketball, which is not what we want. You can see this effect in both the Curve Editor and the viewports.


The Z Position track repeats successfully, but the sawtooth shape of the Y Position track shows that the ball keeps returning to its starting position.


In viewports, the trajectory shows the same effect: Loop creates a closed loop for the ball, instead of forward motion.

3 In the Param Curve Out-Of-Range Types dialog, click the outgoing button for the Releative Repeat option, then click OK.

Param Curve Out-of-Range Types


OK Cancel

Ping Pong


Linear
Relative Repeat

(You can leave the incoming animation set to Constant, because the bounce begins at the start of the scene animation.)
Now the ball bounces as before, but at each continuation of the bounce, the forward motion begins where it ended. You can see the difference in the Curve Editor, if you zoom out in the curve window: The Z Position track goes up and down, but the Y Position track continues in a straight line.


4


Zoom out in the Perspective viewport so you can see the full trajectory of the basketball.


## Save your work:

■ Save the scene as my_bouncing_basketball_continuous.max.

## Next

Add Rotation on page 624

## Add Rotation

The bounce is beginning to look good, but as it bounces forward, the basketball remains perfectly level, and that is not realistic.

## Set up the scene:

- Continue from the previous section, or
 open bouncing_ball_02.max.


## Turn off ghosting:

The rotation of the textured ball is easier to see if you turn off ghosting.

1
Select the basketball, if it is not already selected.

2 From the menu bar, choose Views > Show Ghosting to turn off this option.

If you were to use Auto Key to set rotation keys for the ball, without any preparation, you would run into trouble. The reason is that 3ds Max uses Euler XYZ as the default rotation controller. For continuous animation, there are a couple of problems with this controller: It is not good at handling rotation greater than 180 degrees, and it sets keys for all three tracks, even when you animate only a single axis. These problems are exaggerated when you set the Out-Of-Range type; for example:


Out-of-range curves with Euler XYZ rotation
In this example, 3ds Max has generated extraneous and unrealistic sideways rotation for the ball.

When you want rotation greater than 180 degrees, or continuous rotation about a single axis, the solution is to use a TCB rotation controller.

## Change the controller type:

1 In the Curve Editor, click to select the main Rotation track (not one of the subordinate $\mathrm{X}, \mathrm{Y}$, or Z Rotation tracks).
Basketball
良] Transform
[5+9]Position
WX Position
YY Position
ZZ Position
[医 Rotation
FX Rdastion
FY Rotation
Z R Rotation
FScale

The main Rotation track

2 Right-click the main Rotation track. From the quad menu, choose Assign Controller.
3ds Max opens an Assign Controller dialog.

## Assign Rotation Controller


>AudioRotation Euler XYZ Linear Rotation LookAt Constraint Motion Clip SlaveRotation Noise Rotation Orientation Constraint Rotation List Rotation Motion Capture Rotation Reaction Rotation Script SlaveRotation Smooth Rotation TCB Rotation

Default: Euler XYZ

Make Default OK Cancel

3 In the Assign Rotation Controller dialog, click to choose TCB rotation, then click OK.
Now the basketball has a single Rotation track, with no subordinate X, Y, and Z Rotation tracks.


4 On the Track View - Curve Editor toolbar, click

(Filters).
3ds Max opens the Track View > Filters dialog.


5 In the Filters dialog＞Show group（on the left），click to turn on Controller Types，and then click OK．
Now the controller window lists controller types．

［退TTransform ：Position／Rotation／Scale
臣勃Position ：Position XYZ
WX Position ：Bezier Float
WY Position ：Bezier Float
Z Position ：Bezier Float
Rotation ：TCB Rotation
Scale ：TCB Scale
$\cdots$（．）Object（Editable Poly）
（4）（）Material \＃35

TIP Although by default，3ds Max does not display controller types in the controller window，turning on their display can help you keep track of the animation you are creating．

Now you are ready to create rotation keys for the basketball．
Add rotation to the basketball：
1 Turn on Auto Key（Auto Key）．

2 On the main toolbar，turn on

（Angle Snap）．

3 Drag the time slider to frame 15．In the Perspective viewport，
 rotate the basketball 90 degrees forward in the X －axis．Watch the X field in the status bar to check the value．


Forward rotation at frame 15

4 Drag the time slider to frame 30.


Rotate the basketball forward another 90 degrees along the X -axis.

5 Turn off Auto Key (Auto Key).

## Make the rotation continuous:

1 In the Curve Editor, click the Rotation : TCB Rotation track to highlight it.

NOTE No curves appear in the curve window: The TCB family of controllers uses dialogs to manage animation, rather than editable curves.

2 On the Track View - Curve Editor toolbar, click
(Parameter Curve Out-Of-Range Types).

3 In the Param Curve Out-Of-Range Types dialog, click the outgoing button for the Releative Repeat option, then click OK.

(As before, you can leave the incoming animation set to Constant, because the bounce begins at the start of the scene animation.)

4 Scrub the time slider to see the animation. The texture of the basketball makes it easy to see the rolling motion.

## Save your work:

■ Save the scene as my_bouncing_basketball_rolling.max.

## Next

Add Squash and Stretch on page 631

## Add Squash and Stretch

Squash and Stretch enhances the effect of animation.

Objects deform as they move or collide. In the real world, this effect is sometimes obvious (think of a soap bubble), and sometimes subtle. In animation, it pays to exaggerate this effect: Although the exaggeration might go beyond realism, it reinforces the illusion of realism when we watch the animation. This effect is known as "squash and stretch."

It is worth looking again at the diagram of a bouncing ball:


The ball should stretch as it falls, squash when it collides with the floor, and then stretch again as it rebounds.

The Stretch modifier in 3ds Max provides a convenient way to animate squash and stretch.

Set up the scene:

- Continue from the previous lesson, or

open bouncing_ball_03.max.


## Apply a Stretch modifier to the basketball:

## 1



Select the basketball, if it is not already selected.

2 Go to the
Modify panel. From the Modifier List, choose Stretch.
TIP While the Modifier List is open, you can press the $S$ key multiple times to find modifiers whose name begins with "S."

3 On the Parameters rollout for the Stretch modifier, change the value of Amplification to - $\mathbf{3 0}$.

| Parameters |
| :---: |
| Stretch: <br> Stretch: 0.0 <br> Amplify: <br> Stretch Axis: X <br> Y <br> (O) <br> Z <br> Limits Limit Effect <br> Upper Limit: 0.0 <br> Lower Limit: 0.0 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Positive amplification tends to squeeze an object in the middle as it stretches, while negative amplification makes the middle of the object fatter, which is the effect we're looking for.
We also want the basketball to stretch along the Z-axis: As it happens, that is already the default.

## Animate stretching and squashing:

1 Turn on Auto Key (Auto Key).
2 Drag the time slider to frame 6.
3 On the Parameters rollout for the Stretch modifier, change the Stretch value to $\mathbf{0 . 1}$.

| Parameters |
| :---: |
| Stretch: <br> Stretch: $\qquad$ <br>  <br> Amplify: $\square$ $-30.0$ |
|  |  |
|  |  |
|  |
|  |
| Limits |
| $\square$ Limit Effect |
| Upper Limit: 0.0 |
| Lower Limit: 0.0 \| ${ }^{\text {\| }}$ |

The Stretch field's spinner arrows now show red brackets, indicating that 3ds Max has created an animation key for this parameter. In the viewports, you can see that the basketball is elongated along its direction of travel.


4 Drag the time slider to frame 15, where the basketball collides with the floor.

5 On the Parameters rollout for the Stretch modifier, change the Stretch value to $\mathbf{- 0 . 2}$.
This squashes the basketball at the point of impact. Incidentally, it also corrects the way the basketball used to sink into the floor!


6 Drag the time slider to frame 30, and change the Stretch value back to 0.0 .

TIP Just right-click the spinner arrows to set the value back to zero. In 3ds Max, this is a standard shortcut for setting a numeric field to its minimum nonnegative value.

## 7 Turn off Auto Key <br> (Auto Key).

8 You need to "bracket" the squash so it doesn't begin before impact, and goes away when the ball rebounds.
Shift+copy the key at frame 6 key to the following frames:

- Frame 14
- Frame 16

■ Frame 24

## Repeat the stretch and squash:

1 In the Curve Editor controller window, locate the track for the Stretch parameter.
The hierarchy looks like Basketball > Modified Object > Stretch > Stretch : Bezier Float. You have to scroll down to get past several position, rotation, and scale tracks that you arent using in this exercise.


2 On the Track View - Curve Editor toolbar, click
 Out-Of-Range Types).

3 In the Param Curve Out-Of-Range Types dialog, click the outgoing button for the Cycle option, and then click OK.
Now the squash and stretch pattern repeats indefinitely.


## Play the animation:

- Click $\quad$ (Play) to play the animation.

Animation controls, including playback controls, are in the lower-right corner of the 3ds Max window, just to the left of the viewport navigation controls.


Play button, while playback is active.)
This completes the animation of bouncing a basketball.

## Save your work:

■ Save the scene as my_bouncing_basketball_completed.max.

To see a completed version of the basketball animation, you can
 open bouncing_ball_completed.max.

## Next

Different Types of Balls: Mass, Elasticity, and Friction on page 637

## Different Types of Balls: Mass, Elasticity, and Friction

Not all balls are equal. Mass and elasticity affect how high the ball will bounce, and how far it will travel. So does the friction of the surface on which the ball lands. This lesson compares the bouncing of a bocce ball, a tennis ball, and a golf ball.

Even a hard rubber ball won't bounce, if you drop it onto the dry part of a sandy beach. In this lesson, we assume that the balls are bouncing on a hard, uniform surface such as smooth concrete or a hardwood floor. An uneven surface can cause unexpected motion: That is the subject of the lesson that follows.

The friction of air (air resistance or "drag") can affect a ball's motion as well. Usually this is a subtle effect. On the other hand, even a lightweight, highly elastic ball such as a golf ball eventually loses momentum and comes to a stop. So unlike the indefinitely bouncing basketball in the previous lesson, the balls in this lesson bounce for a limited time only, and with decreasing energy.

## Bouncing a Bocce Ball

We'll start with a heavy ball that doesn't have much bounce to it, at all. Bocce balls weigh from 31 ounces to 42 ounces ( 900 to 1200 grams): on the average, a bit over 2 pounds (about 1 kilogram).

Here is the graph of a bocce ball dropped onto a hard, smooth floor from a height of just over 25 feet ( 7.6 meters):


As the graph shows, the ball bounces only twice, and does not have much forward momentum, either.

NOTE This chart, as well as the charts for the tennis and golf balls, is based on real-world values. It was created by videotaping the actual bounce of the ball, and then rotoscoping the height and forward distances.

## Open the starting scene:

- On the Quick Access toolbar, click

E(Open File), navigate to the Iscenes \animation\auto_key folder, and open compare_bocce_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene contains a bocce ball and a plane that will act as the floor. It isn't animated yet.


Keyframe the bounces and adjust the keys:

1 Turn on Auto Key (Auto Key), and then in the Front viewport,
move the ball to create the following keyframes:

- Frame 12: Down to floor level, and forward about 20 units.

Don't sink the ball through the floor as you did with the basketball: Bocce balls are typically metal or wood, so squash and stretch is not an issue in this exercise!

TIP After you key the first contact with the floor, you can click 는 (Zoom Extents Selected) to get a better view of the ball and its trajectory.

- Frame 19: In the air again, to a height of about 60 units, and forward about 20 units.
- Frame 26: Back to floor level, and forward about another 20 units.

■ Frame 28: In the air again, to a height of about 10 units and forward about 10 units.

- Frame 30: Back to the floor, and forward about 10 units.
- Frame 60: At floor level, forward about 100 units. At this point, the ball is just rolling, so you all you need to do is move it to the right along its X -axis.

2 Turn off
Auto Key
(Auto Key).
The bounce is now blocked out.


As with the basketball, the keys where the ball strikes the floor are not crisp enough, yet.

3 Right-click the bocce ball, and choose Curve Editor from the quad menu.
TIP If the tracks and curves don't appear when the Curve Editor opens, pan in the controller window at the left until you see the position tracks, then click and $\mathrm{Ctrl}+$ click to highlight them.

4 In the Curve Editor, click the Z Position track to highlight it. Then click and Ctrl+click the three keys where the ball strikes the floor.


The three Z Position floor keys selected

5 On the Curve Editor toolbar, click
(Set Tangents To Fast).


The Z Position bounce keys corrected

6 Click to highlight the X Position track. In the curve window, drag a box
to select all the keys along the X Position curve, and then click
 (Set Tangents To Linear).


X Position rolling keys corrected

NOTE The ball is actually rolling as well as bouncing, but because (unlike the basketball) it has a uniform texture, we don't need to worry about rotating it: In viewports, it would look just the same.


Trajectory of the bocce ball after adjusting the keys

- Play the animation.

The keys you created give a convincing animation of a heavy, solid ball.

## Save your work:

■ Save the scene as my_bouncing_bocce_ball_completed.max.

## Bouncing a Tennis Ball

As you might expect, a tennis ball bounces more often than a bocce ball, and travels farther while it does so.


A tennis ball is hollow rubber, coated with felt. The standard weight of a tennis ball is 22 ounces ( 624 grams).

In this section, we won't make you enter keyframes by hand again. Instead, we demonstrate a shortcut way to model the diminishing energy and magnitute of bounces: This is a technique that you could apply to an out-of-range, repetitious bounce such as you created for the basketball in the previous lessons.

## Open the starting scene:

- On the Quick Access toolbar, click

E(Open File), navigate to the Iscenes \animation\auto_key folder, and open compare_tennis_start.max. The scene contains a tennis ball and a plane that will act as the floor. The ball is animated, but it keeps bouncing back to approximately the same height: the scene doesn't yet model a normal loss of energy. (As the ball travels, its bounces do grow closer together: The spacing of the keyframes is based on the real-world chart shown above, but the height of the bounces isn't adjusted, yet.)


Adjust the Z Position curve by using a multiplier curve:
1 In any viewport,
Curve Editor from the quad menu.

TIP If the tracks and curves don't appear when the Curve Editor opens, pan in the controller window at the left until you see them, then click to highlight the position tracks.

2 In the Curve Editor > controller window, click the Z Position track to display this curve in the curve window.


3 From the Curve Editor menu bar, choose Curves > Apply - Multiplier Curve.

3ds Max adds a multiplier curve to the Z Position track. It also changes the curve window display so all curves are visible.

4 Click $\cdot \mathbf{( t h e}$ plus-sign icon that now appears next to the Z Position entry in the controller window). Then click the Multiplier Curve track to highlight it.


As you can see, the default value of the multiplier curve is completely flat.

5 Ctrl+click the Z Position track so you can see both the Z Position track and its multiplier.


6 Click to highlight the key at the right of the multiplier curve.


This key is close to the final key for the tennis ball itself, but is slightly above it, overlapping.

7 A transform curve is extremely sensitive to changes in the multiplier curve you apply to it. Because of this, adjusting the multiplier by dragging in the curve window is not the best method: You can get wild results. Instead, type in the value.
The Key Stats toolbar is the status bar at the lower left of the Curve Editor. The first field shows the current frame number, and the second field is the key value. In this field, initially set to 1.000 , enter $\mathbf{- 0 . 0 1}$.


Now the multiplier curve "damps" the bounce of the tennis ball, simulating the loss of energy as it travels and strikes the floor.


Are the new values realistic? Comparing the results obtained from the multiplier curve with the chart for an actual tennis ball, it appears that in real life, the tennis ball loses energy, and bounce height, even more quickly than our simulation. If realism is a concern, consider keyframing each bounce, as you did for the bocce ball. But if your main concern is creating a general impression, then the multiplier curve is a useful shortcut.

## Save your work:

■ Save the scene as my_bouncing_tennis_ball_completed.max.

## Comparing the Golf Ball

In this section, you simply compare the path of a bouncing golf ball to the other two balls in this example.

A golf ball typically weighs 1.62 ounces ( 45 grams), and is made of rubber (or a comparably elastic plastic) wound around a core, then encased in a plastic shell. Its extreme elasticity means that it bounces a lot: So much so, that to animate it requires more than the default 100 frames of a 3 ds Max scene.


Open the scene with all three balls:

- On the Quick Access toolbar, click
$\square$ Iscenes \animation\auto_key folder, and open compare_completed.max. The scene contains the bocce ball, the tennis ball, and the golf ball. They are animated already. All are dropped from the same height at the same time.



## Compare the balls and how they bounce:



- Play the animation.

The balls bounce according to their mass and elasticity.
Incidentally, the golf ball hits the floor slightly before the tennis ball, which precedes the bocce ball: So our real-world measurements account for air resistance, as well as mass and elasticity.

Click

00(Stop) when you are done observing the animation. You can also play the movie compare.avi to see a rendered version of this animation.

## Next

Using a Helper to Control Changes in Direction on page 651

## Using a Helper to Control Changes in Direction

Bouncing a ball on an uneven surface can cause changes of direction. In this lesson, you use a point helper to control those changes, making the animation easy to edit.

Open the scene:

- On the Quick Access toolbar, click
(Open File), navigate to the \scenes \animation\auto_key folder, and open bouncing_chaos_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene is the bouncing golf ball from the previous lesson. The plane has a texture that suggests a tile floor with recessed grooves for the grout. Uneven surfaces such as asphalt, tiles with grout, and so on, can make a bounce take off in unexpected directions.


You will retain the bounces, but remove the forward motion and replace that with changes of direction in X and Y .

## Remove the motion in $X$ and $Y$ :

1
Select the ball, right-click it, and choose Curve Editor from the quad menu.

TIP If the tracks and curves don't appear when the Curve Editor opens, pan in the controller window at the left until you see them, then click to highlight the position tracks.

2 Highlight the X Position track. Drag to select all keys in the curve window, and then press Delete.
Now the ball bounces in place, with no forward motion.


3 Highlight the Y Position track, and delete all its keys as well.
 Close the Curve Editor.

Now you want to add more "chaotic" motion to the ball: When it strikes the face of a tile, it should continue in the same direction, but when it strikes a groove with grout, it should change its direction.

You could animate this lateral motion using the ball itself, but a better method is to use a helper object: With this method, the helper animation is independent of the ball and its bounce track, so if you later need to change the lateral motion, you can do so without affecting the bounce.

## Create a Point helper to control the ball:

1 On the
Create panel, turn on
 Type rollout, click to turn on Point.
(Helpers), then in the Object


Object Type

## AutoGrid



NOTE Many animators use the Dummy helper instead of Point. The advantage of using a Point helper is that you can adjust its size without having to scale it. Scaling a helper in a hierarchy will affect its children objects: This is an effect that usually you want to avoid.

3 If you are not at frame 0, click
4 In the Top viewport, click near the golf ball to create the Point helper.
5 On the Point helper's Parameters rollout, click Box to turn it on, and then change the size of the box to 40 .
$\left[\begin{array}{l}\frac{\text { Parameters }}{} \quad \hat{\text { Display: }} \\ \square \text { Center Marker } \\ \square \text { Axis Tripod } \\ \nabla \text { Cross } \\ \square \text { Box } \\ \text { Size: } \sqrt{40.0} \mid \hat{v} \\ \square \text { Constant Screehsize } \\ \square \text { Draw On Top } \\ \end{array}\right]$

6 On the main toolbar, click (Align), and then click the ball.
7 In the Align Selection dialog > Align Position (Screen) group, turn on X Position, Y Position, and Z Position. Then choose Center for both Current Object (the Point helper) and Target Object (the golf ball).

8 Click OK to close the Align dialog.

## Link the ball to the Point helper:

1 In the Top viewport, ${ }^{\text {zoom in to get a better view of the ball and }}$ the helper.

2 On the main toolbar, turn on

3 Select the ball, then drag to the box of the Point helper, and release the mouse.


Now the ball is a child of the Point helper: When you move the point, the ball will follow along.

4
Move the Point helper.
The ball and its trajectory both follow the Point.

5


Undo the Point helper movement.

## Animate the changes in direction:

To make the ball move erratically, you want to give it lateral motion (via the Point helper) every time the ball hits the ground. If the ball hits a tile, it should continue forward. If the ball hits grout, it should change direction.

It's easiest to move the Point in the Top viewport, while you watch the effect in the Perspective viewport.

1 In the Top viewport, click
 (Zoom Extents) so you can see all of the floor, once again.

2 Turn on
Auto Key (Auto Key).

3 Drag the time slider to frame 10. This is the first frame where the ball touches down.

4 In the Top viewport, move the Point along its X-axis, forward about one tile. The ball should land on a tile.

5 Drag the time slider to frame 37. Move the point along its X-axis again, about one and a half tiles. This time, the ball should land on grout.


At frame 37, the ball lands on grout.

6 Drag the time slider to frame 59. At this frame, move the ball in both X and Y , to the right and onto grout again.


At frame 59, the ball has veered to the right, only to land on grout once again.

7 At frame 81, change the ball's direction once more, so it moves to the left.

8 By now, you should have the general idea. Move the time slider from one floor-contact frame to the next. After frame 81, these frames are 101, $117,134,147,160,173,183,193,202,219,226$, and 230.
Keep the ball moving laterally in the same direction if it lands on a tile, and change the lateral direction if it lands on grout.
Here is how the completed scene looks, after animating the helper:


## Save your work:

Save your completed scene as my_chaotic_bounce.max.

To see a completed version of the chaotic bounce, you can
 the scene, bouncing_chaos_completed.max.
You can also play the movie chaosbounce.avi to see a rendered version of this animation.

## Summary

This tutorial introduced several basic techniques of animating with Auto Key:

- You can use Auto Key to block out animation.

■ You can use ghosting or trajectory display (or both) to help visualize an animation.

- You can use the Curve Editor to refine initial animation; for example, by changing the tangency and thus the speed of a key, or by deleting unwanted keys.
The Curve Editor also lets you create "out of range" repetition of an animation, and adjust amplitude by using a multiplier curve.
- The TCB Rotation controller is better than the default Euler XYZ Rotation controller when you want to have continuous rotation.
- A helper object such as Point can be useful for "separating" animation into multiple tracks, such as bouncing versus lateral motion.

This tutorial also introduced you to some of the general principles of animation:

■ Mass Making an object behave as if it has weight, perhaps based on real-world observation, greatly increases the realism of an animation.

■ Ease In, Ease Out Having a motion begin a bit slowly, then slow again when it comes to an end, in many cases also increases realism. Auto Key creates ease-in/ease-out timing by default. In some cases, as you saw, this isn't the best solution. When a ball rebounds from a hard surface, the motion should be fast.

■ Squash and Stretch Objects stretch out as they travel, and squash when they are stopped. You can exaggerate this effect, whether for a ball or a character, and still have a successful animation.

## Animating with Set Key

Set Key mode is an animation mode in 3ds Max that allows you to try out different poses on a character or hierarchy, and then use those poses to create keys on selected tracks.

It differs from Auto Key mode, where every transform and each change to an object's animatable parameters will result in animation. In Set Key mode, you have to take an action (clicking the Set Keys button) in order to set a key. Nothing happens automatically.

Mechanical, forensic, and industrial animators might find that Set Key animation provides a precise and deliberate workflow to use instead of Auto Key mode.

This example uses a simple chess set and the quickest possible checkmate, a four-move game, to illustrate a typical Set Key workflow.


The moves you will animate are:

- White king-side knight's pawn moves ahead two squares.

■ Black queen's pawn moves ahead two squares.

- White king-side bishop's pawn moves ahead two squares.
- Black queen moves diagonally to checkmate White king.

In this tutorial you will learn how to:

- Turn on Set Key mode.
- Use keyable icons in Track View.

■ Use key filters.

- Create keys using Set Keys, and use its keyboard shortcut.
- Move a pose in time.


## Skill Level: Beginner

Time to complete: 20 minutes

## Set up the scene:

- On the Quick Access toolbar, click

(Open File), navigate to the Iscenes\animation\set_key folder, and open wood_chess_set.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

This scene is a wooden chess set. It isn't animated yet.

[^4]
## Use Set Key mode to move your pawns:



The Set Key Mode toggle turns red, as does the time slider background and the active viewport outline.

2 In the Perspective viewport, select the pawn in front of the white knight at the lower-right corner. If the transform gizmo isn't already
displayed, right-click and choose


Move from the quad menu.


Pawn selected and Set Key mode turned on

First, you will set a key to keep the pawn in place at frame 0 .


The button turns red for a moment. A key appears at frame 0 on the track bar.

NOTE The Set Keys button also works in Auto Key mode.
4 Drag the time slider to frame 10.

5 Using the transform gizmo,
 move the pawn ahead two squares.


Pawn position at frame 10
6 Click $\square$ (Set Keys) to set a key at frame 10.
A key appears in the track bar at frame 10.


Now you'll animate the first move by the Black side.

## Animate the Black king's pawn:

1 Go to frame 20.

2
Select the Black king's pawn.


3 Press K on the keyboard. This is the shortcut for the Set Keys button. A key appears in the track bar for the Black pawn.

4 Drag the time slider to frame 30.

Move the pawn ahead two squares.
6 Drag the time slider to frame 35.
The pawn jumps back.
The reason the pose was discarded is because you didn't set a key at frame 30. This is an important difference between Set Key and Auto Key. By doing this lesson, you just learned that if you don't set keys while using Set Key, you cannot retrieve your work.

7 Drag the time slider back to frame 30 and
 move the pawn into place again.


Animation at frame 30

Press K again to set the key.

8

- Play the animation.

The White pawn moves, and then the Black pawn moves.

## Animate the bishop's pawn:

1


Select the White king-side bishop's pawn and go to frame 40.


Select this pawn at frame 40.

2 Press K to set a key.

3 Go to frame 50. Now
 move the pawn two squares ahead and press K again.


Animation at frame 50

## Move a pose in time:

You might get a pose completely set up, only to discover that you are on the wrong frame. There's a simple trick that lets you move the pose to another frame in time.

1 At frame 50,

select the Black queen, and press K to set a key.
2 Drag the time slider to frame 55.

3


Move the queen diagonally four squares. Use the corners of the transform gizmo to move in both X and Y at the same time.


Move the queen using the corners of the XY transform gizmo.

TIP Before moving the queen, arc rotate the viewport so you can see the transform gizmo corners. You can also press + on the keyboard to enlarge the gizmo.

Let's say you realize you need this pose to happen at frame 60, not frame 55. Here's what you do.

4 Right-click the time slider frame indicator (it reads 55/100) and drag to frame 60.
Now you are at frame 60, and the queen hasn't jumped back to the previous position.

(Set Keys) or press K to set a key.

## Set keyable tracks and key filters:

You've seen how to use Set Key in its simplest form. Now you'll add a level of complexity by selectively determining which tracks will be keyed.

The Black queen has the White king in checkmate. Traditionally the king is knocked over to end the game.

You'll set the Keyable tracks so that you can animate the rotation of the king, along with its X and Y positions, but not its Z position. You don't want the king dropping through the board.

NOTE When using Set Key animation, it's useful first to determine which tracks will be keyed and which won't. In simple transforms this isn't crucial, but if you're using Set Key to keyframe materials or object parameters, this is extremely important. If you don't define which tracks are keyable, all the animatable material or object parameters will receive keys when you click Set Keys.

1


Select the White king, then right-click and choose Curve Editor from the quad menu.

The Curve Editor dialog is displayed, with the King's tracks displayed at the top of the controller window at the left of the dialog.

2 On the Track View toolbar, click
The tracks for the White king show red "keyable" icons in the controller window.

3 Click the red icons next to the Z position track and the Scale track. The icons turn black to show they are inactive.


Keyable tracks turned off for Z position and scale

Now you will not be able to key the Z position or the scale of the king. You can still key the rotation and the XY position tracks for the king.
If you want to key the rotation and the position tracks individually, you can use the Key Filters.

4 Go to frame 75 and with the White king selected, press K.
This creates a position and rotation key at frame 75.
5 Go to frame 90, then click Key Filters... (Key Filters). This button is to the right of the Set Key button.

6 On the Set Key Filters dialog, turn off everything except Position.

Set Key Filters
All
Position
Rotation
Scale
IK Parameters
Object Parameters
Custom Attributes
Modifiers
Materials
Other

7
 Close the Set Key Filters dialog.

8 Go to frame 100, then move the White king off the board to the left.


Keys) to create a key.

9

- Play the animation. The White king moves off the board, but doesn't rotate, since Key Filters did not allow the rotation track to be keyed.


## 10 Click Key Filters... (Key Filters) and turn Rotation back on, then X close the dialog again.

11 Go to frame 100,

rotate the White king, and then set a key.

TIP If you want to replace a key with a different one, delete the key in the
$\square$ (Set Keys) again to set a new key. Set Keys doesn't automatically replace a key that has already been set.

12

- Play the animation. Now the rotation has been keyframed.


Checkmate!

13 Save your file as mycheckmate.max.

You can


You open quickest_checkmate.max to compare with your file.

## Summary

In this tutorial, you have learned to use Set Key animation. You've learned how to create keyframes with the Set Keys button, set Key Filters, and make tracks keyable in Track View. You will find it useful to apply these lessons to animating complex structures.

## Adding Sound Effects to Animation

In this tutorial, you add audio files to Track View, then in the Dope Sheet Editor, use ProSound to synchronize the sounds with the animation.

The scene shows a World War One airfield somewhere in the north of France. A biplane is poised for takeoff, but it has no sound. Your task is to take a group of four .wav files and assemble them so that they play back as the plane rolls down the runway and takes to the sky.


In this tutorial, you will learn how to:
■ Add audio files to a scene and control audio playback

- Use the Dope Sheet track editor to synchronize playback of audio clips with scene animation
- Use track controls to lengthen or shorten audio segments

Skill level: Beginner
Time to complete: 20 minutes

## Adding Sound Effects

You will start by adding a number of audio files to your scene. Next, you'll display the files as clips on the Dope Sheet track editor and adjust their sequencing to fine-tune the audio playback.

## Set up the lesson:

■ On the Quick Access toolbar, click
 animation $\backslash$ prosound folder, and open prosound_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

Add sound files to your scene:

1 On the main toolbar, click

(Curve Editor (Open)).
2 In the Curve Editor controller window, click the Sound track to highlight it.


World

- ill Sound

Video Post
-(†)........ Global Tracks
.\} Max MotionClip Manager
3 Right-click and from the quad menu, choose Properties.


The Open dialog automatically opens to the sounds folder in your working directory. If the sound files flyby.wav, inflight.wav, start_engine.wav, and takeoff.wav are not there, navigate to the folder where you saved your ProSound tutorial scene files.

5 Highlight the flyby.wav, inflight.wav, start_engine.wav, and takeoff.wav sound files, in any order, then click Open.
The files display as a list in the Input Files group. While it is not mandatory, it can be helpful to place the files in the order in which their sounds are heard in the sound track.

6 From the Input Files group sound files list, highlight start_engine.wav and click Move Up as many times as needed to place the file at the top of the list.


7 Highlight takeoff.wav and click Move Up until it displays just below start_engine.wav. Use Move Up to place the flyby.wav next in the list.

8 Highlight a file in the list and in the File Details group, click the Play button to hear how it sounds.


The File Details group also contains options that let you control how the file plays back in the scene. You can, for example, loop the file so it repeats a specified number of times, or enter the first and last frame on which the sound is played. The Active option lets you include or exclude the sound file in the playback.
In this tutorial, however, you will set these and other file playback parameters in a more visual way by using the Dope Sheet.

9 Close the ProSound dialog.

## View the sound tracks in the Curve Editor and Dope Sheet:

1 On the Curve Editor track view hierarchy, "|" expand the Sound track to display the master track as well as four additional tracks, each of which represent the sound files you loaded into the scene.


- 1 |l Sound
(-) $\ddagger$ - |네 <Master Waveform>
$\cdots \cdots($ ()) - (4) 1 start_engine.wav
…(9)- 仜 takeoff.wav
$\cdots$ …(-). (1) flyby.wav
(ill inflight.wav
Video Post


Expand each track. Each time you do so, highlight the track's Waveform component to display it.


A waveform is an image that represents an audio signal, showing a change in amplitude over time. Soft sounds, like footsteps, produce a narrow pattern, whereas sharp sounds, like the scrape of a chair leg, show a wider pattern. Waveforms help you visualize the events in an audio recording. Notice how only one track waveform is visible at a time in the Curve Editor. (The master track waveform provides a visual compilation of all tracks.)
In this tutorial, it would be helpful to view all the waveforms together, so you can better adjust the timing of their audio segments. You can view multiple waveforms from the Dope Sheet.

3 On the Curve Editor menu, choose Modes > Dope Sheet.


4 Collapse the master track to view just the waveforms and volume components of the four individual sound tracks.


The first, second, and fourth sound tracks were recorded in mono and show a single waveform. The third sound track, flyby.wav, was recorded in stereo and displays two waveforms, one for its left and another for its right channel.


- Play the animation to hear the sound files.


The segments overlap and produce a jumbled sound. You need to adjust the timing so each plays back at a more logical place in the animation.


Stop the playback.

## Synchronize the audio with the animation:

1 On the Dope Sheet toolbar, click

(Edit Ranges).
2 Click the start_engine.wav range bar and move it left and right to see how you can reposition the audio segment anywhere on the timeline.


You need to reposition the start_engine segment to coincide with the part in the scene animation where the biplane propeller starts to turn.

3 Move the Dope Sheet window until the Camera01 viewport is visible.
4 Drag the time slider until you see the propeller start to pick up speed, which is around frame 50.


5 Click the start_engine.wav range bar and drag it until the segment waveform is positioned at the vertical blue lines, which indicate the current frame.


6 For now, concentrate on just the start_engine.wav track by selecting the other track range bars in the Dope Sheet and moving them to the right, past frame 200.


TIP Alternatively, you could temporarily mute the sound tracks in Track View by selecting their file names in the ProSound dialog and turning off the Active checkbox, as described in the previous procedure.

Scrub the animation.
The plane starts to move down the runway at frame 160 . This is where you want to place the start of the takeoff.wav audio segment.

7 Click the takeoff.wav range bar and drag it until the segment waveform starts at frame 160.


As the plane begins to taxi down the runway it would be a good idea to prolong the start_engine audio segment, to simulate a sputtering takeoff.

You could prolong the segment by going back to the ProSound dialog and in the File Details group, set Loops to repeat the segment as many times as needed. The next step shows you a different method.

8 On the Dope Sheet, click the right end point of the start_engine.wav range bar and drag to the right.


As you drag, the audio segment is repeated. You can drag for as many repetitions, or loops, as you like.

The end of each repetition is indicated by a vertical bar, as shown in the next illustration.


9 Continue dragging until the segment is repeated just once.


10 Move the Dope Sheet window until the Camera04 viewport is visible.
11 Scrub the animation again until, at around frame 405, you see the wheels of the biplane detach from the ground.

12 On the Dope Sheet editor, drag the flyby.wav range bar until the segment waveforms start at frame 405.


13 Scrub the animation again.
The waveform should peak at or around frame 435, when the biplane passes directly overhead.

14 On the Dope Sheet, reposition the inflight.wav range bar so that the waveform fades out at the end of the animation, as shown in the next illustration.


15 Replay the animation to hear how all the audio segments fit together. By default, the audio plays forward as you play the animation forward; there is no audio when you scrub animation in reverse.

16 To hear the audio in reverse when scrubbing, highlight, then right-click the Sound track in the Curve Editor or Dope Sheet and from the quad menu choose Properties. In the ProSound dialog $>$ Playback group, turn on Permit Backwards Scrubbing.

```
Playback
    Permit Playback
Channels: Auto ( Only on overflow
Sample Rate: Auto *
Audio Quality: Medium \ Never
    \nabla Track within }0.
    | Permit Backwards Scrubbing
    Play Once
    Specify Play Range 00 啇 to 100 考
    Ping Pong
```

17 Try scrubbing the animation back and forth.
You can now hear all audio in the scene play in reverse.
18 Compare your work with the finished version of the scene by opening prosound_completed.max.

## Summary

In this tutorial, you learned how to add multiple audio files to your scene and mix them in the Dope Sheet editor for playback during an animation.

## Rigging a Car

In this tutorial you establish relationships and other constraints to "rig" the moveable parts of a car so they can be animated together easily.

There is more to animating a car than simply giving it a trajectory. You should also consider such aspects as wheel rotation, the link between the steering wheel and front wheels, as well as body roll. Animating these aspects individually however, can become quite complicated. This tutorial shows how to wire, for example, the steering wheel to the front wheels, so the animation is consistent and realistic.


In this tutorial, you will learn how to:

- Use List controllers to manage animated components of a model
- Define controller behaviour though the use of expressions
- Use the MacroRecorder to automate the assignment of List controllers
- Create a toolbar to hold custom tools
- Use wiring and expressions to rig objects for animation

Skill level: Advanced
Time to complete: 1+ hours

## Using List Controllers

A controller in 3ds Max is a plug-in that manages the values involved in keyframe animation, such as changes in object scaling, color, or translation. List controllers combine two or more controllers and can be very useful when combining relationships between objects.

List controllers, for example, are helpful when using expressions and constraints to control a child object through a parent object, particularly if the child and parent objects are not using the same orientation. The List controller uses added internal controllers that lets you maintain control over the child object's local orientation, even though it remains constrained to that of its parent.


Local orientation of a child object can differ from its parent.
Right: Orientation of the parent chassis
Left: Orientation of the front left car wheel

The child object (car wheel) of the rig you are about to animate in this tutorial, is oriented differently from the parent object (the car body). To turn the wheel using wiring, you would have to rotate the wheel on its Y axis (based on the orientation of the body of the car), not its X axis (the wheel's local orientation). To regain control of the local orientation of the child object, you will add list controllers to the position and rotation tracks of the front left wheel animation.

## Set up the scene:

■ On the Quick Access toolbar, click
 (Open File), navigate to the animation \car_rigging folder and open car_rig_01_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

Manually assign List controllers:
In this procedure, you will manually assign List controllers to the position and rotation tracks of the front left wheel of your Chevy.

1 From the main toolbar Selection Sets list, choose Garage_All.


2 Right-click the Perspective viewport and choose Hide Selection from the quad menu.
All scene objects other than the car are hidden.
3 Press H to display the Select From Scene dialog and expand the Chassis object (the car body).


Notice how the four wheels, as well as the steering wheel, are children of the object. This hierarchy is typical to 3D car models.

4 Choose Wheel-FL from the object list, then click OK.
The front left wheel in the scene is now selected.

5 Go to the
Motion panel and expand the Assign Controller rollout.
A list of default animation controllers displays as tracks in an Explorer format.

6 Highlight the Position:Position XYZ track, then click

(Assign Controller).


7 On the Assign Position Controller dialog, double-click Position List.
8 On the Assign Controller rollout > Position:Position List track, click the + icon to expand the position list.

9 Click the Available track, then click
 (Assign Controller) again.


10 On the Assign Position Controller dialog, double-click Position XYZ. In the explorer, a second Position XYZ: Position track has been created below the first. This track represents the controller that will control keyframe information of $\mathrm{X}, \mathrm{Y}$, and Z axes based on the local position of the child object (the front left wheel).
Next, you will repeat the procedure by assigning a List controller to the rotation track of the front left wheel.

11 On the Assign Controller rollout list of tracks, click Rotation: Euler XYZ and click

(Assign Controller).


12 On the Assign Rotation Controller dialog, double-click Rotation List.
13 On the Assign Controller rollout list of tracks, expand the Rotation: List track by clicking its + icon.

14 Click the Available track and click

(Assign Controller).
15 On the Assign Rotation Controller dialog, double-click Euler XYZ.
A second Euler XYZ track is created. This track controls rotation keyframe information of $\mathrm{X}, \mathrm{Y}$, and Z axes based on the local coordinates of the front left wheel.

## Automating the assignment of List controllers:

MacroRecorder is a simple scripting utility that records your interactions in 3ds Max. It converts your actions into a script that you can reuse to accomplish repetitive tasks.

In the previous procedure, you manually assigned position and rotation list controllers to a single wheel on your Chevy. You will now use MacroRecorder to automatically assign list controllers to the remaining three wheels, as well as the car body and steering wheel, so that the entire rig uses the same coordinate system in its animation.

1 Go to the bottom-left corner of the 3ds Max window, right-click the MAXScript area and choose Open Listener Window.


3ds Max opens the MAXScript listener dialog.


TIP If the upper, Macro Recorder pane (with a pink background) isn't easy to see at first, drag the bar that divides the panels downward, so the two panes are roughly equal in area. You can also resize this dialog.

2 From the menu bar, choose MacroRecorder > Enable.
From this point onward, almost any action you perform in 3ds Max will be recorded in a script.

3 Select the rear left wheel of the car (the Wheel-RL object).
4 Repeat steps 6 through 16 of the previous procedure to assign list controllers to the position and rotation of the rear left wheel.

## File Edit Search MacroRecorder Debugger Help

```
select &'Wheel-RL'
&.pos.controller = position_list ()
&.pos.controller.Available.controller = Position_XYZ ()
&.rotation. controller = rotation_list ()
&.rotation.controller.Available.controller = Euler_XYZ (i|
```

As you progress, notice how the pink Macro Recorder area accumulates scripting data.

5 Right-click a gray area of the main toolbar (below the Selection Sets drop-down is a handy area), then choose Customize.

6 On the Customize User Interface dialog, make sure the Toolbars tab is active, then click New.

7 On the New Toolbar dialog, type myTools and click OK.

8
 Close the Customize User Interface dialog and reposition the new toolbar to the right of the MAXScript Listener window.


9 Highlight the last four lines of the script, then drag and drop them onto the myTools toolbar.


3ds Max creates a button on the toolbar.


10 Right-click the newly created button and choose Edit Button Appearance.
11 On the Edit Macro Button dialog, choose the Text Button option and in the Label field, type List Con, then click OK.


3ds Max changes the button to a text button.
12 On the MAXScript Listener window menu bar, choose MacroRecorder
Enable to turn off script recording.

The MacroRecorder stops recording your actions in 3ds Max.
 Close the MAXScript Listener window, then resize the myTools toolbar until the List Con label is fully displayed.


You are now ready to use the List Con tool to quickly assign list controllers to the remaining wheels of your car model.

14 In any viewport, select the front right wheel of the car (the Wheel-FR object).

15 On the myTools toolbar, click List Con.
On the Motion panel $>$ Animation Controller rollout, expand the Position XYZ track to display one of the list controllers that was assigned by the script you just created.

16 Select the last remaining wheel in the model and click List Con again.
17 Repeat the previous step for the Chassis object.
18 Repeat the previous step for the SWheel object.
NOTE You can apply the MacroRecorder script to only one object at a time. You must therefore click the List Con button once for each object you want to modify.

19 Save your work as mycar_rig_02.max.
The myTools toolbar you created in this procedure is now available for all future 3ds Max work sessions.

In the next lesson, you will learn how to animate the rotation of the car wheels.

## Rotating the Wheels

In this lesson, you will learn how to rotate the wheels by an amount that corresponds to the distance travelled by the car model.


Let's start by taking a look at the trigonometry involved in calculating the wheel rotation.

In any circular object, the amount of rotation $(\alpha)$ is defined by the radius of the circle and the arc length encompassed by the $\alpha$ angle. That amount of rotation $(\alpha)$ expressed in radians, is equal to the arc length, divided by the radius of the circle (arc length / R), where:

- The radius of the car wheel is constant and equal in this case to 13 units.

■ The arc length, when flattened, represents the distance travelled by the car and its wheels.


Therefore, the wheel rotation calculation (arc length / R) becomes distance / 13. Whereas the radius of the wheel is constant and equal to 13 , the distance travelled is variable.

## Set up the lesson:

- Continue from the previous lesson or
 open car_rig_02.max.


## Rotate the wheels (in World X coordinates):

1 In the Perspective viewport, select the car body.
The car is currently oriented on the World X axis: you will begin working in this coordinate system.

2 Right-click the car body object and from the quad menu, choose Wire Parameters.

3 From the menu, choose Transform > Position > (2nd) Position XYZ - X Position.


NOTE It is important to always leave the first animation controller at the top of the list (in this case, the Position XYZ Controller) untouched, since it serves as a "lock" for the parent/child relationship. When choosing controllers to work on, always work from top of the controller list downward, starting with the second controller.

A rubber band shows the link you are about to make between your two selected objects.

4 Select the front left wheel of the car (Wheel-FL).
5 From the menu, choose Transform $>$ Rotation $>$ (2nd) Euler XYZ Z Rotation.


The Parameter Wiring \#1 dialog opens. You use this dialog to set up one and two-way control relationships between objects. The position and rotation of the two objects you just selected to affect one another are highlighted.


6 On the Parameter Wiring dialog, click the right-pointing arrow above "control direction".


This ensures that the Chassis X position is controlling the Wheel-FL Z rotation and not the other way around.
The bottom-right corner of the Parameter Wiring dialog displays the wheel object Expressions panel. It shows the distance travelled as X_Position.

7 Next to X_Position, type /13.
The expression should now read X_Position/13, the distance divided by the radius of the wheel.

## Expression for Wheel-FL's Z_Rotation

## X_Position/13]

8 Click Connect, but do not close the dialog.
9 Test your work by moving the car body on its X axis.
Notice how the front-left wheel does not rotate. Even though you added a position list controller to the car and wheel, the first controller in the list (the one that ensures the parent/child "lock") is still active. You need to make the second position controller (the one used in the wiring process) the active one.

10 If you moved the car model, press Ctrl+Z to undo the move.

11 With the car body selected, on the


Motion panel > PRS Parameters rollout, click the Position button at the bottom of the rollout.

12 On the Position List rollout, highlight the second Position XYZ controller and click Set Active.


13 Try moving the car on its X axis again.

TIP To better see the wheel rotation, use the Front viewport, and change its display mode to Smooth + Highlights.

The wheel now rotates, and at the correct rate, but its motion is backward.
14 In the Parameter Wiring dialog, on the Expressions panel, add a minus sign (-) in front of the expression, then click Update.

15 Move the car on its X axis again and notice how the wheel rotates in the proper direction.

16 Repeat the preceding steps for each of the remaining three car wheels.
TIP To select the wheels on the right side of the car, you can press H after you choose the car body's X Position, and then use the Pick Object dialog to pick the wheel.

Because the wheels were mirrored, the wheels on the right side of the car do not need the minus sign added to their expression, whereas those on the left side do.

17


Close all the Parameter Wiring dialogs.

## Add subcontrollers for Y rotation:

In the previous procedure, you learned how to add controllers that determine car wheel rotation for the length of distance travelled by the model along the World X axis. However, if you tried to rotate the car in any way, wheel rotation would be reduced or stop altogether. You therefore need to add controllers that account for the car's displacement in a Y direction.

1 In the Top viewport, select the car body object and rotate it 90 degrees clockwise so that its front bumper points at 12 o'clock.


The car is now oriented on the World Y axis, so you will begin working in this coordinate system.

2
 of the car.



Move the car forward and backward on the Y axis. Notice that the wheels do not rotate.

To get the wheels rotating, you will need additional animation controllers, ones that will control the car's displacement in the Y direction. You will add these as sub-controllers, so you do not overwrite the controllers already in place.

4 Go to the bottom-left corner of the 3ds Max window, right-click the MAXScript area, and choose Open Listener Window.

5 On the MacroRecorder panel, highlight the line that reads:
\$.rotation.controller.Available.controller = Euler_XYZ ()
Be sure not to include the line's carriage return when you make your selection. Press Ctrl+C to copy this line to memory.
If you are not continuing from the previous lesson, this line will not be available from the Open Listener window. If this is the case, copy the line from the text of this tutorial.
select the front left wheel (Wheel-FL).

7 Click inside the MAXScript entry field (the white box in the bottom-left corner of the 3ds Max window), press $\mathrm{Ctrl}+\mathrm{V}$ to paste the line of code, then press Enter.

8 On the
Motion panel $>$ PRS Parameters rollout, make sure that the Rotation button is active, Then on the Rotation List rollout, verify that a new sub-controller has been added to the rotation list (there should be 3 in all).

## Position Rotation Scale



9 Repeat step 7 to add a fourth rotation sub-controller. You will need this later on in the tutorial.
The front left wheel should now have four Euler XYZ tracks.

10


Select another wheel and repeat steps 7 to 9 until all four wheels have four Euler XYZ tracks in their respective rotation lists.

## Rotate the wheels (in World Y coordinates):

1 Select the car body, then right-click and from the quad menu, choose Wire Parameters.

2 From the menu, choose Transform > Position > (2nd) Position XYZ

- Y Position.


3 Select the front left wheel (Wheel-FL).
4 From the menu, choose Transform $>$ Rotation $>$ (3rd) Euler XYZ Z Rotation.


5 On the Parameter Wiring dialog, click the right-pointing arrow above Control Direction to ensure that the Chassis Y position is controlling the Wheel-FL Z rotation.

6 On the right-hand Expressions panel, type /13, then click Connect. The expression for the left-hand wheel should be $\mathbf{Y}$ _Position/13

7 Click Connect.
8 Repeat steps 3 to 8 for each of the other three wheels.
NOTE The expression for the right-hand wheels should be -Y_Position/13.

9


Close the Parameter Wiring dialogs.

10 In the Top viewport, rotate the car so that it is not pointing horizontally or vertically.

11 On the main toolbar, click
 coordinate system to Local.


12 If you need to, adjust the Perspective viewport so you can see the side of the car.

13 Move the car on its local X axis. Notice how the wheels are rotating properly.

14 In the Top viewport, rotate the car until the front bumper is pointing to the left.

15 Save your file as mycar_rig_03.max.

## Rotate the wheels (under a path constraint):

In the previous procedure, you learned how to add controllers that rotate the car wheels for any distance of travel in World X and Y space. The wheels will therefore rotate properly when you manually move the car around the scene in any direction.

However, you would most often animate motion of a car by placing it on a predefined path using the Path constraint. This type of animation requires a different expression.

This new expression uses the same formula (distance divided by radius) as the ones you have been using, but while the radius of the wheel remains constant, the distance travelled is calculated differently.

1 Continue from the last procedure or
2 From the main menu > Selection Sets list, choose Car Path.


A warning message displays.
3 Click Yes to display the path you will use to animate the car motion.
4 From the main menu, choose Create > Helpers > Point.
5 On the Parameters rollout, turn on Box and set Size to 100.0.

| Parameters | ヘ |
| :---: | :---: |
| Display: |  |
| $\square$ Center Marker |  |
| $\square$ Axis Tripod |  |
| $\checkmark$ Cross |  |
| ( ${ }^{\text {b }}$ Box |  |
| Size: 100.0 |  |
| Constant Screen |  |
| $\square$ Draw On Top |  |

This increases the size of the helper gizmo and makes it easier to select in the scene.

NOTE Many animators use the Dummy helper instead of Point. The advantage of using a Point helper is that you can adjust its size without having to scale it. Scaling a helper in a hierarchy will affect its children objects: This is an effect that usually you want to avoid.

6 In the Top viewport, click a point near the car to place a Point helper.

7 With the Point helper still selected, on the main toolbar click
 (Align), then in any viewport, select the car body.

8 In the Align Selection dialog > Align Position group, make sure X Position and Y Position are on and Z position is off.

9 In the Current Object and Target Object groups, make sure Pivot Point is chosen, then click OK.


10 In the Front viewport, move the Point helper on its X axis to the right until it is just to the left of the rear axle of the car.


Point helper moved to left of rear axle

The Point helper location you have specified will become the pivot point of the car when the front wheels turn.

11 On the command panel $>$ Name And Color rollout, rename the helper Dummy_CAR.

12 In any viewport, select the car body.

13 On the main toolbar, click

(Select And Link), then in the Front viewport, click the car body and drag to the Point helper. This makes the car body the child of the Point helper.

14 On the main toolbar, click

(Select Object) to exit link mode.
15 From the main toolbar Selection Sets list, choose Garage_All. Click Yes to dismiss the warning and unhide the rest of the scene geometry.

16 In the Top viewport, use lot.

17 In the Perspective viewport, click the Perspective label and from the menu, choose Cameras > Camera_Wall-E.

## Animate the dummy by constraining it to a path:

1 In any viewport, select the Dummy_CAR helper.
2 From the main menu, choose Animation > Constraints > Path Constraint.

3 In the Top viewport, click on the green path (CarPath).
The helper and the linked car are repositioned at the start of the path.
NOTE You could, as an alternative, constrain the car directly to the path. In this case, however, it is preferable to constrain the helper parented to the car so you can retain extra control over the car's behavior (such as defining skids around tight corners).

4 Scrub the animation.
The car's orientation remains constant throughout the animation.

5 In the Motion panel $>$ Path Parameter rollout $>$ Path Options group, turn on Follow.

Path Options:
\% Along Path: 0.0


6 Scroll down to display the Axis group, and turn on Flip.

## Axis:

(O) X Y OZ 团flip

The Flip option prevents the car from driving in reverse.
7 Scrub the animation again.
Car motion is improved, but at the last frame the car points at an awkward angle. This is a common behavior to paths based on a NURBS curve. You will now correct this problem.

TIP NURBS curves, when used as animation paths, provide a smoother "ride" than ordinary splines.

8 Go to the last frame of the animation (frame 150), and make sure the Point helper is selected.

9 Turn on Auto Key
(Auto Key).

10 In the Motion panel $>$ Path Parameters rollout $>$ Path Options group $>\%$ Along Path box, type 99.9 and then press Enter.

11 Turn off
Auto Key
(Auto Key) and scrub the animation.
The car is properly oriented on the path, but the wheels no longer rotate. This is because the expression that defined the wheel rotation you formulated earlier no longer applies. The distance travelled by the car was dependent on the X and Y displacement in the World coordinate system. Displacement is now tied to the length of the path and the percentage of the path that the car has travelled. You must therefore modify the expression to reflect this change.

## Wire wheel rotation to a path:

1 In any viewport, select the animation path (CarPath) then go to the


Utilities panel.
2 Click Measure and in the Shapes group, take note of the path length.

## Shapes

Length: 2365.065
Dimensions

3 Select and right-click the Point helper, then from the menu choose Wire Parameters.

4 From the menu, choose Transform > Position > Path Constraint > Percent.


5 Click one of the car wheels and choose Transform $>$ Rotation $>$ (4th) Euler Rotation > Z Rotation.


6 On the Parameter Wiring dialog, set the control direction to the right, which places the Percent parameter in control of the wheel rotation.

7 On the right-hand Expressions panel, type (2365*Percent)/13.
NOTE The value 2365 is the length of the animation path you measured earlier. When multiplied by the percent variable, it calculates the distance the car has travelled at any given moment in time along the path. When divided by the radius of the wheel (13), it provides the amount of rotation needed for the wheel to turn.

8 Click Connect.
9 Scrub the animation to see the wheel rotation.

10 To better see the animation, click

(Time Configuration) and in the Time Configuration dialog > Time Display group, choose FRAME:TICKS.

## Time Display

Frames
SMPTE
(0) FRAME:TICKS

MM:SS:AYCK

11 Repeat steps 3 to 8 to link the Point helper to each of the remaining three car wheels.
Remember to add a minus sign (-) operator to the expression of the wheels on the right side of the model so they don't rotate in the opposite direction.

12 Save your file as mycar_rig_04.max.

## Pivoting the Wheels

You now need to make sure the front wheels pivot or "turn" as the car moves left or right along the animation path. For added realism, you will also establish a relationship between the wheel pivot and the turn of the steering wheel.


Set up the lesson:

- Continue from the previous lesson or

open car_rig_04.max.


## Set up helpers for the front wheels:

In the same way you created a Point helper to direct the car animation along a path, you will also create two more Point helpers to control the pivot of the front wheels by the rotation of the steering wheel.

1 In the Top viewport,

zoom in on the car and press F3 to switch to Wireframe mode.

2 From the main menu, choose Create > Helpers > Point.
3 Click anywhere around the car body and in the Parameters rollout, turn on Box, then in the Size box, type $\mathbf{5 0 . 0}$ and name the helper Dummy_FL.


4 With the helper still selected, click the List Con button on the myTools toolbar you created earlier in the tutorial.
The List Con script automatically assigns the two Position list and Rotation list controllers you set up earlier, permitting you to retain control over the helper's local orientation.

NOTE If the myTools toolbar is not currently displayed on your interface, right-click a gray area on the main toolbar and choose myTools from the menu.


5 From the main toolbar, click


- (Align) and in the Top viewport, click the car body.

6 In the Align Selection dialog > Align Position group, turn off X Position, Y, Position and Z Position. In the Align Orientation group, turn on X Axis, Y Axis and Z Axis.

Align Position (Screen):
$\square$ X Position $\quad \square$ Y Position $\quad \square$ Z Position

| Current Object: | Target Object: |
| :--- | :--- |
| OMinimum | Minimum |
| OCenter | Center |
| O Pivot Point | O Pivot Point |
| Maximum | Maximum |

## Align Orientation (Local):

$\square \times$ Axis $\quad$ Y Axis
V Z Axis:


These settings ensure that the car and the helper have the same orientation.

7 Click OK to close the dialog.
8 From the main toolbar, use Shift+Move and drag the helper to make a copy.

TIP Set the coordinate system to Local to make moving the Point helper easier.

9 In the Clone Options dialog, name the copy Dummy_FR.
Next, you will align the helper and the right front wheel pivot to pivot in $\mathrm{X}, \mathrm{Y}$ and Z positions.

10 In the Top viewport,

select the Chassis object, right-click and choose Hide Selection.


- (Align), and then click Wheel_FR.

12 In the Align Selection dialog $>$ Align Position group, turn on X Position, Y Position, and Z Position.

Make sure Pivot Point is chosen in both the Current Object and Target Object groups.
In the Align Orientation group, turn off X Axis, Y Axis and Z Axis.
Align Position (Local):
X Position $\quad$ Y Position $\quad$ Z Position
Current Object: Target Object:

- Minimum

MinimumCenter
Center

- Pivot Point

Pivot Point
Maximum
Maximum

Align Orientation (Local):

```
X Axis Y Axis
```

ZAxis U

13 Click Apply, then click OK to exit the dialog.

14


Select Dummy_FL, and from the main toolbar click
 (Align) tool again. In the Top viewport, click Wheel_FL.

15 Repeat steps 12 and 13 to align the helper to the front left wheel.


Point helpers aligned to front left and right wheels

Now you will now rework the hierarchy and parent/child relationships of the car setup, so you can pivot (steer) the wheels. These steps also prepare for the body roll you will rig in the next lesson.

Link the wheel helpers to the car helper:

1 On the main toolbar, click (Select And Link).

2 Ctrl+select the two wheel helper objects, then drag to the Dummy_CAR object.
This links the helpers as children of the Dummy_CAR object.

## Link the rear wheels to the car helper:

■ With

(Select And Link) still active, select both rear wheels (Wheel-RL and Wheel-RR) and drag to the Dummy_CAR helper.

Link the front helpers to their wheels:

1
Link the front left wheel (Wheel-FL) to the Dummy_FL helper.


Linking front left wheel to front left wheel helper

2
Link the front right wheel (Wheel-FR) to the Dummy_FR helper.

3 Click

(Select Object) to turn it on and turn off Select And Link.

## Unhide the car body:

- In the viewport, right-click and choose Unhide By Name from the quad menu. On the Select From Scene dialog, choose Chassis, and then click Unhide.


## Rotate the wheels (in World X coordinates):

1 Click the Camera_Wall-E viewport label and from the menu, choose Cameras > Camera_Birdseye.

2 On the main toolbar, click
3 In the Camera viewport, select the steering wheel (SWheel).
4 Right-click the steering wheel and choose Wire Parameters.
5 From the menu, choose Transform > Rotation > (2nd) Euler XYZ > Z Rotation.


6 Click the Dummy-FL object, which is the front left wheel helper, and choose Transform > Rotation > (2nd) Euler XYZ > Z Rotation.


7 On the Parameter Wiring dialog, set the control direction to both ways, since the manual turning of either object affects the other.


8 Click Connect, and leave the Parameter Wiring dialog open.

9 On the main toolbar, turn on coordinate system to Local.


10 Rotate the steering wheel on its local Z axis.
Notice how the steering wheel and the front wheel turn in the opposite direction. You will correct this by modifying the controller expression. A second adjustment is also required. The front wheel needs to turn far less than the steering wheel. This is because the pivot range of a front wheel is about 90 degrees, whereas a steering wheel range of movement is two to three complete revolutions.


Steering wheel and front wheel turn in opposite directions

11 Cancel or undo the rotation you made in the previous step.
12 In the left-hand Expressions panel, under "Expression for SWheel's Z_Rotation", type: -Z_Rotation*8.

13 In the right panel, under "Expression for Dummy_FL's Z_Rotation", type: -Z_Rotation/8.

| Master () | Update | Master |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Expression for SWheel's Z_Rotation | Disconnect E |  | Expression for Dummy_FL's Z_Rotation |  |
| -z_Rotation*8 | - | -z_Rotation/8 |  | - |
|  | * |  |  | * |
| 1 |  | 1 | , |  |

The minus sign (-) operator ensures that the two rotations are aligned, and the *8 and /8 factors ensure that the front left wheel pivots (rotates in Z) eight times less than the rotation of the steering wheel.

14 Click Update and test your work by rotating the steering wheel on its local Z axis again.
Notice the more realistic behavior.

15 Repeat steps 4 to 14 to wire the steering wheel and the front right wheel helper. (You can use H to select the front right wheel helper.)
Be sure to specify exactly the same expressions as you did in steps 13 and 14 , since the right wheel helper was copied, not mirrored, from the front left helper.
You can see the effect of wiring the front right wheel in the Top viewport.

Animate the steering:

1 If your timeline is displayed in frames and ticks, click
 (Time Configuration) and in the Time Configuration dialog $>$ Time Display group, choose Frames.

Time Display
(O) Frames

- SMPTE

FRAME:TICKS
OM:SS:TICKS

2 Activate the Top view, press F3 to switch back to Smooth + Highlights
mode, then click (Zoom Extents) so you can see the entire animation path.

3 Go to frame 50, the point where the car is in the middle of its first turn.

4 Select SWheel and on the main toolbar, click

(Select And Rotate).

[^5]

Steering wheel rotation at $\mathbf{- 2 8 0}$ degrees about the $Z$ axis

6 Go to frame 115, the point where the car is in the middle of the second turn, and rotate the steering wheel until the Z axis status bar reads 500 .


Steering wheel rotation at $\mathbf{5 0 0}$ degrees in the $\mathbf{Z}$ axis

7 Go to the end of the animation and rotate the steering wheel until the Z axis status bar reads -220 .

8 Turn off Auto Key (Auto Key) and test your animation.

9 Save your file as mycar_rig_05.max.

## Setting Car Body Roll

Body roll is a phenomenon that occurs when a car rounds a sharp corner. This behavior is not usually apparent in modern day cars unless they are travelling
at high speed. In older cars, such as our 1957 Chevy, however, the amount of body roll is discernible to both passengers and bystanders even when the vehicle is travelling at low speed.


## Set up for the lesson:

- Continue from the previous lesson or



## Create the body roll effect:

In this lesson, you will create the effect of body roll by rotating the car along its local X axis. Roll direction will be based on the rotation of the steering wheel.

1 Make sure you are at frame 1 in your animation.

2 In the Top viewport,
 Wireframe mode on.

3 On the main toolbar, click

(Select And Rotate) and make sure the coordinate system is set to Local.

4 In any viewport,
select the steering wheel object.
The steering wheel rotates about its local Z axis.
5 Select the car body object.
The car body rolls about its local X axis.
6 Select the steering wheel again, then right-click and from the quad menu, choose Wire Parameters.

7 Choose Transform > Rotation > (2nd) Euler XYZ > Z Rotation.


8 Click the car body and choose Transform $>$ Rotation $>$ (2nd) Euler $\mathrm{XYZ}>\mathrm{X}$ Rotation.


9 On the Parameter Wiring dialog, set the control direction to the right so the steering wheel rotation in Z controls the body roll in X .

10 On the right-hand Expressions panel, complete the expression so it reads: Z_Rotation/40, then click Connect.

NOTE The /40 factor in the expression divides the steering wheel rotation by 40 to ensure body roll rotation is significantly smaller than the rotation of the steering wheel. If you like, try experimenting with other values.

11 Click the Camera viewport label and choose Camera > Camera_Wall_S then scrub the animation to see the effect of the body roll.


Body roll visible in the Left viewport

12 Save your file as mycar_rig_06.max.

## Adjust Driver Viewpoint

As a driver, when you use a steering wheel to initiate a turn, your eyes tend to follow the direction of the turn. When you turn left, you look left: when you turn right, you look right. In this lesson, your final task is to make the viewpoint of the driver react to the rotation of the steering wheel.


Set up the lesson:

- Continue from the previous lesson or
 open car_rig_06.max.


## Change the driver's point of view:

In this procedure, you will wire the rotation of the "driver view" camera to the steering wheel.

1 On the Display panel $>$ Hide By Category rollout, turn off Cameras to re-display the cameras in the scene.

2 In the Front viewport, select the Camera_Driver object.


Camera_Driver object

This is the camera that occupies the driver's seat.
3 Click the List Con button on the myTools toolbar you created earlier in the tutorial.
The List Con script automatically adds position and rotation list controllers, permitting you to retain control over the camera's local orientation.

NOTE If the myTools toolbar is not currently displayed on your interface, right-click a gray area on the main toolbar and choose myTools from the menu.

4 With the camera object selected, go to the hierarchy panel and on the Adjust Pivot rollout, click Affect Pivot Only.

Notice that the swivel axis needed for the camera is the Y axis (displayed in green).


## Camera swivel on Y axis

5 Click Affect Pivot Only again to exit pivot mode.
6 Select the steering wheel, right-click it, and from the menu choose Wire Parameters.

7 Choose Transform > Rotation > (2nd) Euler XYZ > Z Rotation.


8 Click the Camera_Driver object and choose Transform $>$ Rotation (2nd) Euler XYZ > Y Rotation.


9 On the Wiring Parameter dialog, set the control direction from left to right so the steering wheel controls the camera rotation.

10 On the right-hand Expressions panel, complete the expression so it reads: Z_Rotation/10 and click Connect.
Keep the dialog open for now.
NOTE The /10 factor in the expression prevents the camera from rotating too far in either direction. You can experiment with different values to produce the results you need.

11 In the Camera viewport, click the Camera_Birdseye label and choose Views > Camera_Driver.

12 Scrub the animation to observe the wiring effect.
As the steering wheel rotates, the camera viewpoint swivels in the wrong direction.

13 In the Wiring Parameters dialog, add a negative operator in front of the expression, so that it reads: -Z_Rotation/10, then click Update.

14


Close the Wiring Parameters dialog and scrub the animation again.

The rig is now complete. To view a version of the finished product, open car_rig_final.max.

## Summary

In this tutorial, you learned how to assign controllers to components of a model, and use expressions to ensure the controllers animate the components correctly. You also learned how to use Point helpers to animate a model along a path and were shown how to rework the model hierarchy so that a child object can respond to the animation of its parent.

## Character-Animation Tutorials

3ds Max Provides two character-animation systems: CAT and character studio. The first section of this chapter demonstrates how to use CAT tools to skin a character. The second section demonstrates how to use character studio for skinning and animating characters, and how to manage various kinds of character motion including walk cycles.


This tutorial shows how to skin a character. In the first brief part you use the Skin modifier to apply a character skeleton from CAT to a mesh-based character model. After that you fine-tune the relationship between the two with the
ability of the Skin modifier to set weights on a per-vertex basis. If this subject is new to you, rest assured: All of the puzzling terminology in this introductory paragraph will be explained.

As a bonus, the last part of the tutorial briefly presents methods for adjusting a skinned character for mesh and rig changes, as well as a method for quickly transferring skinning data between models of varying resolution, which can save lots of time when skinning similar characters that require different numbers of polygons.


In this tutorial, you will learn how to:

- Use the Skin modifier to transfer animation from a rig to a character mesh.

■ Adjust vertex weighting to correct animation at joints and other moving parts.

■ Account for changes in the mesh and rig.
■ Transfer animation between character meshes of different resolutions.

Skill level: Intermediate to Advanced
Time to complete: 4 hours

## Performing the Initial Skinning

The initial portion of this tutorial involves opening the scene containing the character mesh to skin, opening a rig to serve as the character skeleton, connecting the two with the Skin modifier, and finally animating the character using an included file.

## Set up the lesson:

1 Reset 3ds Max.

2 On the Quick Access toolbar, click
 \character_animation \skinning $\backslash$ folder, and open the file applying_skin.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The character model in the scene appears at the world origin $(0,0,0)$.


Meet Emma, a medium-resolution character mesh of about 7,500 polygons. Emma is great with kids and works well in TV, games, movies, and other applications that don't require extreme closeups. In addition to the main character mesh, which is what you'll be working with, the scene contains separate objects for the hat, hair, and eyeballs.
Next you'll load the character rig to which you'll skin Emma.

## Load the Emma rig:



1 On the Create panel, click
(Helpers) and then choose CAT Objects from the drop-down list.
You might be familiar with character studio; CAT is a newer, separate character-animation system included with 3ds Max that offers a different albeit overlapping set of capabilities. This tutorial deals minimally with CAT features, instead spending most the time with the Skin modifier.

TIP For detailed info about CAT, see the CAT section in the main help.

2 On the Object Type rollout, click CATParent.
The CATRig Load Save rollout that results provides a list of preset character rigs, but you'll be using a different rig created especially for this tutorial. The easiest way to do this is to load it onto an existing CATParent.

3 On the CATRig Load Save rollout, make sure (None) is highlighted, and then in the Perspective viewport, next to Emma, drag out a CATParent object.


## CATParent on right

4 Go to the


Modify panel, and on the CATRig Load Save rollout, click

(Open Preset Rig). Navigate to the $\backslash$ sceneassets $\backslash$ animations $\backslash$ folder, and open emmarig.rg3.
The rig appears at the CATParent location.
NOTE This rig has been specially modified, or "posed," to fit the shape of the Emma model. Usually you need to do this yourself before skinning a model, so the initial application of the Skin modifier doesn't require too much adjustment, but that's not within the scope of this tutorial. At any rate, the process is fairly straightforward, especially as bones in CAT rigs are, in effect, standard polygon geometry. They're compatible with all of the modeling tools in 3ds Max, and can even be replaced by other objects.

While skinning a character it's usually desirable to hide the rig, but for times when you might want to toggle its visibility, it's best to give the entire rig a name so it's easy to select.

5 Navigate the viewport so the character mesh and rig don't overlap, then

(Select Object) on, drag a region around the rig to select all of its bones. In the Named Selection Sets field on the main toolbar (currently reads "Create Selection Set"), type the name EmmaRig and press Enter to make sure the software registers the name. This is the same name as the CATParent, but as it's a selection set, not an object, there's no conflict.
Ideally, when skinning a character, the rig should be centered on the skin mesh. Because Emma is already positioned at the world center, this is easy to do.

6 Make sure the CATParent (named EmmaRig) is selected, and then activate

(Select And Move) on the main toolbar.
7 Right-click the X and Y spinners on the status bar (the small up/down arrows next to the numeric fields) to set them to $0 . \mathrm{Z}$ should already be at 0 .
The skeleton jumps to the world center and is perfectly aligned with the Emma character mesh.


Next you'll apply the bones to the mesh using the Skin modifier.

## Set up for skinning:

1 With

(Select Object) on, select the Emma object and from the Modify panel > Modifier List > Object-Space Modifiers category, choose Skin.

This applies the Skin modifier to the mesh. The next step is to tell the Skin modifier which bones are to affect the mesh shape. In this case, it's all of them.

2 On the Parameters rollout, click the Add button next to Bones.
This opens the Select Bones dialog, which is the same as the familiar Select From Scene dialog.

3 Set the Display filters to Display Geometry only and highlight all list entries except the first four. One easy way to do this, because all the desired bones start with "Emma," is simply to type $\mathbf{e}$ in the Find field. Click Select to finish.


The bones appear in the list on the Parameters rollout and the basic skinning is done. You can demonstrate this by moving the leg via the foot platform.

4 Select EmmaRigLPlatform, the wireframe rectangle under the left foot, and move it around.


You can probably see some problems already, such as the loss of volume at the knee. You'll deal with these in the following sections of the tutorial.

5 Before continuing, save your scene with the name MyEmma1.max.

## Animate the rig:

When skinning a character, to work efficiently it's best to first create a basic animation containing the various poses that the character is likely to assume. This lets you adjust skinning anomalies in the different poses without having to consume time posing and reposing the character manually.

We've included an animation file you can load onto the rig using CAT's Clip Manager feature. It's instructive to go through this process, and it doesn't take long, but if you prefer to start skinning now, skip to the next section.

1 Continue working from the previous section or load the file you saved at the end of it.

2


Select the CATParent: the triangular object at the base of the rig.

3 Go to the Motion panel and scroll down to the Clip Manager rollout. Make sure the Clip button is active.
This is where you load and save animation for CAT rigs.

4 At the bottom of the rollout, click
(Browse), and then use the Open dialog to open the file \sceneassets \animations \emma_stretching.clp. When the Clip Options dialog opens, click Load to accept the default settings.

CAT has two modes: Setup, for modifying the rig, and Animation, for animating it. Setup is the default mode; to play animation it's necessary to switch to Animation mode.

5 At the top of the Layer Manager rollout you can see the
 Setup/Animation Mode Toggle button, indicating the rig is currently in Setup mode. Click this button.

The button image changes to

, signifying that Animation mode is active.

6 Also, click in the animation controls section of the 3ds Max window to open the Time Configuration dialog. Set Length to 500 and click OK to close the dialog.

7 Activate the EmmaRig selection set, right-click in the viewport, and choose Hide Selection.

8 Scrub the time slider or * play the animation. It "exercises" all parts of the body that are likely to need skinning adjustments, starting with the feet and ending with the fingers.
However, the cap, hair, and eyeballs, or "accessories," don't move with the rest of the mesh.

9 Return to frame 0, then, on the main toolbar, activate And Link), and drag from each accessory to the EmmaRigHead object to
link them as children (four drags in all).

- Play the animation again to ensure that everything moves together.

TIP Alternatively, select the four accessories first, then activate Select And Link and drag from any of the selected accessories to the EmmaRigHead object. This links them all at once.

10 Exit Select And Link mode by clicking

(Select Object) and then right-click in the viewport and choose Unhide All.

11 Save your scene with the name MyEmma2.max.

## Weighting the Character's Lower Half

In this portion of the tutorial you learn to improve the skinning by adjusting the Weight setting for vertices with respect to rig bones, thus determining how the rig animation affects the character mesh. You start with the lower half of the character, beginning with the feet.

## Set up the lesson:

- Continue from the previous section or, on the Quick Access toolbar, click

(Open File), navigate to the \character_animation $\backslash$ skinning $\backslash$ folder, and open the file configuring_skin.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

This scene contains the Emma character skinned and animated, with the correct links already in place and the rig hidden.

## Start skinning the character:

NOTE Much of the information in this procedure and the following one provides background information on how Skin works. We recommend you read over it now, but don't worry if it's not fully comprehensible. Continue working through the tutorial, following the steps and reading the explanations, and after you've gained some hands-on experience with adjusting Skin, return here and read these explanatory sections again. They'll probably make a lot more sense the second time around.

1 Scrub the time slider or 」 play the animation and check for problem areas. For example, around frame 70 the knees become narrower, and thus look unnatural. Even more blatant is the distortion of the shoulder around frame 210.

IMPORTANT Loss of volume, such as the narrowing of the knees when bent, is the main thing to correct for when adjusting character skinning. A potential second issue is the interpenetration of the mesh around bent body joints, but that tends to be less noticeable in the final animation, and can be accounted for to an extent by attributing it to folds in the character's clothing. This tutorial focuses on correcting for volume issues.

2 Return to frame 0.

3 Make sure

(Select Object) is active. Select the Emma object and go to the Modify panel. On the Parameters rollout, click Edit Envelopes.
The character mesh turns gray except for a color gradient around the pelvis region. The gradient shows the weighting of the skin vertices assigned to the pelvis. By default, EmmaRigPelvis is the first entry in the Bones list on the Parameters rollout, so its values are the first to be displayed when you turn on Edit Envelopes.

The term "weighting" will be explained shortly.

TIP The Skin modifier has quite a few parameters spread out among several rollouts. In some cases you might want to see more settings than can fit comfortably in a single column. To expand the command panel, position the mouse cursor over the left edge so it becomes a horizontal, two-headed arrow, and drag leftward until you see two columns.


Show All Vertices
Show All Gizmos
Show No Envelopes
Show Hidden Vertices
Draw On Top
Cross Sections
Envelopes

Advanced Parameters
Gizmos

Drag the left edge of the command panel to the left to expand it to multiple columns.

4 Try clicking some of the other entries in the list to see the weighting of vertices in other parts of the skin mesh. Alternatively, click the bone representations in the viewport; each is displayed as a straight line with a (non-mesh) vertex at either end. As you do so, the highlighting in the list on the Parameters rollout switches to that bone.


Bones appear as straight lines with vertices at the ends.

IMPORTANT A bit of background info on how the Skin modifier works is in order here. When you add bones to Skin, the modifier looks at the mesh to which it's applied and automatically assigns each vertex to one or more bones based on proximity. It also calculates a Weight value for each bone assigned to a vertex to specify the degree to which moving the bone affects the vertex; again, this is based on proximity. If a vertex is close to one bone but relatively distant from any others, it's assigned to that bone with a weight value of 1.0, which means 100\%. In other words, the vertex responds to movement of that bone only, and moves in exactly the same direction and distance as the bone.

If, however, a vertex is, say, equidistant from two bones but far from any others, Skin assigns both bones to the vertex and gives each a Weight value of 0.5 , or $50 \%$, for that vertex. In such a case, the motion of both bones contributes equally to that of the vertex. If only one of the bones moves, the vertex moves half that distance. This is how the Skin modifier accommodates for the motion of a character mesh around bending joints such as knees and shoulders.

The Weight values for a highlighted bone appear by default on the mesh as a gradient, with red representing higher weights, decreasing to orange, yellow, green, and then blue for the lowest values. Vertices use the same color scheme, and since you'll be adjusting weights at the vertex level, it's usually best to have the viewport set to Smooth + Highlights + Edged Faces display mode (toggle with F4) or Wireframe mode (toggle with F3).

Incidentally, the Skin modifier determines which vertices are affected by a bone or bones by creating an "envelope" around each bone, which is a capsule-shaped 3D volume that you can edit interactively to adjust the vertex weighting at a high level. However, you have better control by adjusting Weight values for individual vertices and groups of vertices. This is a more-common practice in professional environments such as game-development studios, so it's the one this tutorial focuses on. This method is a bit more painstaking, but can produce optimal results reasonably quickly.

Make no mistake, however: Skinning a character is a detail-oriented task, and requires lots of experimentation and trial-and-error, so it benefits from a liberal supply of patience. This aim of this tutorial is to demonstrate the overall process, but it's impractical to describe every step in detail in such a context. In other words, we can't show you exactly what to do every step of the way, but instead provide guidance and examples; the rest is up to you.

5 Save your work under a different filename, such as MyEmma3.max.

We won't keep reminding you, but it's important to remember when going through a complex method such as skinning a character to save your work incrementally as you go so you can easily return to a previous version if things start to go wrong.

## Examine some Skin modifier options:

You edit a vertex's weight by changing its Weight value with respect to a particular bone. In order to do that, the vertex must be assigned to two or more bones, because Weight is a relative value. For a given vertex, if its Weight value with respect to bone A is, for example, 0.6 , and its Weight value with respect to bone $B$ is 0.4 , then bone A's motion has half again as much influence over the vertex's motion than does that of bone B. The total of Weight values for each vertex must always equal 1.0. So, when skinning a character using this method, you need to know which bone or bones a vertex is assigned to and the Weight values for all vertex-bone assignments.

NOTE Best practice when skinning a character, which this tutorial follows, is to focus on one body part at a time. When you're done with that part, mirror the changes to the other side, as appropriate. To be more specific, you select a bone, make sure most of the surrounding vertices are set to a Weight value of 1.0, and then adjust the weights in the bending areas. You can think of this as "blocking out" the weighting, much as you block out an animation by working on isolated segments of the character's movement before integrating the overall motion.

For example, in this tutorial you'll start with the left leg, working upward from the foot bone, and then mirror (copy and flip) the vertices' settings to their counterparts on the right leg. You can always go back later and tweak the weights anywhere, but you work most efficiently by concentrating on a specific area at any given time.

1 Even though you won't be editing envelopes directly in this tutorial, it might help you better understand how Skin works by taking a quick look at this feature of the modifier. By default the envelopes are set not to display in this scene, but you can enable them by going to the Display rollout and turning off Show No Envelopes.


With the forearm bone selected and Show No Envelopes off, the capsule-shaped inner and outer envelopes appear in the viewport.

As a very brief explanation, each envelope comprises two concentric capsule-shaped volumes; vertices within the inner volume are fully affected by that bone, and then the weighting falls off increasingly for vertices that lie outside the inner volume and inside the outer volume. Select some of the different bones to see their envelopes, and then turn Show No Envelopes back on again.
Using envelopes is a fairly crude, high-level method of setting vertex weights in Skin, and is suitable mainly for saving time when skinning fairly simple bone-and-mesh setups.

2 Turn Show No Envelopes back on, as you won't be using envelopes in this tutorial.

3 While you have the Display rollout open, take a look at the other options here.

$\left[\right.$| Display |
| :--- |
| $\square$ Show Colored Vertices |
| $\nabla$ Show Colored Faces |
| $\square$ Color All Weights |
| $\square$ Show All Envelopes |
| $\square$ Show All Vertices |
| $\square$ Show All Gizmos |
| $\nabla$ Show No Envelopes |
| $\square$ Show Hidden Vertices |
| Draw On Top |
| $\square$ Cross Sections |
| $\square$ Envelopes |

Show Colored Faces is on; you've already seen its effects.
4 If you turn on Color All Weights, you can see the vertex weighting throughout the character mesh, not just for the current bone.


With Color All Weights on, weighting is visible for the entire mesh, not just the selected bone.

That's not what we want for this tutorial, so turn it back off.
5 If you turn off Draw On Top > Envelopes, you can no longer see the bone representations superimposed on the mesh, so keep that one on.


Disabling envelope display makes it impossible to select a bone in the viewport.

6 Try the other options if you like, but when you're done be sure to restore them to their previous settings, as shown here:

$\left[\right.$| Display |
| :--- |
| $\square$ Show Colored Vertices |
| $\nabla$ Show Colored Faces |
| $\square$ Color All Weights |
| $\square$ Show All Envelopes |
| $\square$ Show All Vertices |
| $\nabla$ Show All Gizmos |
| $\nabla$ Show No Envelopes |
| $\square$ Show Hidden Vertices |
| Draw On Top |
| $\nabla$ Cross Sections |
| $\nabla$ Envelopes |

## Begin adjusting vertex weights:

1 Back on the Parameters rollout, turn on Select > Vertices.
This setting is off by default, but it needs to be on for adjusting vertex weights, so always turn it on before starting a skinning session using the method described in this tutorial.

The "stretching" animation begins with the feet and moves up the body, so you'll follow the same progression in adjusting the skinning.

2


Zoom in on the calves and feet, and make sure the display is set to Smooth + Highlights + Edged Faces, as shown in the following illustration.


3 Scrub back and forth through the first 50 frames or so of the animation. Notice how the bending of the feet also affects the bottom portion of the calves. This is not realistic; it happens because the default envelope assigned by Skin to this bone is a bit too large.

4 Select each of the foot bones in turn: EmmaRigLCalf, EmmaRigLAnkle, and EmmaRigLToe.


From left to right: calf, ankle, and toe bone selected.

End with EmmaRigLAnkle selected. The shading (orange, yellow, and blue) indicates that most of the vertices' weights for this bone are less than 0.5 , which is undesirable.

5 On the main toolbar, from the Selection Region flyout, choose the Lasso Selection Region tool.


This is the best tool for region-selecting a contiguous group of vertices with an arbitrary outline.

6 Drag a region around the foot and ankle vertices, as shown:


Because the Backface Cull Vertices switch is off, this also selects most of the vertices facing away from you. Depending on the view angle and where you drag the region, a few vertices might not be selected. To make
sure all foot and ankle vertices are selected,

orbit around the model to double-check. Add any vertices you missed to the selection, and remove any vertices that shouldn't be selected.
To undo the orbit, press Shift+Z.
TIP To add vertices to a selection, Ctrl+select them, and to remove vertices from a selection, Alt+select them.


7 On the Parameters rollout, in the Weight Properties group, set Abs. Effect to $\mathbf{1 . 0}$.

Absolute Effect is the absolute weight setting.
The entire foot turns red, as a visual result of the weight setting change. This way you know that no other bones can influence these vertices.


You can confirm that the toe animation no longer affects the foot mesh by scrubbing the animation. You'll fix that next.

8 Select the toe bone (EmmaRigLToe).
The foot is gray, indicating no weighting for this bone, but some blue coloring is evident in the shin, indicating influence that the toe should not have over this area.

9 Drag a region around the blue vertices (it doesn't hurt to select too large an area), and then set Abs. Effect to $\mathbf{0 . 0}$.
This removes any remaining leg vertices from the influence of the toe bone.
Next you're restore the vertices at the front of the foot to the influence of the toe bone.

10 Drag a region around the front of the foot, just above the third lace (raised portion at the top of the shoe). Again,

orbit around the model to
make sure the selection is correct. To undo the orbit after the selection is correct, press Shift+Z.


TIP A good way to check quickly whether your selection is correct is to use
 (Zoom Extents Selected). For example, if you inadvertently selected vertices on the other side of the character, the resulting view will be wider than expected.

11 Set Abs. Effect to 1.0.
The selected vertices and surrounding mesh turn red. Now, when you scrub the animation, the break between the weighted and unweighted vertices for the toe bone is readily apparent, as compared to the right foot. At the greatest amount of bend, around frame 10, the fourth lace (unweighted) sits directly below the third lace. If you select the ankle bone, you can see that there's no transition between the weighting at the front and the rear of the foot.

The way to resolve this is to create a transition mid-foot by weighting those vertices between the two bones.

Return to frame 0 and then select the vertices for the two uppermost laces.


13 Drag upward slowly on the Abs. Effect spinner so you can see the color change as the vertex weighting increases. Stop when you see a yellow-orange color, around 0.4.


When you scrub now, the transition looks better. However, the uppermost lace is too low.


14 Select the vertices of the uppermost lace, select the ankle bone, EmmaRigLAnkle, and drag the Abs. Effect spinner gradually upward.
As you do, you see the lace move upward due to the increasing influence from the ankle bone. Stop around 0.6 or 0.7 .

TIP For a useful guide while adjusting clothing vertices, keep in mind the material of the clothing. For example, the sneakers might be made of canvas, which is a fairly stiff fabric, so creasing that might not occur with a softer fabric might be permissible for canvas. Also, with medium-resolution models like this one, there might not be enough vertices for a fully natural look, so a certain amount of compromise is necessary.

15 Continue adjusting the lace vertices around the bend until you get a reasonable-looking effect.


NOTE Adjusting the laces is a good example of the back-and-forth type of adjustments required for good skinning. First you make the gross settings for the front and rear portions of the foot, then you go in and select one lace at a time and adjust it so it looks good with the rest of the laces in the bend.

16 Next, looking at the bottom of the foot, you might notice a fairly wide gap between the set of vertices at the bend and those immediately behind them. Again, select the offending vertices and raise the Abs. Effect spinner value gradually until the shoe looks more realistic.


TIP In general, when adjusting vertex weights for a skinned character, try to keep polygon sizes consistent; this allows for minimal distortion when the character is animated.

17 Advance to animation to frame 20, where the foot is bent the furthest in the opposite direction.
There's a fairly sharp bend at the bottom of the foot, but there's not much you can do about it because of the relatively low resolution of the character mesh. Even if the budget allowed for more polygons in the mesh, they would probably go into the face, which has higher priority, so this type of distortion is usually tolerated in commercial applications such as games.

Weight the rest of the leg:

1


Zoom out and select the ankle bone, EmmaRigLAnkle. Check the animation that it affects, approximately from frame 30 to 50 .
It looks all right, but the ankle influence goes fairly far up the calf, which is incorrect.

2 Select all of the affected calf vertices. It doesn't matter if you go too high, but be sure not to select any of the ankle vertices.


Wireframe display makes it easier to see the selected vertices, which are outlined in white.

3 Select the calf bone, EmmaRigLCalf, and set Abs. Effect to 1.0. This removes the calf vertices from the ankle bone's influence.

4 Select the loop of vertices at the top of the ankle and set them to $\mathbf{1 . 0}$ for the calf bone as well.

TIP This is a good place to take advantage of the Skin modifier's loop-selection tool. Select two adjacent vertices on the loop of edges around the ankle and then, near the top of the Parameters rollout, click the Loop button. This automatically selects all the vertices in the same edge loop as the two vertices you selected.


Lower than this is where the ankle bends, so you need to weight the vertices between the ankle and calf bones.

5 Select the next loop down and set the calf weight to $\mathbf{0 . 5}$.


This loop is now weighted half for the calf bone and half for the ankle bone.

6 Next, zoom out, if necessary, so you can see both legs.


Some vertices on the right leg are influenced by the left calf bone, which you can easily correct for.

7 Drag a region around the affected vertices in the right leg. Toggle wireframe display mode and orbit around the model to make sure you get all of them.

8 Set Abs. Effect for the selected vertices to 0.0.
Similarly, the calf has a bit too much influence over the thigh vertices of the left leg, which is part of the cause of the loss of volume in the knee when it bends. You'll deal with this in a bit, but first take a look at the thigh.

9 Select the thigh bone: EmmaRigLThigh.
Again, the default volume of influence is too large.
10 Go to frame 0 and select all the vertices on the right side of the mesh (your left side) and set their weights to $\mathbf{0 . 0}$.


Great precision isn't necessary here; the main thing is to remove the right-side vertices from the influence of the left-side bone.

## Start using the Weight Tool:

In this section you'll continue to block out the leg weighting, using the convenient, powerful Weight Tool dialog.

Given a selection of vertices with the same bone and weight assignments, Weight Tool lists all bones that affect the vertices along with the corresponding Weight values. It also lets you edit the Weight value for the current vertex selection and bone assignment, setting either an absolute Weight value or adjusting the weights of the vertices relative to their current values. In addition, Weight Tool provides controls for copying and pasting Weight values and controls such as Ring and Loop for modifying the vertex selection.

NOTE If you select multiple vertices with different Weight values and bone assignments, the Weight Tool dialog shows the settings for the vertex with the lowest sub-object ID. To see settings for more than one vertex at a time, use the spreadsheet-like Weight Table.

1 Near the bottom of the Parameters rollout, click

(Weight Tool).

The Weight Tool dialog opens. Drag it to a convenient, out-of-the-way location. You can keep it open as you work.


2 Select different vertices while keeping on eye on the list at the bottom of the Weight Tool dialog.
The list shows the selected vertex's bone assignments and the Weight value for each assignment. Note that the Weight values always add up to 1.0. If, for example, you change the Weight value for a particular bone for a vertex that's influenced by three different bones, 3ds Max changes the values for the other two bones in the opposite direction, in proportion to their current values.

Note also that the Set Weight value doesn't change; this is a write-only field.

3 Select all the vertices in the lower half of the knee area, down to the bottom of the Capri pants.

4 Make sure the calf bone is highlighted in the Weight Tool list, and then click the 1 button on the Weight Tool dialog.


This sets the Weight value for all selected vertices to 1.0 with respect to the calf bone. Note that the weights for the other two bones in the list are now 0 . You can get rid of 0 weights in the entire mesh by clicking Advanced Parameters rollout > Remove Zero Weights, but thats not necessary at the moment.

5 Select the thigh vertices above the knee, select the thigh bone, and click the 1 button on the Weight Tools dialog.


6 Just to clean things up, select the calf bone in the right leg and any vertices in the left leg that it influences and set their weights to 0 . Do the same thing for the right thigh bone.

NOTE After you select the right-leg calf or thigh bone and then region-select the affected left-leg vertices, it's possible that the bone doesn't show up in the Weight Tools dialog list because the selected vertex with the lowest ID isn't influenced by that bone, but that's okay. Just go ahead and click the 0 button on the dialog; 3ds Max still recognizes that you're setting the weights for the selected bone.

This goes toward the general philosophy that you work more efficiently by keeping things as clean as possible as you go, rather than going back and trying to optimize them later. It's analogous to the modeling practices of paying attention to edge flow and making as many polygons as possible quadrilateral, avoiding triangles or n-gons.

## Fix the knee:

1 Go to frame 40 and adjust the view so you can see both knees.


This is a good before-and-after view. The right knee is "before," showing marked volume distortion, while the left knee, after blocking out the thigh and calf weights, looks more realistic.
However, if you look closely at the back of the left knee when the leg is bent, it's apparent that a good deal of fine-tuning remains to be done. This requires a lot of tweaking, experimentation, and examining the results, and, again, it's not practical to give every detail of the process here. We will, however, give you an example to start you off.

2 Start by selecting the calf bone, if necessary, and then select the uppermost loops of vertices around the top of the knee. These aren't technically loops (they merge and split off), so select them manually, combining region selection and clicking, rather than with the Loop tool described preceding.


3 Go to frame 40, where the leg is bent the most at the knee, and reduce the weighting gradually until the vertices are better positioned.

TIP One good way to do this is to repeatedly click the - button all the way to the right of the Set Weight button. Each click subtracts 0.05 from the current Weight value of each selected vertex. Likewise, each click of the + button next to it adds 0.05 to the weights.

If you'd like to take a look at the completed, fully skinned model, open the included file configuring_skin_finished.max. In that file you can example the weighting for all vertices that we came up with through extended trial and error.

In general, what we ended up doing was weighting the vertices in the lower half of the knee mainly to the calf, and, starting halfway up the knee, giving gradually more weight to the thigh. Some manual tweaking was required to accommodate for the "wrinkle" vertices at the back of the knee.

4 As you're going through and adjusting vertex weights, you'll probably encounter bones for which the selected vertex has a 0 weight. To keep things simple, if you're not planning to influence that vertex with the bone, make a practice of clicking the Remove Zero Weights button on the Advanced Parameters rollout. This affects the entire mesh, and helps keep things as simple as possible.

## Weight the pelvis:

After you finish skinning the left leg, it's time to move up to the pelvis.
1 Select the pelvis bone: EmmaRigPelvis.


Following the practice of blocking out the weighting, the fact that no red is visible is not a good sign.

2 For the reason why, select the thigh bone and note that it has an inordinate amount of influence over the pelvic vertices.

3 With the thigh bone still selected, select all vertices between the bottom of the pelvis (including the top of the side pouch on the pants) to the top of the belt, inclusive.


4 Select the pelvis bone and set the Weight value to 1.0.


5 Scrub the animation and stop around frame 67.


The schism between the weighting of the pelvis and thigh is glaringly obvious. Fortunately, fixing this is relatively easy.

6 Go to frame 0 and select the vertices at the crease between the leg and pelvis, at the front of the body only. Make sure not to select any vertices on the rear end.


7 Go back to frame 67 or so and then reduce the weighting so the vertices move up and out of the deep crevasse they were in, giving a more natural look to the bend.


## Complete the leg and mirror the weights:

In this section you'll correct the weighting on the vertices in the character's rear end, and then quickly fix the weighting on the right side by mirroring the vertex weights from the left side.

The first thing to fix is some unwanted influence of the first spine bone on some pelvic vertices.

1 Select the EmmaRigSpine1 bone and note that several vertices in the front of the pelvis area, on the left side, are highlighted.
The bone also influences vertices on the right side, but because you'll mirror all the vertex weights from the left side to the right, that's not a concern.

2 Select the highlighted vertices on the left side (don't worry about selecting too many) and then click the 0 button on the Weight Tool dialog.

3 Next, select the nine vertices in the lower crease, near the bottom of the rear end, as shown in the following illustration.


Select the nine vertices on the character's lower backside.

TIP You can select the vertices by clicking each in turn, holding down Ctrl after the first one. Another, slightly easier way, is to turn on Backface Cull Vertices in the Select group on the Parameters rollout, and then region-select the vertices. Make sure the Weight Tool dialog shows "9 Vertices Selected" and be sure to turn off Backface Cull Vertices after making the selection.

Currently these vertices are weighted only for the pelvis bone, so you need to add weighting for the thigh bone.

4 Select the thigh bone, set the vertex weights to 0.5 , and adjust from there. For example, the lowest three vertices on this crease stick out too much,
so you need to increase the thigh-bone weighting for them compared to the other six vertices.

5 Continue working on the vertices in the rear end, adjusting them so you get a realistic, rounded effect, like this:


As before, when in doubt, refer to the finished scene, configuring_skin_finished.max, for specific guidance.

6 Also adjust the vertices in front, at the crease between the thigh and pelvis. And while you're at it, set weights to 0 for any torso vertices influenced by the thigh bone.

7 When you've finished weighting the pelvis vertices, go to the Mirror Parameters and turn on Mirror Mode.
The bones and vertices now use color coding: blue for the left side and green for the right. Centered items, which cannot be mirrored, are colored red.


A few notes about the Mirror Mode settings:

- Mirror PlaneThe axis normal of the plane about which the vertex weights are mirrored. The default setting, which you'll use for this tutorial, is X , which means the YZ plane. The plane appears as an orange wireframe in the viewport.
- Mirror OffsetThe distance along the X axis to move the mirror plane. The default value, 0 , centers the plane to the character, so for this tutorial it's the desired setting.
- Mirror Thresh(old)The amount of leeway for the detection of symmetry. If this is too high, mirrored weights might go to the wrong vertices, but if it's too low, the Skin modifier won't be able to detect
symmetrical bones and vertices. You'll experiment with this setting in the next step.

8 Right-click the Mirror Thresh. spinner to set it to 0 , so that all the bones turn red, and then increase it until all the leg bones and arm bones turn blue and green.
The default value is $0^{\prime} 0.5^{\prime \prime}$, but in our scene we were able to reduce this to $0^{\prime} 0.19^{\prime \prime}$, which potentially allows for greater accuracy in mirroring weights. Your results might vary slightly.
To do the actual mirroring, you use the five buttons under the Mirror Mode button. From left to right, they mirror selected vertices only, all bones from either side to the other, and all vertices from either side to the other. For this tutorial, you'll use Paste Blue To Green Verts, the button outlined in red in the following illustration:


9 On the Mirror Parameters rollout, click
(Paste Blue To Green Verts).
All of the weighting you've done for each vertex on the left side of the character has now been copied to the vertices' counterparts on the right side, instantly correcting the skinning throughout that side. The left-side vertices, previously blue, are now yellow to indicate that they've been mirrored:


10 Exit Mirror Mode by clicking the Mirror Mode button, and then scrub the animation through the first 100 or so frames.
The animation looks mostly good on both sides of the character's lower half. However, there's a slight problem around frame 80, when the leg bends back, where the crease between the leg and buttock is a bit too deep.

11 Select the crease vertices and increase their weights gradually with respect to the thigh bone until the folding looks better.

TIP A tool that can potentially help in a situation like this is Blend, which evens out, or averages, the weighting of selected vertices. First save your work as a backup, then select the vertices in and around the area of the crease and then, at a frame where the crease is in effect, click Blend on the Weight Tool dialog a few times. If it looks better, great. If not, load the saved file and weight the vertices manually.

When you're satisfied with the results, mirror the vertices to the other side.

Another important consideration is the center line of vertices around the pelvis, which are currently weighted $100 \%$ for the pelvis. In reality, these areas would be pulled around by the movement of the legs, so they need to be weighted accordingly.


12 Select the three center vertices at the bottom-front of the pelvis, select the right thigh bone, and click the 1 button on the Weight Tool dialog. Then select the left thigh bone and click the .5 button. Finally select the pelvis and gradually increase its weight for the vertices, checking the animation as you go, until it looks right.
That way you give equal weight to both thigh bones, maintaining that balance as you then bring the pelvis into the equation.

13 Similarly, weight the vertices on the character's left side of those center vertices slightly toward the left thigh bone, and the ones next to those a little bit further toward the left bone. When everything looks good, mirror the vertices to the right side.

Save your work:
$\rightarrow$ Click (a)

## Weighting the Character's Upper Half

In this concluding section of the skinning tutorial you weight Emma's torso, neck, head, and hands, and learn some finishing-up techniques.

## Set up the lesson:

- Continue from the previous lesson, or, on the Quick Access toolbar, click

(Open File), navigate to the \character_animation $\backslash$ skinning $\backslash$ folder, and open the file configuring_skin01.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

This scene contains the Emma character with the skinning corrected for the lower half of the character mesh.

## Weight the torso:

Next you'll adjust the weighting for Emma's upper body. By now, you know the drill: Look for problem areas, examine the weighting for vertices in those areas, and adjust accordingly.

1 Start by examining the animation of the torso, roughly between frames 120 and 180.
It mostly looks okay, except for visual artifacts in the lower abs around frame 149:


This happens because the four vertices illustrated following are overly influenced by the first spine bone at the sake of the pelvis bone.

2 To resolve this, go to frame 0 and select the four vertices shown here:


NOTE These vertices should be influenced only by the EmmaRigPelvis and EmmaRigSpine1 bones. If you find any other bones influencing them, select each bone and set the weight to 0 .

3 Select either bone and set its weight to 0.5.
Now, at frame 149, the artifacts are greatly diminished.


4 Back at frame 0, select the head bone, EmmaRigHead, and look at the surrounding vertex weighting.


Head motion should not affect the chest vertices; this is easy to fix.
5 Select the affected vertices on the front and back of the left side (from the character's point of view) of the chest and weight them to $\mathbf{0 . 0}$. As you'll be mirroring later, you needn't bother with the ones on the right.


Fix the collarbone:
Currently the collarbone is not being used properly. To best correct that, you first block out and adjust the arm.

1 Select the left upper-arm bone, EmmaRigLUpperArm, then select the upper-arm vertices and weight them to $\mathbf{1 . 0}$.


Make sure not to select the vertices at the edge of the shirt.
The forearm has two bones so it can rotate the same way a person's does. In Emma the bones are end-to-end rather than side-by-side, as in a real human skeleton, but the end result is the same.

2 Select each forearm bone in turn and weight the vertices surrounding it to 1.0. Also select the main hand bone, EmmaRigLPalm, and weight all the hand vertices at $\mathbf{1 . 0}$ to it.

3 Weight the elbow vertices the same way you did the knee. The forearm should have priority over the upper arm. Again, if you need guidance, examine the included final scene.


Back to the collarbone: The shoulder is probably the biggest problem area. For most arm animation, the upper-arm bone controls the skin adequately, but when the arm is raised, the collarbone needs to come into play. However, the collarbone currently does not have enough influence, which results in the type of artifact illustrated here:


TIP When resolving a problem like this, it helps to have different poses to work on, as found in the animation in this tutorial. Thus, if you get stuck trying to fix the skinning in one pose, you can move to a different pose and do some weighting there. This often helps you find the route to success.

4 Go to frame 210, select the collarbone (EmmaRigLCollarbone), select the vertices around the shoulder and top of the arm, and click the 1 button on the Weight Tool dialog.


Left: Shoulder and upper-arm vertices selected

Right: After weighting to 1.0 for the collarbone

5 Continue working on the arm, evening out the weights and keeping a reasonably even distance between edge loops. While doing so, you probably need to assign the uppermost upper-arm vertices partially back to the upper arm bone, and some lower ones partially to the collarbone. When you've done all you can, go to frame 220, continue working on the upper arm and shoulder, and likewise at frames 230 and 240.
The following illustration shows four different animation frames with the weighting completed:


1. Frame 210 with collarbone selected
2. Frame 220 with upper arm bone selected
3. Frame 230 with collarbone selected
4. Frame 240 with upper arm bone selected

TIP The underarm is not weighted the same as the upper arm. For example, it's influenced by the upper-spine and ribcage bones, while the upper arm is not.

Also, the Copy and Paste functions come in handy for this sort of weighting. If you find a good balance for a vertex, copy and paste its settings to its neighbors and then adjust from there.

## Weight the head and neck:

If you scrub through the animation section in which the neck moves, between frames 250 and 320, you can see that the neck bone has too much influence over vertices outside its usual anatomic domain, such as the collarbone area.

This is most evident on the character's right side, because you've improved the collarbone's influence over the upper-chest vertices on the left side. So the first thing to do is mirror the changes.

1 Select the hair object and hide it so it doesn't get in the way.
2 Go to a neutral position, such as at frame 265, and select the vertices of the upper arm, upper chest, and lower neck.


Make sure not to select the vertices on the vertical centerline of the neck.

3 On the Mirror Parameters rollout, turn on Mirror Mode and then click

[x]
(Mirror Paste).
The selected vertices' settings are mirrored to the opposite side of the mesh. Now the distortion is less when bending the neck, but the neck's influence still extends beyond its proper volume.

4 Turn off Mirror Mode.
5 Select the neck bone and the colored vertices on the shirt (front and back) and upper chest and set their weights to $\mathbf{0 . 0}$.

6 Select the head bone and remove any influence from the vertices of the lower neck and upper torso.

TIP You can save time by reweighting only the character's left side, as you'll eventually mirror everything to the right side anyway.

7 With the head bone still selected, select the head and upper-neck vertices and weight them to 1.0 .

Next you'll weight the three neck loops increasingly (from top to bottom) for the neck bone.

## Start weighting the neck:

1 Select the neck bone, and use the Loop tool to select the uppermost of the three neck loops. Weight it to $\mathbf{0 . 2 5}$.

2 Select the next loop down and weight its vertices at $\mathbf{0 . 5}$ for the neck bone, so it's also weighted 0.5 for the head.

3 Select the lowest neck loop (one up from the loop at the base of the neck). There's a significant amount of influence here from the top spine bone, EmmaRigSpine3, which is undesirable.

4 Select EmmaRigSpine3 as well as the vertices in the neck and upper torso and weight the vertices to $\mathbf{0 . 0}$.

5 Again select the lowest neck loop (one up from the one at the base of the neck), then select the head bone and click the .25 button on the Weight Tool dialog.
This sets the weighting proportions for this loop at 3 to 1 between the neck and head.

6 Select the loop at the bottom of the neck and set it to 1 for the neck bone. This is just a starting point; then you adjust the side vertices for the influence of the collarbones.

7 Manually select the bottom vertices on the right side of the neck (all the way around except for the very front and back), then select EmmaRigLCollarbone and click the .5 button on the Weight Tool dialog.

8 Scrub the neck-twisting section of the animation and make sure the movement looks natural.

9 Select the vertices you've just been working on, activate Mirror Mode,
and click
(Mirror Paste).
10 Turn off Mirror Mode.
11 Again, scrub the animation through the neck exercises and verify that the weighting is good; for example, the collarbone should not move. If not, tweak the weights as necessary.

## Complete the neck:

The vertices in the vertical centerline of the front of the neck need to be weighted equally to both collarbones. This is important to do because center vertices are not mirrored.

1 Starting at the base of the neck and going upward, select the first three vertices in the front centerline.


These vertices are currently weighted $100 \%$ for the neck bone.
2 Select either collarbone, click the 1 button on the Weight Tool dialog, then select the other collarbone and click the .5 button.
The vertices are now weighted at $50 \%$ for each collarbone.
3 Select the neck bone and go to a frame such as 260 where the central neck vertices are not positioned correctly.

4 On the Weight Tool dialog, click the + button to the right of the Set Weight button repeatedly (but slowly), adding weight incrementally until the centerline is in the correct position.


As you do so, 3ds Max subtracts equal amounts of weight from the vertices with respect to the two collarbones.
As you can see from the included final version, a bit more fine tuning was required. We ended up with the bottom vertex at 0.6 for the neck and 0.2 for each collarbone, and the upper two at 0.65 and 0.175 respectively

The three vertices immediately to the character's left of the centerline vertices are too far over, so they need to be adjusted.

5 Adjust the three vertices to the character's left (your right) of the previous three vertices.


Again, some fine tuning is required here. We ended up with:
■ Top: 0.15 head, 0.85 neck
■ Middle: 1.0 neck
■ Bottom: 0.65 neck, 0.35 left collarbone.
6 Mirror these three vertices to the other side.
7 Orbit around to the character's back, scrub the animation, and adjust the center vertices as necessary.
For example, vertices in the shirt should not be influenced by the head. If the central vertices in the back of the shirt move in response to head and neck movement, assign them to the top ribcage bone. Similarly, you might need to reduce the influence of the collarbone over vertices at the top edge of the shirt.
A fair amount of fine tuning is required in this area of the character, and it's impractical to detail it here, but, as always, when in doubt, check the results in configuring_skin_finished.max.

8 When you're done weighting the upper torso, select all the left-side vertices and use Mirror Mode $>$ Paste Weights to mirror them to the right side.


Save your work.
In the next part you'll learn how to skin the wrist and hands.

## Skin the hand:

You'll start with the wrist and then move on and skin a finger.
1 Adjust the view to focus on the character's left forearm and hand, and scrub the animation between frames 350 and 380 .
Currently the wrist is weighted $100 \%$ for the second forearm bone, so the joint looks unnatural when bent.

2 Select the loop of vertices around the wrist and weight the vertices 50\% between the nearby forearm bone and the wrist bone, as a starting point.


3 Scrub the animation again. If it still doesn't look right, continue to adjust the weights of the wrist vertices until it does. Chances are, for this particular loop, that you'll need to increase the forearm weighting to about 0.7.

TIP Sometimes you might want to give the forearm bone a bit of influence over the vertices on the back of the hand nearest the wrist as well, but in this case it's probably not necessary.

## Weight the fingers:

1 Scrub the animation through the frames in which the fingers move. Currently you see only the bones moving, because all of the hand vertices are weighted for the palm bone.

2 Select all the vertices for one finger. For this example we'll use the forefinger.


3 Select the first bone of that finger; in this case EmmaRigLIndex1. Set it to $100 \%$ weighting.
The whole finger now responds to the motion of the first bone.
4 Select the vertices from the loop above the first joint to the end of the finger, and weight them to the second bone: EmmaRigLIndex2.


5 Repeat the process, weighting the end set of vertices, after the second joint, to the last bone.


This is high-level blocking; next you'll work at a more atomic level.
6 Select the six vertices below each joint and weight them 100\% for the underlying bone; do the same for the six vertices above each joint.


TIP Most likely the best way to select these vertices is one at a time.
Next you'll weight the joint vertices.
7 Select the eight vertices around each finger joint and weight them to $50 \%$ for each neighboring finger bone.


This allows for an even blend at the finger joints.
TIP If necessary, you can also use the Blend tool to weight the vertices near each joint's edge loop.

8 Similarly, weight the knuckle vertices 50\% for the palm, and the vertices just beyond the knuckle, near the top of the finger, at $25 \%$ for the palm.


This can vary depending on the animation and the location of the vertex. The goal is to prevent distortion of faces that get "crushed" when the finger bends. Aim for results that look like the following illustration:


9 Do the same for each remaining finger, including the thumb, and then mirror the results to the opposite side of the mesh.

## Save your work:

■ Save the results as MyEmmaFinished.max.
This concludes the basic skinning portion of our program; you can find the final version in the included file configuring_skin_finished.max. The remaining section deals with follow-up techniques.

## Next

Adjusting the Character Mesh and Rig on page 800

## Adjusting the Character Mesh and Rig

In some cases, after you've skinned a character, you might need to make adjustments, either to the character mesh (for example, adding details such as pockets or increasing mesh resolution for more realistic-looking joints) or to the rig, such as modifying the structure. This section shows how to recover from such a situation without having to re-skin the character.

This section also covers using Skin Wrap to transfer a skinning solution to a similar character with a different mesh resolution.

## Set up the lesson:

- On the Quick Access toolbar, click

B(Open File), navigate to the $\backslash$ character_animation $\backslash$ skinning $\backslash$ folder, and open the file modifications_post_skin.max.
This scene contains the final Emma character with two modifications: First, a patch has been added to the upper arm of the character mesh:


Second, the thigh bones have been subdivided to lend the rig more articulation:


## Let the Skin modifier automatically adjust for mesh changes:

You can follow along on the included character or simply use this as a procedure for your own project.

1 Expose the rig, if necessary, and return to Setup mode by selecting the

CATParent (the triangle under the rig), going to the
(Animation Mode) so the button image
 (Setup mode).
The rig snaps back to its original position.

2 Go to the
 Modify panel, select the character mesh, and turn off the Skin modifier.

3 Go to the Editable Poly level in the modifier stack and make your changes to the character mesh.

For example, in the included scene, you could delete the shoulder patch and use Bridge to replace it with clean quads.

4 Turn the Skin modifier back on and re-enable
 (Animation mode) for the rig.
The Skin modifier weights any new vertices automatically according to surrounding existing vertices.

5 Scrub through the animation and tweak the auto-generated weighting as necessary.

## Let the Skin modifier automatically adjust for rig changes:

This method uses a special function in the Skin modifier that toggles whether rig changes affect the character mesh.

1 Go to the Modify panel, highlight the Skin modifier, and on the Advanced Parameters rollout, turn off Always Deform.

2 Turn off the Skin modifier and set the rig to Setup mode.
3 Adjust the rig as necessary. For example, you might have been handed a rig in which the leg bones were not of the same proportions. In this case, you'd lengthen or shorten a bone in one of the legs.

4 After you finish making changes, select the mesh, turn on Always Deform, and then turn the Skin modifier back on.

5 Select the CATParent and return to Animation mode.
The rig changes do not cause any unwanted deformation of the character mesh.

NOTE This method is not foolproof. If, for example, the character is properly skinned and you drastically change the proportion of the bones in one leg, that leg's skinning will probably need adjusting. This is mainly for instances where the skinning is correct but the rig does not conform to the mesh in an isolated area.

## Transfer skin to another mesh:

A quick way to transfer a skin map from one character to another that uses the same rig is with the Skin Wrap modifier. Basically, Skin Wrap uses location to transfer animation from one object to another. It does not depend on topological similarities.

IMPORTANT Be sure to perform all the steps in this procedure at frame 0. You can scrub in between steps to check the animation, but always return to frame 0 before changing settings, applying modifiers, and so on.


Open the final version of the Emma scene file (configuring_skin_finished.max), turn off the Skin modifier, and place the rig in Setup mode.

2 Open the final version of the Emma scene and use Tools menu > Clone to copy the mesh to two new objects. Name them Emma_LowRes and Emma_HighRes. Move them to either side of the original.

3 Select Emma_HighRes, delete the Skin modifier, and apply the MeshSmooth modifier. On the Parameters rollout, under Separate, turn on Materials and Smoothing Groups.
This produces a model with about four times the number of vertices.
4 Select Emma_LowRes, delete the Skin modifier, and apply the ProOptimizer modifier. On the Parameters rollout, click Calculate, and then set Vertex \% to 50.0.

This produces a model with the same look but about half the number of vertices. It's suitable for a mobile 3D application or for a character that's viewed only from relatively far away.
An important requirement of Skin Wrap is that the objects between which you're transferring animation be in close proximity. You'll start with the low-resolution model.

5 Move Emma_LowRes to the same location as Emma, which is $(0,0,0)$.
TIP If you previously moved it on the $X$ axis only, just right-click the spinner to the right of the $X$ field on the status bar.

6 Apply the Skin Wrap modifier to Emma_LowRes. On the Parameters rollout, click the Add button, press H to open the Pick Object dialog, and select the Emma object. Right-click to exit Add mode.

There will probably be a short delay while Skin Wrap performs its calculations.

7 Right-click in the viewport or click the Add button again to exit Add mode.

8


Select the Emma object, turn on the Skin modifier again, set the rig back to Animation mode, and hide the object and rig.

- Play the animation. It plays back perfectly.

The process is the same with Emma_HighRes, except that applying Skin Wrap takes longer because of the greater complexity of the mesh.

## Save your work:

- Save the file under a new file name.


## Summary

You covered quite a bit of ground in this tutorial. You learned how to fit a complex character mesh to an animated rig, how to adjust for edits to the mesh and rig, and how to transfer the skinning data to a character with a markedly different resolution. The main work in skinning a character is to make sure the vertices at bend points are properly weighted among the bones that influence the motion. This requires patience and attention to detail. But the result, in obtaining a realistically animated virtual person or other character, is well worth it!

## Learning Biped

These tutorials introduce you to the fundamentals of character animation using the 3ds Max Biped and Physique components. You will learn how to create and control a virtual skeleton, which will drive the motion of your character.


## Features Covered in This Section

- Adjusting your biped with Figure Mode.
- Applying Physique.
- Creating a walk cycle using footsteps.
- Creating and editing a generated walk cycle using footsteps.
- Setting keys in freeform mode.
- Combining animation clips to create an animated sequence.
- Animating multi-legged creatures.


## Biped Quickstart

This tutorial introduces you to the elements of the 3ds Max character studio feature and the workflow for some of its most important components.


In this tutorial, you will learn how to:

- Create and pose a biped.

■ Associate the biped with a mesh using the Physique modifier.

- Animate the biped using two different methods, freeform and footstep animation.
- Combine motions in the Motion Mixer.

Skill level: Beginner

Time to complete: 1 hour

## Creating a Biped

In this lesson, you'll create a default biped: a simple skeleton consisting of bones connected in a hierarchy. A default biped is different from 3ds Max Bone system objects because the biped structure automatically has built-in joints like a human being. You can bend your knee so your foot touches the back of your thigh, but you can't bend it forward so that your toe touches the front of your thigh. Biped creates skeletons in the same fashion. They are ready to animate, and work accurately without additional setup .

## Set up the lesson:

- Reset 3ds Max.


## Create a biped:

1 On the


Create panel, click (Systems).

2 On the Object Type rollout, click Biped (Biped). The Biped button highlights.

3 If you can't see the Height spinner in the Create Biped rollout, scroll to the bottom of the command panel.

4 In the Perspective viewport, place your cursor over the center of the grid, press and hold the left mouse button, and drag upward. A biped appears and grows with your cursor movement.

5 Drag upward until the Height spinner on the Create Biped rollout reads approximately 70 units, then release the mouse button.
A biped is created in the viewport.
The biped is a hierarchy of special objects. Its parent object (Bip01) is its center of mass (COM). The COM is displayed in the viewports as a small, blue tetrahedron, initially centered in the biped's pelvis. After you create a biped, only the center of mass object is selected (not the entire biped).

## Name the biped:

When you create your first biped, it has a root name of Bip01. The root name of each additional biped is incremented, so the next biped you create has a root name of Bip02. The root name acts as a prefix for each part of the biped, to make it unique from any other bipeds in the scene.

1 In the Create Biped rollout, highlight the current root name entry, Bip01, in the Root Name field.

Root Name
Bip01

NOTE You can also change the biped root name from the Motion Panel if you expand the Biped rollout.


Name: |Bip01

2 Enter the new root name, MyBiped.
Renaming the biped's root name to the name of the character is common practice and helps with scene organization.

3 On the Quick Access toolbar, click
 as MyBiped.max.

## Posing a Biped

Once you've created a biped, you need to pose it to match the character model that the biped will control. This is done in Figure mode, which allows you to bend, rotate, and scale parts of the biped to conform to the character mesh. In this lesson, you will adjust a biped to fit a character mesh.
Character meshes are usually built in one of two stances. The most common is with the arms out and the legs slightly spread, like da Vinci's drawing of the Vitruvian Man. Or, the character mesh is built in a resting position with arms at its sides and legs together.
For this lesson, you'll be working with a character named Dr. X.


Left: Dr. X exhibiting the Vitruvian Man stance; right: a resting position.

## Set up the lesson:

1 Reset 3ds Max.

2 On the Quick Access toolbar, click
 \character_animation \quick_start folder, and open dr_x_01.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

This scene contains a character mesh named DoctorX.

## Build the biped:

Now that you know how to create a biped, you're going to use the character mesh as a template for building the biped that will control Dr. X.

1 On the


Create panel, click

(Systems).
2 Turn on Biped (Biped) and make sure you can see the Height spinner in the Create Biped rollout.

3 In the Front viewport, click down at Dr. X's feet and drag up until the biped is about 1.0 m in height
This will place the center of mass (COM) roughly at Dr. X's pelvis.


The new biped and Dr. X.

4 In the Create Biped rollout, change the Root Name to Dr. X.
NOTE When you change the name on the Create Biped rollout, the name is used as a prefix for all the biped's component parts; for example, Dr. X L Foot. If you use the usual Name And Color rollout, only the name of the biped's COM is changed; all other parts remain prefixed with Biped01 (or whatever the current sequence number is).

## Position the biped:

Once the biped is added to the character mesh, you need to adjust the biped to better match the stance of the mesh. First, you'll adjust the position of the biped within the Dr. X model.

1 Click the
Motion panel tab.

2 In the Biped rollout, turn on
 (Figure Mode). All changes to the biped's reference pose must be done in Figure mode.

3 In the Left and Front viewports, click

(Zoom Region), and zoom in around the pelvis of Dr. X.
The illustrations show the COM in white and arrows pointing at the center line of the mesh.


Zoom into Left viewport


Zoom into Front viewport

4 In the Track Selection Rollout, make sure

(Body Horizontal) button is turned on.

5


Move Dr. $X$, the COM, in both the Left and Front viewports so that it lines up with the vertical center line of the character mesh.


Bip01 moved in the Left viewport


Bip01 moved in the Front viewport

## Adjust the legs:

Next, you'll adjust the legs so they conform with those of the character. When adjusting legs, you'll want to pay close attention to the key bend points at the knees and ankles.

1 Activate the Front viewport. Maximize the viewport by pressing Alt+W, then click


2


Select the biped's left thigh, Dr. $X$ L Thigh. This is colored blue by default, and its name appears in the name field at the top of the Motion panel when selected.


Selection Level:
TIP If you select the mesh by mistake, deselect by clicking outside the figures, and then try again.

3 From the Track Selection rollout, click
The biped's right thigh, Dr. $X$ R Thigh is now added to the selection set.


4 In this step, you rotate the biped's legs to run roughly along the legs of the mesh. To make these rotations, you'll have to switch between the Front and Left viewports. Press F and L on the keyboard to make these switches.

Click
(Select And Rotate) and make the following rotations:
■ In the Front viewport, rotate about 12.0 degrees about the Z axis. A readout appears in yellow as you rotate the selection.

TIP Sometimes the legs will rotate in parallel, instead of in opposite directions. If this happens to you, select and rotate each leg individually.


■ In the Left viewport, rotate about $\mathbf{- 8}$ degrees about the Z-axis.

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5 On the main toolbar, choose

- (Select And Non-Uniform Scale). Scale the thighs along the X-axis until they match the skin model: about 85 percent. Type in the value or use the spinners while viewing the results in the viewport.


6 Press the Page Down key on the keyboard.
Page Up and Page Down are shortcuts for moving up and down the hierarchy. Since both thighs were selected, now both calves are selected after you press Page Down.

7 As you did with the thighs, scale the calves until they match the mesh: about 90 percent along the X axis.
This aligns the biped's ankles more closely with the ankles of the character mesh.


The Left view of the scaled thighs and calves.

8 Press Page Down again to select the biped feet. Scale the feet from the Front and Left views to more closely fit in the shoes.


9 On the Structure rollout, adjust the Ankle attach value to slide the foot to better fit in the mesh: about 0.1.


10 In the Front viewport, rotate the feet so they align with the mesh.


Rotate the feet to fit the mesh.

11 Save the scene as my_drx01.max.
The procedures you've just completed give you an idea of what it takes to align a biped to a mesh, and that patience is the key to this process. This character still needs work: the feet as well as the entire upper body must be adjusted. If you want, read the following tips for biped alignment, then use the same procedures to experiment with aligning the rest of the biped. Otherwise, continue to the next lesson.

## Tips for Biped Alignment

Here are some tips that may help when adding a biped to a character mesh.

- The most important tip is to make sure the COM is always aligned with the mesh.
- When scaling and rotating biped parts, pay attention to the model in multiple viewports. A rotation, for instance, may look good in one viewport, but another viewport may indicate a problem.

■ Examine the character mesh's complexity. If the character is wearing mittens or shoes, you probably don't need five fingers and toes. Adjust the biped structure accordingly.

- Remember ponytails. If the character has a lot of hair or a long nose, like an elephant trunk, you can use a ponytail to control that part of the mesh.

■ If the character mesh has a short torso or long neck, it may be best to reduce the number of Spine Links or increase the number of Neck Links. You can add up to 25 links in the neck, tail or ponytails, and up to ten links in the spine.

- If the character is carrying something like a weapon or tool, add a Prop to control that object.


## Applying Physique

After the biped is posed to match the character mesh, you apply the Physique modifier to the character mesh. The Physique modifier associates the biped with the character mesh.

After Physique is applied and set up, any animation on the biped is passed on to the mesh, making it move as if there were bones and muscles underneath.

## Set up the lesson:

1 On the Quick Access toolbar, click
 (Open File), navigate to the \character_animation \quick_start folder, and open dr_x_02.max.
This scene contains Dr. X and a completely posed biped.
2 In the Front viewport, zoom in on the biped's pelvis (orange triangle) and the center of mass, or COM (blue tetrahedron).

## Apply Physique:

1 Select the character mesh, DoctorX.

2 On the
Modify panel, choose Physique from the Modifier List. The Physique rollouts appear in the command panel.

3 In the Physique rollout, click
 (Attach To Node), then click the biped's COM.
The Physique Initialization dialog displays.
4 Click Initialize.
The character mesh is now associated with the biped. The orange deformation spline running through the mesh indicates that the entire biped structure has been associated with the mesh.


Orange spline follows Dr. X mesh. (This view uses See-Through display mode with the biped bones hidden.)

TIP To toggle the view to See-Through display mode, select the DoctorX mesh and press Alt+X.

## Adjust the envelopes:

Physique associates the biped with the mesh by means of the mesh's vertices. Each biped part is surrounded by an area called an envelope, and mesh vertices that lie inside an envelope are effected by that biped part. The default size of an envelope depends on the size of the biped part, which you set when you pose the biped.

Often, envelopes must be manually adjusted to make the biped work properly with the mesh. If you notice irregular spikes poking out from the mesh, it's a good indication that one or more vertices lie outside of an envelope's area of influence. You can see this effect by rotating the arm.

1 Right-click the Top viewport to activate it and use

(Region Zoom) to view Dr. X's left arm.


2 Select DrX Biped L Forearm, and
 rotate it up and down. Some vertices don't move with the arm.


Vertices that are not influenced by the envelope pull out of shape.

3 Press Ctrl+Z to put the arm back to its original position so you can adjust the envelope.

4 Select the DoctorX mesh again and in the modifier stack, click the plus (+) symbol next to Physique and highlight the Envelope sub-object.


The orange splines running through the biped have turned yellow. These are deformation splines, which deform the mesh as the spline moves.

5 Select the deformation spline running along the biped's left forearm to display the associated envelopes.


Notice that each biped part has two envelopes, an inner one (red) and an outer one (purple). Some of the vertices near the opening of the glove are outside the outer envelope boundary. These vertices won't be affected at all by the biped's lower arm unless the envelope is enlarged.

6 In the Blending Envelopes rollout, in the Envelope Parameters group, increase the Radial Scale parameter to 2.0.
The vertices at the opening of Dr. X's glove are now within the envelope.


The dark outer envelope completely encompasses the lower arm.

Many more small adjustments are needed to make all the envelopes fit the mesh correctly. In the next lesson, you'll load a file that has a mesh with envelopes that are properly adjusted.

NOTE Keep in mind that the default envelopes are based on the size of the biped bones. Therefore, if you adjust the envelopes of a character that uses the Classic biped body type, and later change to the Skeleton body type, the envelopes are going to be much smaller and will require more editing.

When you have finished adjusting envelopes, you can apply a MeshSmooth modifier to the mesh above the Physique modifier to make the mesh look smoother.

7 Apply the MeshSmooth modifier to the mesh above the Physique modifier, and make sure that its Iterations value is set to 1.
When MeshSmooth is placed above Physique on the stack, you only need to adjust envelopes for the low-poly version of the model. The Physique settings are passed up the stack to the MeshSmooth modifier.

8 Save your work as my_drx02.max.

## Animating the Biped with Freeform Animation

There are two types of animation that a biped can perform: Freeform animation and Footstep animation. In this lesson, you'll use Freeform animation to make Dr. X do a series of deep knee bends. Freeform animation does not use footsteps. You manually set all the keys in a Freeform animation.

To get an idea of how your animation should turn out, view the preview animation, $d r_{-} x_{-} k n e e b e n d s . a v i$, in the folder \sceneassets $\backslash$ renderassets $\backslash$.


Dr. X doing his deep knee bend exercises.

## Set up the lesson:

1


Open dr_x_03.max.
This scene contains Dr. X with properly adjusted envelopes.


2 Press the H key and choose DrX Biped L Foot from the object list.

## Plant the feet:

Since Dr. X is doing squats, his feet are not required to move. You'll plant his feet to keep them from moving throughout the exercise.

1 Go to the Motion panel.

2 Expand the Key Info rollout, and expand the IK expansion bar. The left foot is selected, so you can set a key for it.

3 the Key Info rollout, click $\theta$ (Set Planted Key).

4 In the Track Selection rollout, click $+2$ (Opposite) to select DrX Biped R Foot.

5 Click (Set Planted Key) to set a key for the right foot.

## Animate the first knee bend:

You'll start by animating the knee-bending motion. Dr. X will start the knee bend in his current stance with arms outstretched, and perform a total of four squats. When completed, he'll return to his original stance.

When the feet are planted, you animate the knees bending by moving the biped's center of mass up and down.

1 Make sure the time slider is at frame 0 .

2 In the Track Selection rollout, click $\ddagger$ This selects the center of mass's body vertical track.

3 Turn on Auto Key (Auto Key).
4 Move the center of mass (COM) downward slightly to make the character's knees bend a little bit.


This places a key for the center of mass's body vertical track at frame 0 .
5 Right-click the Front viewport to activate it, and drag the time slider to frame 15.

6


Move the COM down about -0.25 m on the Z -axis.
Watch the Coordinate display Z-field until it reaches about -0.25 m and release the mouse button. A key is automatically created at frame 15. This is Dr. X's squatted pose.


7 Scrub (drag) the time slider to see Dr. X bend his knees once.

## Copy and paste the standing posture:

1 Drag the time slider to frame 0 .
2 Expand the Copy/Paste rollout.
The tools on this rollout enable you to quickly copy and paste keys from one frame to other frames. By default, the Posture option is selected. This option pastes keys from individual body parts.

3 In the Copy/Paste rollout, click Collection Dr. X poses.

4 Click (Copy Posture).
5 In the Copied Postures field, rename the posture Standing.
6 Drag the time slider to frame 30.

7 Make sure Auto Key (Auto Key) is still on.

8 On the Copy/Paste rollout, paste options group, click Vertical).

9 Click (Paste Posture).

Dr. X stands up again. When you paste a posture with Auto Key turned on, a key is created at the current frame with the new posture. Here, a new key was created for the COM's Body Vertical track at frame 30.

## Copy and paste the squatting posture:

1 Go to frame 15.

2 On the Copy/Paste rollout, click

(Copy Posture). Rename the posture Squatting.

3 Go to frame 45, and click (Paste Posture).

## Paste the remaining postures:

Now that you've stored the two postures, you can easily paste them to other frames.

1 Go to frame 60. Choose the Standing posture from the Copied Postures list, and click Paste Posture.

2 Go to frame 75. Choose the Squatting posture from the Copied Postures list, and click Paste Posture.

3 On frame 90, paste the Standing posture.
4 On frame 105, paste the Squatting posture.
5 On frame 120, paste the Standing posture.
You have now created all the knee-bend motions for this animation. If you like, you can play the animation to see the motion.

6 Turn off
Auto Key
(Auto Key).

7 Save the scene as MyDrX02.max.

## Animate the arms:

Now that the legs are set to bend, you'll rotate the arms and lock the upper body. As Dr. X dips down, his arms are going to swing forward, then back out to his sides as he rises. You'll also set two keys to lock the upper body to keep Dr. X facing forward.

1 Press the H key and choose DrX Biped L UpperArm.

2 On the Track Selection rollout, click 3 opposite upper arm.

3 Drag the time slider to frame 0 .

4 On the Key Info rollout, click (Set Key).
This sets a key for the arms in their outstretched position.
WARNING Be sure to use the Set Key button on the Key Info rollout, not the Set Key text button under Auto Key.

5 On the Copy/Paste rollout, click
 Arms Out.

6 Drag the time slider to frame 15.

7 Turn on Auto Key
(Auto Key).

8 In the Top viewport,

rotate the arms about -75 degrees around the Z-axis.
Look at the Z-field in the Coordinate display Z-field when rotating the arms. A key is added, and Dr. X's arms are in the forward position.

TIP Sometimes the arms will rotate in parallel, instead of in opposite directions. If this happens to you, select and rotate each arm individually.


9 On the Copy/Paste rollout, click Copy Posture, and name the posture Arms Forward.

10 Paste the copied postures to set keys for the arms on these frames:

- Frame 30: Arms Out

■ Frame 45: Arms Forward
■ Frame 60: Arms Out
■ Frame 75: Arms Forward
■ Frame 90: Arms Out

- Frame 105: Arms Forward

■ Frame 120: Arms Out

11 Turn off
Auto Key
(Auto Key).

## Play the animation:

1 Select all the parts of the biped, and right-click and choose Hide Selection.

2 Select the mesh. On the


Modify panel, turn on the MeshSmooth modifier by clicking the light bulb to turn it on.

3


Stop the animation when you are done watching playback.
4 Save the scene as my_drx03_freeform.max.

## Save a motion clip:

When you're happy with the results of the animation, you want to save it so that in the future you can apply the motion to other bipeds in other scenes. When you save a motion, it is saved in the .bip file format, the native format for biped character movement.

1 Right-click a viewport and choose Unhide All.
2 Select any part of the biped.

3 On the Biped rollout, click


3ds Max displays the Save File dialog.
4 Specify a folder where you are storing your motion files, such as a new \character_animation\motions folder.

5 Type my_kneebends as the file name and click Save.
The motion is saved as a BIP file.
To learn more about freeform animation, see the tutorial Freeform Animation on page 907.

## Animating the Biped with Footsteps

Now that you're familiar with freeform animation, you'll learn the basics of footstep animation. Footstep animation only controls the placement of the biped's feet. In this lesson, you'll create a footstep animation where Dr. X walks for eight steps.
You can see what your animation should look like by viewing the preview animation, dr_x_walk.avi, in the folder \sceneassets $\backslash$ renderassets $\backslash$.


## Set up the lesson:

1 Once again,
 open $d r_{-}$x_03.max in the \character_animation\quick_start folder.
This scene contains Dr. X with Physique applied to the mesh, and all envelopes adjusted. The mesh is ready for animation.


2 Press the H key and choose DoctorX from the object list.
3 In the Perspective viewport, right-click the mesh and choose Hide Selection from the quad menu.
Hiding the mesh makes it easier to select the biped and test the animation. This is especially true if you have a highly detailed mesh.


4 Press the H key again and choose DrX Biped, the center of mass.

## Create the footsteps:

Now you'll make Dr. X walk forward in a straight line.

1 Go to the Motion panel.

2 On the Biped rollout, turn on :8 (Footstep Mode). Using the rollouts that now display, you'll create footsteps for Dr. X.

3 On the Footstep Creation rollout, click (Create Multiple Footsteps).
3ds Max opens the Create Multiple Footsteps: Walk dialog.

| General |  |  |
| ---: | ---: | ---: |
| Start Left $C$ | Number of Footsteps: | $\boxed{4}$ |
| Start Right $\varsigma$ | Parametric Stride Width: $\sqrt{1.0}$ |  |
| Alternate $\bar{V}$ | Actual Stride Width: $\sqrt{0.11 \mathrm{~m}}$ |  |
|  | Total Distance: $\sqrt{0.68 \mathrm{~m}}$ |  |


| OK |
| :---: |
| Cancel |
| Default |



4 In the General group, increase the Number Of Footsteps to 8, then click OK.

5 On the Footstep Operations rollout, click
Footsteps).


When the footstep keys are created, Dr. X changes his pose.


6 Click - (Play Animation). You can also scrub the time slider to examine the animation more closely.


By just watching the biped walk, you can tell that Dr. X's walk doesn't look right. You can see that the feet are too close together, and his arms are straight down at his side. In addition, the shoes and hands will collide or intersect with other body parts when the mesh is displayed again. Next, you'll do some fine tuning to make Dr. X's walk look better.

## Fine-tune the animation:

In this part of the lesson, you'll make a few adjustments to clean up the animation.

1 If you don't see footsteps outlined in front of Dr. X, do the following:

- On the Biped rollout, click the gray expansion bar below the buttons. Additional buttons appear.

■ In the Display group, click $\quad$ (Show Footsteps And Numbers).

2 In the Perspective viewport, zoom out, if necessary, to see all the footsteps. Drag a selection window around all the footsteps. Be sure to include the two footsteps under the biped's feet.
The footsteps turn white after they're selected.
NOTE Because you're working in Footstep mode, only the footsteps can be selected, so you can drag over the biped without fear of selecting other objects.

3 On the Footstep Operations rollout, turn off Length and increase the Scale to 2.5 .


The biped's stance widens to more closely match how it looked in Figure mode. However, now that the stance is wider, the hands will intersect the legs when the mesh is unhidden. You'll fix that next.

## Rotate the arms:

With the wider stance, the hands intersect the legs as they swing past. Now you'll do a little freeform animation to give the arms some clearance.

2 Press the H key and select DrX Biped L Upperarm.

3 In the Track Selection rollout, click A8 (Symmetrical). Notice the keys in the time line. At each of the keys, you'll rotate the arms.

4 Turn on
Auto Key
(Auto Key) and
| a 테 click the right arrow on the time slider.
The time slider jumps to frame 30.

5 On the main toolbar, click
(Select And Rotate).
6 On the Coordinate display, in the Y field, enter 12.
The arms are rotated out away from the body.


TIP Sometimes the arms will rotate in parallel, instead of in opposite directions. If this happens to you, select and rotate each arm individually.

7 Continue clicking the right arrow on the time slider to jump to the next key and repeat the same amount of rotation for each key on the time line.
Don't forget the key at frame 0 .

8 Turn off Auto Key
(Auto Key) to end the animation process.

9

- Play the animation.



## Save the motion in a BIP file:

You can save the footstep motion for later use in other scenes.

1 On the Biped rollout, click


The Save File dialog displays.
2 Specify a folder where you are storing your motion files, such as a new \character_animation\motions folder.

3 Type my_DrXWalk as the file name, and click Save.
The footstep motion is saved in the BIP file.

## Prepare for playing or rendering:

1 Press the H key. In the Select From Scene dialog, click

(Select All), then click OK.

2 Right-click the biped and choose Hide Selection.

The biped is now hidden.
3 Right-click again, and choose Unhide By Name from the quad menu. The Unhide Objects dialog displays.

4 Select DoctorX from the list and click Unhide.
Dr. X's mesh is unhidden.
5 Click the mesh to select it.

6 On the


Modify panel, make sure the MeshSmooth modifier is turned on (the light bulb icon should be white).

7 Click the Perspective viewport and then click


- (Play Animation).


8 Save the scene as my_drx03_footsteps.max.

## Combining Motions with the Motion Mixer

In this lesson, you'll use the Motion Mixer with the two motion files you've just created. The Motion Mixer lets you create a smooth transition between Dr. X doing his deep knee bends and walking.

Set up for this lesson:

- Once again,

open $d r_{-} x_{-} 03 . m a x$ in the folder \character_animation \quick_start \.
This scene contains Dr. X ready for animation.



## Open the Motion Mixer:

The Motion Mixer is like a sound mixer, except here you work with animation files instead of audio files. You'll add motion clips, which are .bip files, to the Motion Mixer, and create transitions between the clips to blend them smoothly together.

1 Select any part of the biped.

2 Go to the Motion panel.

3 On the Biped rollout, turn off
4 On the Biped Apps rollout, click $\quad$ Mixer (Mixer).
3ds Max opens the Motion Mixer window.


The biped is automatically displayed in the Mixer. It has a default trackgroup labelled All, where you will start laying out your tracks, motion clips, and transitions. The label All indicates that motions placed on tracks will apply to the entire biped, rather than specific body parts.

TIP The Motion Mixer window can be resized. For better viewing of what's added to the Mixer, you can drag the edge of the window vertically and horizontally.

Opening the Motion Mixer also automatically turns on the Mixer Mode button on the Biped rollout.

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When Mixer Mode is on, the biped performs the motions in the Motion Mixer.

## Add the clips to the Mixer:

Trackgroups are populated by tracks, in the form of Layer tracks or Transition tracks. On each track, you add clips and transitions. The final product of your efforts is called a mix.

Here, you'll add two clips to the trackgroup with a transition between them.
1 Click the topmost track on the All trackgroup to select it. The track turns a lighter gray color when selected.


By default, the topmost track is a layer track, which is designed for consecutive clips with no transitions between them. You want to create a transition between two clips, so you'll need a transition track.

2 On the Mixer menu bar, open the Tracks menu and choose Convert To Transition Track.


The track is changed to a transition track that is taller than the original, with room for two tracks and a transition.

TIP You can right-click the track to access the same menu options.

3 From the Tracks menu, choose New Clips $\boldsymbol{>}$ From Files.


3ds Max displays the Open dialog.
4 If you've done the two previous lessons and want to use the motions you created, browse to the folder where you saved your motions, and choose $m y \_k n e e b e n d s . b i p$. Otherwise, browse to the folder \sceneassets \animations $\backslash$ folder and choose kneebends.bip.

The clip holding the knee-bend motion is added to the track.
5 Right-click a blank area of the transition track, and choose New Clips From Files from the pop-up menu. Choose the file my_drxwalk.bip or dr_x_walk.bip.
The second clip is added to the track, and a transition is automatically added between the two clips. The transition is colored with a darker version of the clip color, and spans the transition time between the two clips.

|- - ㅁ
6 On the Motion Mixer toolbar, click (Zoom Extents) so you can see the entire mix in the display.


7 On the Motion Mixer toolbar, click

(Set Range).
This feature automatically sets the length of the animation to the number of frames needed for the mix. In this case, it sets the animation length to 225 frames.


## Play the mix:

You've just created a basic mix comprised of two clips and a transition. Now you'll play the animation.

## 8

1 On the Biped rollout, turn on
(Mixer Mode) if it's not already on.

2 Click - (Play Animation). Watch the animation in the viewport and its progress in the Mixer window.
Dr. X does his knee bends in the first clip.


He smoothly transitions to walking in the second clip.


The feet slide a little during the transition. This problem can be fixed with the Mixer, but that's beyond the scope of this tutorial.

3 Save the scene as my_drx03_mixer.max.
TIP If you want to render this animation, hide the biped, select the mesh, and turn on the MeshSmooth modifier on the Modify panel before rendering.

## Summary

This tutorial introduced you to some of the essential components of character studio: creating a Biped system, using the Physique modifier to skin the Biped, animating the Biped in both freeform and footstep modes, and using the Motion Mixer to combine animated clips that have already been created.

## Animating with Footsteps

Footstep mode uses a unique footstep gizmo to control the contact of the foot with the ground. When you move a footstep gizmo to a new location, the animation updates to match the move.


In this tutorial, you will learn how to:

- Animate a biped using footsteps.
- Make a biped walk, run, jump, and follow uneven terrain.
- Change the duration of a footstep animation using IK keys.

Skill level: Beginner
Time to complete: 1+ hours

## Creating a Distinctive Walk

In this lesson, using automatically created motion as the basis, you'll animate a biped walking with a rolling, springy step.


The automatic footsteps generate a starting point for you. You'll then change the automatic walk into something more expressive and distinctive. This sophisticated yet simple approach results in a natural-looking motion that you can create quickly.

## Set up the lesson:

1 Reset 3ds Max.

2 On the Quick Access toolbar, click

(Open File), navigate to the \character_animation\footstep_animation folder, and open walk_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

In this file, a biped is standing near the origin.


Biped near origin of grid.

3 Switch to Local coordinates, if they are not already active.


4 Maximize the Perspective viewport by pressing Alt+W.
5 Click any part of the biped to select it.

A white box outlines the selected body part.

6 Go to the
Motion panel.
The Biped controls are displayed.
Next you'll turn on Footstep Mode. If Figure Mode was on, it turns off automatically.

## Create multiple footsteps:

1 On the Motion panel $>$ Biped rollout, turn on (Footstep Mode).

2 On the Footstep Creation rollout, click (Create Multiple Footsteps).

3 In the Create Multiple Footsteps: Walk dialog > General group, change Number Of Footsteps to 8, then click OK.
Footprints are displayed in white in the viewport. These are inactive footsteps. They do not yet control any animation for the biped. If you click the Play Animation button, the biped won't move.


4 In the Footstep Operations rollout, click (Create Keys For Inactive Footsteps).
The footsteps are activated. Animation keys are created for the biped.

5



The biped takes a step.


The biped takes another step.


The biped keeps on walking.

6 On the Biped rollout, turn off the Footstep Mode button.
Notice that the first footstep is numbered 0 , and the last footstep is numbered 7 .


7 In the Track Selection Rollout, click (Body Horizontal), if is not already turned on. This selects the horizontal position track for the center of mass (COM) object.
The track bar displays keys for the length of the animation.


Body Horizontal keys

8


The biped walks, but without much character.
In the following procedures, you'll begin individualizing the motion by adjusting the keys for the Body Horizontal, Vertical, and Rotation tracks. You'll exaggerate the rotation of the center of mass to create a more energetic walk.

## Adjust body rotation keys:

$\square$
1 In the Perspective viewport, click ViewCube) to shift the view so that the biped is walking toward you. Then drag the time slider to frame 0 .


Be sure that a part of the biped is still selected. In the Track Selection rollout, click (Body Rotation).

2 Right-click the track bar, and from the pop-up menu choose Filter Current Transform.
Now the track bar displays the rotation keys.

|게터
3 On the 3ds Max status bar, click (Key Mode Toggle) button to turn it on.

Key mode lets you use Previous and Next Key buttons to jump between keyframes for the selected object. You can also use the < and > keys on the keyboard to move between keyframes without clicking the mouse.

4 Press > on the keyboard to advance the time slider to frame 24.
5 Use the Transform gizmo to adjust the body rotation. Move your cursor over the gizmo; when the circle turns yellow and the X in the center turns red, click and drag to rotate. If you can't see the X , zoom into the viewport. Rotate $\mathbf{5}$ to $\mathbf{1 0}$ degrees about the X axis to move the hips down toward the leg that is in motion. When you rotate, one foot will cross the other.

TIP The rotation is displayed in yellow text above the Transform gizmo, and also in the Coordinate fields on the status bar. You can use the plus (+) and minus (-) keys to change the size of the Transform gizmo.


Rotation of the center of mass object about the $X$ axis.

6 On the


Motion panel $>$ Key Info rollout, click
(Set Key).
When you set the key, the biped will shift position slightly. In the viewport, you can see that the blue foot is no longer crossing the green.


Biped foot snaps away from the other foot.

What is happening is that the foot, calf, and thigh bones are being controlled by the footstep gizmos. The footsteps represent a pair of keys with IK Blend set to 1 and the Join To Prev IK key turned on. When you set the key, these settings force the foot, calf, and leg bones back into the correct path for walking.

7 Click Next Key three times to move to frame 40.
8 Rotate the Transform gizmo -6 to $\mathbf{- 1 0}$ degrees about the X axis.


Negative rotation with blue foot in contact with the ground.

9 Slowly go through the rest of the rotation keys, repeating this process. At keys where the blue foot comes in contact with the ground (frames 40, 69, and 99), rotate about the X axis in a negative direction, then set a key. At keys where the green foot is down (frames 54, 84, 116), rotate about the X axis in a positive direction, then set a key.


Positive rotation at frame 54.

10 Repeat this pattern until you have finished rotating the COM at the end of the animation. Don't make your adjustments too precise. Slight variations from frame to frame make the motion look more natural.
When you are done, play the animation and notice the increased hip swings that result from rotating the center of mass back and forth.

11 On the Biped rollout, click
(Save File) and save the file as mywalk.bip.
If you load the newly saved mywalk.bip file into a scene containing a skinned character, the character will swing its hips according to the instructions you saved in this file. Play the animation to determine if you need to adjust it. For instance, Dr. X (from the quick start tutorial) has huge feet, which may need to be moved further apart so they don't pass through the legs accidentally.


Dr. X character with distinctive walk.

## Add spring to the step:

1 Continue from before, or load the mywalk.bip file that you saved earlier.

To load a BIP file, create or select a biped. On the
Motion panel

Biped rollout, click
 (Load File), and open the file. This transfers all the movement information in the file to the biped.

2 On the Track Selection rollout, click $\xlongequal[\text { (Body Vertical). }]{\text { \& }}$ This selects the vertical position track for the center of mass object.

4 Starting at frame 0, move through the animation using the $<$ and $>$ keys. When you come to a frame where either a green or blue foot comes in contact with the ground, move the COM down just a few units.
The knees bend because the feet are controlled by the footsteps.

5 After making a change at a frame, click
(Set Key) on the Key Info rollout.

This sets a key for the change you've made in the viewport; otherwise, the change is discarded.

6
」 Play the animation.
The biped walks with newfound bounce.

7 On the Biped rollout, click
(Save File). Name the file mywalk2.bip.

## Add arm and hand motions:

Arm and hand motions are an integral part of an individual's gait. In the following sequence, you'll customize the arm motion by moving the hands and rotating the arms.

You previously created keyframes using the Set Key button; however, for this technique, you'll use Auto Key instead.

1 Continue from before, or load mywalk2.bip, the file you saved in the previous section.

If you prefer, you can begin at the end of the last procedure by opening springystep.max.

2 Turn on Auto Key (Auto Key).

3 Drag the time slider to frame 0.
4 Dragging the time slider to the right, flip through the frames of animation. Drag forward and backward, and watch the how the arms and legs swing. Study the motion carefully.

When the green foot is extended, the blue arm swings forward. When the blue foot swings out, the green arm swings forward. See if you can find the frame at which the hand extends the farthest forward.

5 In the viewport, select the green hand of the biped (Bip01 RHand). The track bar displays the keys for the hand.

6 Drag the time slider to frame 30.
There is a key in track bar at that frame for the hand object.
7 Right-click the hand, and choose Move from the quad menu.
Using the Transform gizmo, move the hand approximately 10 units upward on the Z axis.

By moving the hand, you've also rotated the two arm bones. The keys for the hand and arm bones are stored on a single track.


The hand moved upward.

8 Select the Bip01 R UpperArm object, then right-click and choose Rotate. Rotate the upper arm approximately $\mathbf{- 3 0}$ degrees about the Z axis.


The upper arm rotated around the Z axis.

9 Rotate the upper arm approximately $\mathbf{2 0}$ degrees about the Y axis, so the elbows are flying out and away from the body.

10 Select the forearm object (Bip01 R Forearm) and rotate it so the hand moves closer to the chest.


The hand rotated close to the chest.

You can position the arm using forward kinematics (the rotation of the parent objects) or inverse kinematics, using position transform on the end of the chain: in this case, the position of the wrist. You can also rotate the hands.

11 Use
 - (Orbit) to adjust the view angle so you can see the angle of the other arm behind the biped.


View of the arm behind the biped.

12 Select the blue hand, and right-click to choose Move. Move the hand further away from the biped's body. Then move the blue hand upward on the Z axis so the elbow bends slightly.


13 Scrub the time slider back and forth to observe the animation so far.
14 Repeat the process at frames 60 and 90.
15 Repeat for the other side at frames 45 and 75.
TIP If you want exact duplication of these arm positions, you can use the tools in the Copy/Paste rollout. Select both arm assemblies, create a collection, then use Copy Posture and Paste Opposite at the correct frames. See Creating a Simple Freeform Animation on page 908 for information on using those features.

- Play the animation.

回
Save it as mywalk3.bip.

17 To see your work on a skinned character,

Eopen $d r$ _ $x_{-} 03 . m a x$ from the folder \character_animation \quick_start \folder, and then load your mywalk3.bip file. For comparison, you can also load distinctive_walk_final.bip from the folder \sceneassets \animations $\backslash$. Remember to select part of the biped to access the Biped rollout.


Dr. $X$ with spring in his step.

## Add head motions:

You can edit the head motion to make the biped's walk look more natural. In this procedure, you'll add head rotations to accentuate the COM rotation.

1 Turn on Auto Key (Auto Key), if it isn't on already.

2 Turn on
(Key Mode Toggle), if it isn't on already.
3 Drag the time slider to frame 0 .

4 In the Perspective viewport, select the biped's head using

(Select And Rotate).

5 Rotate the head down as if the biped is asleep.


The head rotated downward.

6 Advance the time slider to the next keyframe by pressing the $>$ key.
7 Keyframe rotations for the head. You can rotate the head to counterbalance the angle of the shoulders. Or, you can rotate the head in the opposite direction so it follows the rotation of the COM. Each
rotation will give a different result. Extreme rotations should be avoided. Also, be careful to put the rotations only on existing keys.


Rotate the head to follow the movement, or rotate the head to oppose the shoulders.

8 Continue to jump through the head's keys, setting rotations of your choice to animate the head.
Natural head motion is smooth, so the orientations should change gradually from one key to the next.


10 Play the animation, and notice how much the biped's head movements add to the animation.

You can now save your work as mywalk4.bip. You can check your file against head_rotate_with.bip and head_rotate_against.bip. Both these BIP files are in the folder \sceneassets \animations $\backslash$.


Dr. X's distinctive walk with head rotation.

To see a finished version of the walk, you can go to $\backslash$ scenes \character_animation $\backslash$ footstep_animation and open distinctive_walk.max.

## Modifying Footsteps

In this lesson, you'll learn how to copy and paste biped footsteps to extend an animation. You'll also learn how to adjust and bend the steps, and to produce the effect of walking on uneven terrain. You'll also make the biped take a jump.

## Set up this lesson:

- Continue from the previous lesson, or
 paste_footsteps_start.max. This scene is in the folder \character_animation $\backslash$ footstep_animation $\backslash$.


## Extend the walk:

1 Select any part of the biped.

2 On the
Motion panel
Biped rollout, turn on
 (Footstep Mode).
The Footsteps sub-object level is activated, and only the footsteps can be selected.

3 Activate the Top viewport, then press Alt+W to maximize it.

4 Using
(Select And Move), region-select footsteps 3 through 7.

5 On the Footstep Operations rollout, click
 (Copy Footsteps) to place the selected footsteps into the footstep buffer.

6 Click (Paste Footsteps) to paste the selected footsteps into the viewport.
The new footsteps appear next to the biped's current footsteps.


## Pasted footsteps appear.

TIP If you have Transform gizmo on, use the minus key (-) to shrink the Transform gizmo, so it doesn't cover up the footsteps.

7 The new footsteps can be moved as a set. Move them so the first footstep of the new set is over footstep 7 of the original set. When footstep 7 of the original set turns red, release the mouse button.
Footsteps from the original motion are inserted. Now there are 11 footsteps visible.

8 Press Alt+W to display four viewports.
9 To display the entire animation in the Perspective viewport, zoom out and adjust your view until the biped and all 11 steps are visible.


Pasted footsteps extend the motion.

10 With the Perspective viewport active, play the animation.
Since you are still in Footstep mode, the Motion panel is available. This
is a good time to save your mywalk_pasted.bip file, using Save File on the Biped rollout.

## Scale the walk:

1 Make sure that (Footstep Mode) is on.

2 In the Top viewport, region-select all the footsteps.
3 On the Footstep Operations rollout, turn off Length, and leave Width selected.

4 Set Scale to 2.0 to double the spacing between the left and right footsteps.

5


- Play the animation.

The biped walks with legs apart.
6 Set Scale to $\mathbf{0 . 2 5}$ or smaller to reduce the spacing between the left and right footsteps to half of the original scaling (one-quarter the current setting).

If you hadn't previously doubled this parameter, a setting of 0.5 would have scaled the width by $50 \%$.

Now the biped puts one foot in front of the next.
TIP If your character has big feet, or if it's walking on a wire or a ledge, use Scale Width and Length to adjust the footsteps.


Scale the width between the steps.

7


The biped walks as if on a tightrope.

## Bend the walk:

1 In the Top viewport, select all the footsteps from 7 on.
2 On the Footstep Operations rollout, set Bend to 20.0.
The footsteps bend to the left, beginning at footstep 7.
3 Play the animation.

Walk on uneven terrain:
You can raise and rotate the footsteps to create the illusion of walking on uneven terrain.

1 Make sure that Footstep mode is still on.
2 Maximize the Perspective viewport.

3 Use
(Select And Rotate) to select all the footsteps from 4 on.
4 Use the Transform gizmo arrows to rotate the selected footsteps approximately - $\mathbf{1 5}$ degrees about the X -axis so the footsteps go up a hill.

5 Select footsteps 8 through 11.
6 Rotate the selected footsteps about the X-axis approximately 21 degrees, so that the footsteps go back down the hill.

7 Select footstep 11. Rotate it so it's parallel with the grid.
8 Play the animation.
The biped's feet follow the footstep placement.

## 10 ${ }^{2}$ <br> 8 <br> 

## Add a jump:

If there is a period of time during a footstep animation when neither foot is on the ground, the software interprets this period as a jump. There are several different ways to create a jumping animation. In this set of procedures, you'll move footstep keys in Track View to make the jump.


Open footsteps_jump_start.max.
This is a slightly longer version of the same file you've been working on. It has 15 footsteps instead of 11 .

## Move footstep keys in Track View:

1 Select Bip01. On the


Motion panel $\boldsymbol{>}$ Biped rollout, turn on -
(Footstep Mode), if it isn't already on.
2 In the viewport, right-click and choose Curve Editor from the quad menu. Track View is displayed.

3 On the Track View menu bar, choose Modes > Dope Sheet. Pan the controller window until you can see the Bip01 Footstep track displayed in Track View. Expand the Bip01 Footstep track


Dope Sheet shows special footstep keys.

In the Dope Sheet display of footsteps, each blue block represents a left footstep, and each green block represents a right footstep. The length of the blocks is the period of time that the foot is in contact with the ground during the footstep. The spaces between the blue and green blocks represent periods in which the biped is not supported by the left or right foot.

4 Resize the Track View window, or zoom into the track so you can see the start and end frame numbers on each footstep.

5 Select footsteps 11 through 15 by drawing a box around them in Track View, or by dragging a selection region in the viewport.
In Track View, notice that footstep number 11 starts at frame 165.

6 On the Track View toolbar, click


7 In Track View, click in the center of footstep 11 and drag it to the right until the number 166 (indicating the first frame of footstep 11) increments to number 180. Release the mouse button.
This creates a gap between step 10 and 11 . The keys in the other biped tracks adjust to the change in the footstep track.

| $\begin{gathered} 018 \\ 0^{18} \end{gathered}$ | $\begin{array}{r} 30 \\ 2 \end{array}$ |  | 60 |  | 90 6 |  | $\begin{array}{r} 120 \\ \mathbf{8} \end{array}$ |  | $\begin{array}{r} 150 \\ 10 \end{array}$ | $\begin{aligned} & 195 \\ & 0120 \end{aligned}$ |  | $\begin{aligned} & 225 \\ & 0140 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $0^{0} \quad 1$ | 34 | ${ }^{45}$ |  | 75 |  | 105 7 |  | $\begin{array}{r} 35 \\ \mathbf{9} \end{array}$ |  | $\begin{aligned} & 180 \\ & 0110 \end{aligned}$ | $\begin{aligned} & 210 \\ & 0130 \end{aligned}$ | $\begin{aligned} & 240 \\ & 0150 \end{aligned}$ |

The keys shifted to the right to create a gap.

By creating an area in the footstep track where neither foot is supporting the biped, you have changed a walking step into a jumping step

8 Minimize Track View and then play the animation.


The gap between footsteps creates a jump.

9 In the viewport, move footstep 10 so it is next to footstep 9.
10 In the viewport, move footsteps 11 through 15 so there is more of a gap for the jump. Move these footsteps about 5-7 units in the X-axis direction.


More gap for the jump.

Now, if you shorten the duration of footstep 10, you can accentuate the jump.

11 On the Track View toolbar, click
 - (Move Keys).

12 In Track View - Dope Sheet, click the right edge of footstep 10.
A white dot appears only on the right side of the key to show it's selected.
13 Drag the right edge of footstep 10 to the left to shorten the duration of the key. Change the key so it ends at frame 160.

| 150 |  | 160 |
| :---: | :---: | ---: |
|  | 10 | 0 |

[^6]14 Play the animation and observe the jump.
15 Turn off Footstep Mode.

## Make the biped crouch before the jump:

The preparation for the jump, between footsteps 9 and 10, looks a little stiff because the biped is not crouching enough before jumping. Resetting a vertical key will fix this problem.

1 On the Motion panel > Track Selection rollout, click (Body Vertical).

2 Drag the time slider to frame 153, where there is a Body Vertical track key.

3 Press H and select Bip01, the center of mass.
4 Move the center of mass down approximately -5 units. Then on the Key

Info rollout, click (Set Key).
If the biped jumps back to its original position, click Set Key and try again. Click Set Key when you have a crouching position as illustrated here.


Lower the center-of-mass object using the Body Vertical track.

5 Scrub the time slider to view the animation.
There appears to be a glitch in the motion. There are two Body Vertical keys next to each other that are causing this problem.

6 Drag the time slider to frame 153.

7 On the Key Info rollout, click (Next Key) to move to the next key at frame 154. Then click
 (Delete Key) to remove this second key.

8 Select Bip01 R Foot.
9 Drag the time slider to frame 167. Click Body Vertical and raise the foot slightly, so the biped's knee is bent.

10 On the Key Info rollout, click $\therefore$ (Set Free Key) to hold the bent knee position. Set additional keys on the foot if it hyperextends before it hits the ground, or if it goes through the ground at takeoff.

11 Play back the animation and observe the motion.

12 On the Track Selection rollout, click

O(Body Rotation). Drag the time slider to frame 160. Using the Transform gizmo, rotate the center of mass so the body pitches forward.
The jump looks more natural now. The result should be similar to the jump in footstep_jump_final.bip, which is in the folder \sceneassets $\backslash a n i m a t i o n s ~ \ . ~$


## Making a Biped Stop and Start Walking

In just a few key strokes, you can generate multiple footsteps to make a biped walk. But what if you want the biped to stop and pause? To do that, you'll use a simple manipulation of the footstep keys in the Track View - Dope Sheet. Just stretching the length of the selected footsteps changes the animation so the biped pauses in its path.

Set up the lesson:


Make the biped stop and start:
1 In the viewport, select any part of the biped.

2 Go to the Motion panel.
The Biped controls are displayed in the rollouts.

3

- Play the animation of the biped.

The biped walks seven steps forward without stopping.


You'll use footsteps 4 and 5 as the footsteps where the biped pauses.

4 On the Biped rollout, turn on
5 In the Perspective viewport, select footsteps 5-7, then right-click and choose Move.

6 Move the footsteps so that footstep 5 is next to footstep 4.


7 Play the animation to observe the change.
The animation looks a little funny right now; something's not quite right.
It's good practice to deactivate the footsteps, and then create new keys from the moved footsteps. This will recreate the correct upper body motions. You'll do that next.

## Create keys to correct upper body motions:

1 In the viewport, select footsteps 4-7. On the


To manipulate the footstep keys, you'll use Track View in Dope Sheet mode.

2 On the 3ds Max menu bar, choose Graph Editors > Track View - Dope Sheet.

3ds Max displays the Dope Sheet.
3 In the controller window, expand the Bip01 Footsteps > Transform track, and click to highlight it.
You should see the footsteps in the keys window.
4 Right-click the top of the Track View window and choose Dock Bottom.

The Dope Sheet moves out of the way of the viewport.
5 Make adjustments as needed to your viewport so you have a clear view of the footsteps and the biped. When you select footsteps in the viewport, you also select footstep keys in Dope Sheet.

6 Select footsteps 4-7 in the viewport, if they aren't already selected.
In the Dope Sheet, the selected keys appear in a brighter color, with white dots on them.

7 Hold down the ALT key and click the white dot at the left side of footstep key 4. This deselects the left side of that footstep key. Repeat for key 5, deselecting the left side of the key.
Keys 4 through 7 are selected, but keys 4 and 5 display only one white dot.


8 From the right side of key 5, drag to the right so the key ends at frame 200.


9 On the keyboard, press ALT+R to extend the animation to match the footstep keys.

Frames are automatically added to the animation.


The light grey background extends behind the footstep keys. The time slider now shows that there are 230 frames in the animation.

10 Play the animation and observe the biped motion.
The biped walks, then stops and waits, and then walks again. The motion seems a bit odd, though, as he steps off around frame 180.

TIP There are a number of different ways to play and observe biped motion. One way is to drag the time slider to play the animation. For more control, press the < and > keys on the keyboard. This lets you stop instantly if you see a problem, and is more like a traditional animator flipping through the pages of drawings.

11 On the Footstep Operations rollout, click
Footsteps).
12 Play the animation again.
The motion is better. When new keys are created, 3ds Max applies a new upper-body motion.

TIP For this reason, when you animate starting with footsteps, work out the foot motion before you worry too much about the upper body motion.


13 Save your work as my_standstill.bip.

You can
 scene.

## Changing Footsteps Using IK Keys

Footstep and Freeform modes both use the same underlying inverse kinematics (IK) to animate the biped skeleton. Footstep gizmos are a method for manipulating sequences of IK keys.

With inverse kinematics, you animate a hierarchy, such as a biped's leg, by animating a lower link in the hierarchy: for example, the biped's foot. Inverse kinematics is the opposite of forward kinematics. Forward kinematics doesn't use the hierarchy; for example, you might animate a leg by rotating the thigh.

In this lesson, you'll learn how changing the IK keys affects the footsteps.

## Set up this lesson:



Open footsteps_keys_start.max.
A biped is displayed with four footsteps in the viewport.


## Set IK Keys to create footsteps:

1 Scrub the time slider to play the animation.
The biped hops on his right foot. Notice that there is no footstep for the right foot between footsteps 2 and 3 .


2 At frame 45, select Bip01 R Foot.

3 On the
 Planted Key).
The pivot point is displayed in the viewport. If you can't see it, change to Wireframe viewport shading, or navigate the viewport so you can see beneath the heel.

| $\boldsymbol{a}_{1}$ 어
4 On the 3ds Max status bar, turn on
(Key Mode Toggle).
5 Click
(Set Planted Key).
The pivot point shifts to the toe.


Note that the lowest IK pivot is selected by default for cases where IK is applied to new keys.

6 At frame 54, click (Set Planted Key).


The biped is moved back to the ground. A footstep is displayed beneath the biped's foot.
A footstep has been created, because there is now an interval of time where IK is applied between the two planted IK keys. However, if you drag the time slider to play the animation, you will see that the walk still needs work.

## Change the duration of footsteps using IK keys:

 1 At frame 60, click (Set Planted Key).2 Play the animation now. The walk cycle is much better.
3 Right-click the foot and choose Dope Sheet.

4 On the Dope Sheet tool bar, turn on already.

5 On the Biped rollout, turn on ?
(Edit Keys) if it is not on the track in Dope Sheet.

6 Expand the Bip01 Footsteps > Transform track. Notice that footstep 3 extends for 15 frames, from frames 45 to frame 60.

7 5 Turn off Footstep Mode.

8 Select Bip01 R Foot once more.
The keys for the foot are displayed in the Dope Sheet

9 At frame 63,
 set another planted key.

## 10 Turn on


(Footstep Mode).
The Dope Sheet editor again displays the Footsteps track.
The duration of the footstep now is 18 frames, from frames 45 to 63 .

| 45 |  | 63 |
| :--- | :--- | ---: |
| 0 | 3 | 0 |

11 Turn off
(Footstep Mode).
12 Close the Track View - Dope Sheet window.

## Remove footsteps using IK keys:

By editing IK keys, you can remove footsteps as well as add them.

1 At frame 45, select the Bip01 R Foot object in the viewport, then set a free key.

2 At frame 48, set a free key.

3 At frame 54, set a free key.

NOTE The body vertical position is modified. The biped now floats up into the air at frame 54.

4 At frame 60, set a free key.
The footstep disappears.
There is only one IK key left. With no IK interval defined, there is no duration, and therefore no footstep. The result is that the biped hops between footsteps 2 and 3.

The animation could be made more realistic by adding arm movement to the hopping steps, or by creating a freeform period for the hop, then adding poses for a crouch, spring and landing. The point of this lesson, however, has been to demonstrate that footsteps can actually be created or removed by changing the IK keys.


## Summary

In this tutorial, you learned how to animate a biped using footsteps, add upper-body freeform animation, and how to modify the footsteps to make the biped, walk, run, and jump. You also learned how to change the duration of a footstep animation using IK keys.

## Freeform Animation

This tutorial shows you how to animate a biped using the freeform technique. This technique does not use footsteps; instead, you are responsible for animating every part of the biped.

Freeform animation gives you fine control over the biped's motion.


In this tutorial, you will learn how to:

- Use planted, sliding, and free keys.
- Create a traditional walk cycle using animated pivot points.
- Create a stretchy leg and a shaky walk using Biped SubAnim controllers.
- Create animated 3ds Max bones from a biped animation.

Skill level: Beginner to Intermediate
Time to complete: 2 hours

## Creating a Simple Freeform Animation

This lesson provides an introduction to using freeform animation techniques with Biped.


In this lesson, you will animate a biped swimming in place. You'll use freeform animation methods to produce the kicking legs and arm strokes.

In order to create this motion, you'll use a combination of rotations and moves. You'll also make use of Copy and Paste Posture Opposite to animate one arm and copy its tracks to the other.

## Set up the lesson:

1 Reset 3ds Max.

2 On the
Create panel, click

(Systems).

## Create a biped and load a FIG file:

1 Click to turn on Biped (Biped), and then create a biped in the Front viewport.

2 Go to the
Motion panel.
3 Turn on (Figure Mode), then click 3ds Max displays the Open dialog.

4 Open the file tut_swimmer.fig. This file is in the folder $\backslash$ sceneassets $\backslash$ animations $\backslash$.
The biped takes on new structural elements saved in the FIG file. This simplified figure has one large toe on each foot and one large finger on each hand, and its spine contains two segments instead of four.


The biped with FIG file applied.

5 Turn off

(Figure Mode).
NOTE You cannot animate in Figure mode.

6 Select all the biped objects, and then click (Zoom Extents All).
7 Save the scene as MySwimmer01.max.

## Start a freeform animation:

You start a freeform animation by activating automatic key recording and transforming any part of the biped.

1 Right-click the Left viewport.
This activates the Left viewport without affecting the selection in the scene.

2 Press Alt+W to maximize the viewport for a closer view of the biped.
The biped should be in wireframe. Change the shading display of the Left viewport if it is not wireframe.

3 Turn on
Auto Key
(Auto Key).
The button turns red, and the active viewport is outlined in red.

4 On the
Motion panel $>$ Track Selection rollout, click
 (Body Rotation).

NOTE Activating any of the Body ... buttons on the Track Selection rollout automatically selects the center of mass (COM) object.


Rotation transform gizmo

The rotation transform gizmo lets you easily rotate an object about a chosen axis. As you move your cursor over the gizmo in the viewport,
the axis circles turn yellow, indicating the axis around which the rotation will occur:

■ The red circle, displayed as a vertical line in this viewport, affects the X axis.

- The green circle affects the Y axis.
- The blue circle, displayed as a horizontal line in this viewport, affects the Z axis.

■ The light gray circle, displayed around the green circle, allows free rotation around all three axes.

5 Move your cursor over the green circle.
The cursor turns yellow, meaning that any rotation is locked to that axis.
6 Rotate the center of mass approximately 90 degrees about the Y axis. Watch the coordinate readout near the gizmo to see how far you're rotating the biped. Rotate until the biped is lying prone.

TIP If you like, you can press A to turn on Angle Snap, which lets you easily rotate to 90 degrees.


An animation key appears at the far left of the track bar, at frame 0 .
You can select all three COM tracks under Track Selection to create keyframes simultaneously. Try this:

7 On the Track Selection Rollout, click
(Lock COM Keying), and then click
 (Body Rotation).

8 On the Track Selection rollout click to turn on both

Horizontal) and
$\ddagger$ (Body Vertical).
All the multiple tracks for the COM are now active.


9 Expand the Key Info rollout and click
(Set Key).
This sets keys for all the COM tracks at frame 0 . The trackbar key shows a multi-color display, indicating that both position and rotation keys have been created.

10 Click Lock COM Keying again to unlock the COM tracks.
TIP It's a good idea to set a key at the start of your animation for the three COM tracks.

## Pose one leg:

Now that the biped is prone, you're ready to animate the swimming motion. First, you'll position the legs. You'll work on the right leg first, setting up its position at frame 0 .

1 Press Alt+W so you can see all four viewports again.
2 Select Bip01 R Thigh by clicking the lines of the thigh in the Left viewport.

TIP As you hold your cursor over an object in the viewport, the object's name is displayed in a tooltip. You can also select an object by pressing H to choose objects from the selection list.


The right thigh is selected.

3 Rotate Bip01 R Thigh approximately - 30 degrees about the Z-axis. The right leg is rotated, but the right foot is pointing straight down.


4 Press Page Down twice to select the right foot.
TIP The Page Up and Page Down keys let you quickly navigate through the objects that make up a biped.

5 Rotate Bip01 R Foot about -50 degrees around the Z-axis. The foot looks more natural in this position.


So far you've used only forward kinematics to animate the biped. Next you'll use inverse kinematics by moving the foot to move the entire leg.

6 Right-click the same foot and choose Move from the quad menu.
TIP You can choose the transform tools either from the main toolbar or by right-clicking to open the quad menu.

The Transform gizmo switches to an axis tripod showing two of three arrows in this viewport. They are displayed at right angles with the $Z$ axis pointing up and the $Y$ axis pointing left.


Ready to move the foot.

7 In the Left viewport, move the cursor over the Y axis of the gizmo until it turns yellow, then move the foot a little to the right.

The knee bends to accommodate the new position of the foot.


The knee bends.

In this move, you've just used inverse kinematics. The foot, calf, and thigh are linked together in a hierarchical chain. By moving the end of the chain, the foot, you rotated the lower and upper leg objects.

8
$\square$ Save the scene as MySwimmer02.max.

## Animate the leg:

Everything you've done so far has been at frame 0 . Now you'll move forward in time and animate the pose at frame 10.

1 Drag the time slider to frame 10.

2


Move the foot downward on the Z axis until the knee straightens out.


3 Press Page Up twice to select Bip01 R Thigh.
4 Right-click and choose Rotate from the quad menu, then rotate the Bip01 $R$ Thigh approximately -10 degrees about the Z axis.


Rotating the thigh.

5 Scrub the time slider back and forth between frame 0 and frame 10. The leg moves up and down.

## Use copy and paste:

Now you'll use some specialized Biped tools to pose and animate the opposite leg.

1 Return the time slider to frame 10.
2 Double-click Bip01 R Thigh.
The entire leg is selected from the thigh down to the toes.


3 On the
Motion panel, expand the Copy/Paste rollout.
The Copy/Paste functionality includes the creation of collections. You must create a collection before you can start creating postures.

4 On the Copy/Paste rollout, click (Create Collection). This creates a collection named Col01. Rename it to Swim - Crawl.

5 Make sure that the Posture button is active.

```
Posture Pose Track
```

6 Also make sure that Capture Snapshot From Viewport is chosen. This button is just above the Paste Options group.

```
d 全 呑
```

Choosing Capture Snapshot From Viewport forces the thumbnail of the pose to be taken from the active viewport. This particular posture, for example, is better seen from the Left viewport rather than the Front.

7 Click (Copy Posture).


The posture of the right leg is copied into a buffer. Change the name of the Copied Posture to RLeg - downkick.

8 Drag the time slider back to frame 0 . Click (Paste Posture Opposite).
The left leg rotates downward. The right leg hierarchy is still selected.


9 At frame 0, click


10 Drag the time slider to frame 10.

11 Click
(Paste Posture Opposite) again.
Now the left leg is raised, and the right leg is down.


12 Scrub the time slider back and forth between frames 0 and 10 and watch the legs kick.
Now you'll repeat this process to make the legs kick several times.
13 Save the scene as MySwimmer03.max.

## Use Paste Posture to create multiple kicks:

You can use the Copy Posture tools to quickly duplicate all the leg keys from one frame to another to create repeated kicking motions.

Auto Key
(Auto Key) is still on and drag the time slider
1 Make sure that to frame 0 .

2 On the Track Selection rollout, click委 (Symmetrical). Now both legs are selected.


3 At frame 0, click
(Copy Posture). Name the copied posture $\mathbf{R}$ up L down.


Both legs are added to the collection.
4 Drag the time slider to frame 20.
TIP You can type in the frame number in the Current Frame time control.


5 At frame 20, click $\xrightarrow{\sim}$ (Paste Posture).

6 Go to frame 30 and click (Paste Posture Opposite).

From this point forward, you can click either Paste or Paste Opposite as you create a kicking cycle. For a smooth kick cycle, simply alternate the posture every 10 frames up to frame 80 . The track bar displays a total of nine keys for the animation of the legs.

7 In the Copy Collections group click the Save Collection button to save your collection. Name the collection Swim - Crawl. The CPY extension is automatically added to the name.

8 Save the scene as MySwimmer04.max.
Animating a kicking leg was fairly easy, requiring only two poses: one with the leg up, and one with the leg down. Animating the arms is more complex. To animate the stroke of an arm, you'll need five poses:

■ The arm outstretched

- The arm down
- The arm back
- The arm drawn up out of the water near the ear

■ The arm entering the water

When one arm is animated correctly, you'll use Copy Track and Paste Opposite Track to animate the second arm. You'll adjust the timing of the second arm by sliding the keys in the track bar.

## Animate one arm:

1 Make sure that

(Auto Key) is still on, and drag the time slider to frame 0 .

2 Press H. In the Select From Scene dialog, select Bip01 L UpperArm.

3 In the Left viewport,
 rotate Bip01 L UpperArm approximately -160 degrees about the Z axis, until it is extended in front of the biped.


4 Right-click the Top viewport and press Page Up to select Bip01 L Clavicle and rotate it -20 degrees about the Y axis.
This should prevent the arm from passing through the head.


5 In the same viewport, press Page Down three times to select Bip01 L Hand. Rotate it approximately -90 degrees about the X axis so the palm is facing down.


This completes the first arm pose, so it's a good time to save your data.
6 Double-click Bip01 LClavicle to select the entire left arm hierarchy.
7 Activate the Perspective viewport so that the snapshot will be easier to identify, and then click Copy Posture. Name the pose LArm extended.


8 Drag the time slider to frame 10.

9 On the main toolbar, click
(Select And Move), and then change the Reference Coordinate System to World, if it isn't already set to World.


This will facilitate working with the Transform gizmo in different viewports.

10 Right-click in the Left viewport. Move Bip01 L Hand downward on the Y and Z axes until it points straight down. This completes the second arm pose.

TIP If you grab the Move gizmo by the corner where the two axes meet, you can move selected objects on both axes at once; that is, on the YZ plane.


11 Double-click Bip01 LUpperArm to select the arm hierarchy, then click
(Copy Posture). Name the pose LArm down.
12 Drag the time slider to frame 20.

13


Move Bip01 L Hand along the Y axis toward the legs.


14 Activate the Front viewport and press Page Up three times to select Bip01

L Clavicle.
 Rotate this part about 24 degrees around the Z axis. This completes the third arm pose. Save it by double-clicking Bip01 L

UpperArm in the Top viewport to select the hierarchy, then click
 Copy Posture. Name the pose LArm back. If you activate the Perspective viewport before you copy the posture, you can adjust the viewport so the pose is clearly visible in the thumbnail.


15 Drag the time slider to frame 30.
16 Activate the Top viewport.

17


Move Bip01 L Hand in the XY plane until the hand is level with the shoulder.


18 In the Left viewport,

move Bip01 L Hand on the Z axis so it is near the ear.


19 Finally,

rotate Bip01 L Hand about the X axis so the palm is flat.

This completes the fourth arm pose. Save it to the collection by double-clicking the upper arm to select the entire hierarchy, then click

(Copy Posture). Name the pose LArm up.


20 To create the fifth pose, go to frame 37.

21 In the Left Viewport, move the Bip01L Hand object on the Y axis so it is in front of the head, and is level with the shoulders. Double-click the Bip01 L Upperarm to select the entire arm hierarchy, activate the

Perspective viewport, and then click pose LArm stroke.
(Copy Posture). Name the

NOTE The fifth pose is used to ensure that the rotation of the arm is correct going from the out-of-water pose to the extended pose.

22 Save the scene as MySwimmer05.max.

## Applying a twist pose:

You can use twist poses to correct upper arm rotations. Twist poses are primarily used to correct arm twisting, but in this case we'll use it to simply position the arm efficiently.

## 1 Turn off <br> Auto Key <br> (Auto Key) if it is on.

2 Select Bip01 L Upperarm.
3 Drag the time slider to frame 33.
4 Expand the Twist Poses rollout.
5 In the Twist Poses drop-down list, choose each pose and observe the change to the arm in the viewport.
Consider these default poses as additional copied postures that you can use to "straighten out" problems by defaulting to fixed rotations.


[^7]6 When pose 5 is selected, the arm will be rotated and positioned correctly.

Expand the Key Info rollout and click
(Set Key) to keyframe the twist pose.


Default Twist pose 5.

TIP Twist poses are designed to help you fix twisting that occurs in the mesh attached to the biped. If you go to Figure Mode, you can enable Twist Links by turning on the Twists check box, then set the number of twist links you would like for the upper arm, forearm, thigh, calf, or "horse-link" (the extra link in the Leg if Leg Links are set to 4). Unfreeze and unhide all and you will be able to see the twist bones that have been added using this method. Once the Twist Links functionality is enabled you can play with the Twist and Bias settings.

## Copy the Arm pose:

To complete the arm cycle, in the next few steps you'll copy the arm pose to frame 40.

## 1 Turn on <br> Auto Key <br> (Auto Key).

2 In the Top viewport, double-click Bip01 L Clavicle to select the entire left arm.


3 At frame 33, click (Copy Posture).

4 Advance the time slider to frame 40, and click (Paste Posture). If you see any unusual rotations or out-of-place movements, you can set additional keys to refine the animation.

5 Drag the time slider and watch the animation.

## Repeat the animation:

If the animation is going to be 80 frames in length, you'll need to repeat the arm movement.

1 Double-click Bip01 L Clavicle, to select the entire left arm, if it's not already selected.

2 In the track bar, drag a selection window around the keys for frames 10 through 40 .

3 Hold down the Shift key and copy these keys by dragging them to the right. When the first key is over frame 50, release the mouse button.

4

- Play the animation. The biped should perform two complete strokes with its left arm.


## 5 Save your scene as MySwimmer07.max.

## Add rotation to the spine:

Next you'll add some rotations for the spine to make the animation more convincing. This spine of this biped figure (tut_swimmer.fig) has only two segments. You'll rotate the large section representing the upper torso.

1 Make sure that $\qquad$ (Auto Key) is still on.


Select Bip01 Spine1.
NOTE The first spine object is Bip01 Spine. The large second spine object is Bip01 Spine1.

3 Right-click the Front viewport.

4 Drag the time slider to frame 0, and on the Key Info rollout, click (Set Key).
This sets a start key for the rotation.

5 Drag the time slider to frame 10 and

rotate Bip01 Spine1 approximately $\mathbf{- 1 5}$ degrees about the X axis. This makes the body appear to follow the movement of the arm.


Spine rotation

6 On the track bar, click the key at frame 0 to select it, then hold down the Shift key and drag a copy to frame 30 . Watch the status area to know when you are at frame 30.


The spine now rotates once in the 40 -frame cycle.
7 Select Bip01 Pelvis.

8 Drag the time slider to frame 0, and on the Key Info rollout, click (Set Key).
This sets a start key for the rotation.

9 Drag the time slider to frame 10, and rotate the pelvis a few degrees in X so it follows the movement of the left leg.


Rotate the pelvis.

10 Copy these two keys to frames 20 and 30.
TIP For the pelvis, you can also add a few degrees of rotation around the $Y$ axis, if you like.

Next, you'll copy the pelvis and spine rotation keys to repeat the motion.

11 Make sure that the pelvis is still selected, then hold down the Ctrl key and click the Bip01 Spine01 object (the large torso spine object).

12 In the track bar, drag a selection rectangle around the four visible keys.

13 Hold down the Shift key and drag the keys so the leftmost key is copied to frame 40 . Scrub the time slider back and forth to see the animation.

14 Copy the key from frame 0 to frame 80 to complete the set of keys.


The final set of Bip01 Spine1 keys.

## Animate the head:

The biped can breathe as it swims, if you animate the head rotation appropriately.

1 Make sure that Auto Key (Auto Key) is still on.

2 In the Left viewport,

select the biped's head, Bip01 Head.

3 Drag the time slider to frame 0, and

rotate the head about 70 degrees around the X axis, so the biped's left ear is pointing down.


Rotate the head for breathing motion.

TIP Watch the Perspective viewport while rotating in the Left viewport.

4 At frame 20,
rotate the head back down.


5 Hold down the Shift key and drag to copy the key at frame 0 to frame 40. Watch the status area to know when you are at frame 40.

6 Scrub the time slider to observe the head rotation. Actually, it would look better if the head were turned up at frame 30 .

7 Slide the key you made at frame 20 along the track bar to frame 30. Do not hold down the Shift key for this step.
The biped lifts and lowers its head once in the 40 -frame cycle.
TIP You can drag the time slider to frame 30, then slide the key on top of it.
8 To explore another way to copy keys, right-click the time slider.
The Create Key dialog is displayed. This lets you create keys by choosing a source and a destination.


TIP You don't have to turn on Auto Key to set keys this way.

9 Set Source Time to 30 and Destination Time to 70, and then click OK.
10 Right-click the time slider again.
11 Set Source Time to 0 and Destination Time to 80, and then click OK.

This completes the head motion, but the right arm motions still need work. That comes next.

## Animate the other arm with Copy Tracks:

Copy Tracks lets you copy and paste the animation tracks of selected objects to other objects, or to opposite body parts.

1 Make sure that Auto Key (Auto Key) is still on.
2 In the Top viewport, double-click Bip01 L Clavicle to select the entire left arm.

3 Activate the Perspective Viewport.
4 On the Copy/Paste rollout, turn on Track (Track).

5 Click (Copy Track).
The track is copied to the buffer. Name the track LArm - Crawl.


6 Click (Paste Track Opposite).


7

- Play the animation.

The biped is swimming the butterfly stroke. The two arms move together. Next you'll change the timing so the arms alternate.

8 In the Top viewport, double-click the Bip01 R Clavicle. The entire right arm is selected in the viewport.

9 Drag a box around all the keys in the track bar to select them. Slide all the keys 20 frames to the right.


The biped swimming a freestyle stroke.

10


Now the beginning and end are not quite right. The easiest way to correct this is to copy and paste poses.

Fix the beginning and end:

1 Make sure that
Auto Key (Auto Key) is still on.

2 In the Top viewport,
 double-click the Bip01 R Clavicle to select the entire right arm, if it's not already selected.

3 On the Copy/Paste rollout, click Posture (Posture).

4 Drag the time slider to frame 50, and click (Copy Posture).

5 Drag the time slider back to frame 10, and click (Paste Posture).


6 At frame 40, click
(Copy Posture), then at frame 0, click (Paste Posture).
Now the arms alternate.


To correct the other end of the animation, you can crop the animation to 80 frames.

7 In the time controls, click
3ds Max opens the Time Configuration dialog.


8 In the Animation group, change the End Time to 80. Click OK.
WARNING Do not click Re-scale Time.

9

- Play the animation.


## Save your work:

1 On the Biped rollout, click
(Save File) and save the motion as MySwimmer.bip.


## Perfecting the animation:

- If you like, you can improve the animation by adding some rotation keys to the pelvis and spine and by adding secondary motion to the feet and hands. Stagger the rotations of the extremities a few frames following the movement of the hands and feet.

To see a finished version of the swimmer, you can go to \scenes \character_animation \freeform_animation and open swim.max.

## Using Controllers with Biped

You can add controllers on top of Biped animations to create a wide variety of effects. You can use scale controllers to create stretchy legs or arms for cartoon animation, or create the illusion of breathing by adding a scale controller on the spine objects in the chest. You can add noise rotation controllers to the spine to make a biped shake while he walks, or to create twitching or random motion in the limbs or head.

Controllers can be added in the Motion panel $>$ Assign Controllers rollout, or by using the Workbench.

Although this lesson is performed with footsteps, it could have been accomplished just as easily with a freeform animation.

## Set up the lesson:



Open stretchyleg_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

## Create stretchy legs with controllers:

In this exercise, you will add a scale controller to a biped's legs to stretch them during a portion of an animation.

1

- Play the animation.

The biped walks for 10 paces, zooms to a lower level, and then walks another five steps. You'll add the scale controller, then animate the biped so that its legs stretch during the period of the downward leap.

2 Drag the time slider to frame 162, then
select the Bip01 L Thigh object, the blue leg.

3 On the Motion panel, open the Assign Controller rollout.

4 In the controller list window, expand the Biped SubAnim entry. Now you can see the three list controllers.

5 Click the plus sign (+) next to BipScaleList to expand this controller
hierarchy. Select the entry marked Available, then click
 (Assign Controller).

3ds Max opens the Assign Scale Controller dialog.
6 Choose Scale XYZ from the list, and click OK to close the dialog.

7 On the 3ds Max main toolbar, click

(Select And Scale). The Scale gizmo is visible on the thigh in the viewport.

## 8 Turn on Auto Key <br> (Auto Key).

First, you will set a key to start the stretch. You don't want the stretch to start before frame 162. You want the biped to have a normal leg (unstretched) from the start of the animation up to this frame.

9 Using the Scale gizmo, stretch the leg very slightly in the X-axis at this frame, so the final value in the Coordinate rollout is 100 (no stretch).


The leg at frame 162 (no stretch).

10 Go to frame 164, and stretch the leg so the foot reaches the footstep.


11 Go to frame 167, and again stretch the leg in the X-axis, so the foot stays on the footstep gizmo.


Leg stretch at frame 167.

12 Go to frame 169. Here, you begin to shorten the leg stretch.


Leg shortens at frame 169.

13 Go to frame 181, and stretch the leg back to normal. Adjust it visually until the leg looks correct.


Leg at frame 181 appears normal.

14


- Play the animation. The biped's back foot stays on the footstep and the leg stretches out as the biped descends to the lower set of footsteps.
For extra credit, add a scale controller to the green thigh, and stretch that leg out, roughly between frames 161 and 171.


16


Save your work as mystretchy_leg.max.

You can open stretchyleg_final.max to compare this version of the animation.

Once you have controllers added to the biped body parts, you can animate their parameters, or animate their weights. Here's an example that shows animation of parameters.

Animate the weights of SubAnim controllers:

1


2


- Play the animation.

The biped takes a few steps, pauses for a moment or two, then walks on.
3 In the Perspective Viewport, select Bip01 Spine, the lowest spine object.


4 On the
Motion panel, open the Assign Controller rollout.
5 In the Assign Controller window, expand the Biped SubAnim so you can see the list controllers.

6 Expand the BipRotationList, and highlight the entry marked Available.


7 Click
 (Assign Controller).

3ds Max opens the Assign Rotation Controller dialog.
8 Choose Noise Rotation in the list, then click OK.
3ds Max opens the Noise Rotation Properties dialog. Don't close this dialog.
$9 \quad$ Play the animation in the viewport.
The biped shakes drastically as it walks.
10 In the Properties floater, turn off Fractal Noise.
11 As the animation plays, change the Frequency in the Properties dialog, using the spinner. Lower the value until the shake becomes slower and more rhythmic. Probably a value of $\mathbf{0 . 2}$ or less will be good to use, but you can choose whatever you like.

12 As the animation plays, change the $\mathrm{X}, \mathrm{Y}$, and Z values. Set the three values to $\mathbf{0 . 0}$, then change them individually, one at a time.
To create a shimmy effect, set X Strength to be 2.0, Y and Z Strength to 0.0 .


13 Close the Noise Rotation Properties dialog.

In this example, the biped should shake only while walking. The frames from 69 through 191 should not have any shaking. To complete this effect, you will animate the weight of the noise controller.

Animate the weight of the noise controller:

1 On the
Motion panel, expand the Weight entry of the Noise Rotation controller you added to the spine object. Highlight Weight 0.


There is a trick to accessing the weights.

2 Open the Keyframing Tools rollout and click
 SubAnims).

The Motion panel now displays additional rollouts for Position List, Scale List, and Rotation List.

3 Scroll to the Rotation List and select the layer Noise Rotation.


Now you're ready to animate the Weight field.
4 Turn on Auto Key (Auto Key).
5 Drag the time slider to frame 70.
6 Near the bottom of the Rotation List rollout, right-click the Weight field spinner. This sets it to zero.

TIP Right-clicking any spinner resets it to its lowest possible nonnegative value.

```
Weight: }0.
```

7 Drag the time slider to frame 69.
TIP Use the < and > keys on the keyboard to move from frame to frame.

8 Change the Rotation List Weight field to 100.0.
The spinner is outlined in red to show its value is animated.
9 Drag the time slider back and forth from frame 0 to frame 100 to see the animation. The biped shakes while walking and stops shaking during the pause.

10 Next, you make the biped start shaking again at frame 191. At frame 190, set a key with the Noise Rotation Weight set to 0.0, and to $\mathbf{1 0 0 . 0}$ at frame 191.

TIP At frame 190, hold down the Shift key while you right-click the spinner. This will set a key without changing the value.

11 On the Keyframing rollout, turn off

(Manipulate SubAnims) when you're done.

12


13


Save your file as myshake_and_walk.max.

You can
 open shake_and_walk_finished.max to compare this version of the animation.

If you are exporting to a game engine, or if you want to use this animation with Layers or in the Motion Mixer, you will need to collapse the list controller
animation (see following procedure). This will add the controllers animation keys to the tracks of the Biped SubAnim.

NOTE 3ds Max has different behaviors for controllers and constraints. The controller animation will be layered onto the existing keys in the Biped SubAnim track. If you have used a constraint, however, it will replace the Biped Subanim tracks.

## Collapse the list controller track:

1 Continue from before, or
 open shake_and_walk_finished.max.

2 If you open the file,

select the Bip01 Spine object, open the

Motion panel, and expand the Assign Controller rollout.
3 In the Assign Controller window, highlight Biped SubAnim, and then right-click.

4 Choose Properties from the pop-up menu.

| Q Transform: Spine |  |
| :---: | :---: |
| Expand Tracks | 1SubAnim: Bip |
| Collapse Tracks | pScaleList : Sca |
|  | Noise R |
| Select All | Noise Rotatior |
| Select Invert | Available |
| Select None | Weights |
|  | WWeight 0: |
| Properties | - |

3ds Max opens the SubAnim Property dialog.
5 In the Enable options, turn off Position List and Scale List, so the Rotation List is the only one active.

6 In the Collapse options, turn off Position, and turn on Rotation List, Don't Delete, and Per Frame.


7 To collapse the rotation track, click the Collapse button at the bottom of the SubAnim Property dialog.

Wait while the calculations take place.
When the collapse is completed, the dialog closes and the track bar fills with keyframes.


8
回
Save your work as mycollapsed_shaking.max.

You can
 version of the animation.

TIP You can use the Workbench to reduce the number of keys created by collapsing the tracks.

## Creating Animated Bones with Biped

You can take the animated biped skeleton and use it to generate a 3ds Max bone structure that follows the same animation, by using the File Export and Import capabilities. In just a few steps, you will be able to take your biped animation and use it without the biped attached.

## Set up the lesson:

■ On the Quick Access toolbar, click
 (Open File), navigate to the \character_animation \freeform_animation folder, and open createbones_start.max.


Biped takes a bow.

## Create animated bones from bipeds:

1 Play the animation.
Observe the biped and its movement.

2 From the


Application menu, choose Export.
3 Name the file mycreatebones.fbx. From the Save As Type list, choose Autodesk (*.FBX), and then click Save.

3ds Max opens the Export FBX dialog.
4 Accept all the default values. and click OK.
Wait while the exporter calculates the TRS animation.

5 From the


Application menu, choose Reset.
The biped disappears and the viewports reset.

6 From the
Application menu, choose Import, then import the FBX file you just exported.

The import dialog appears.
7 In the Import Configuration group, click the More button next to Bones. Use the Advanced Bone Options dialog that opens to set the Bone Objects > Width and Length both to 3.

8 Click OK to close the dialog. Click OK again to import the FBX file and create the bones.
A bone skeleton appears in the viewport.


9 Play the animation.
The skeleton has the identical animation as the original biped.


Save your file as mycreatebones.max.

You can $\square$ open createbones_final.max for comparison.

See MotionBuilder Interoperability on page 1786 for more information about working with bone animation, FBX files, and the MotionBuilder application.

## Summary

This tutorial showed you a variety of ways to animate a Biped without using Footsteps mode. In addition, it showed how you can apply a Biped animation to a skeleton made from 3ds Max Bones.

## Walk Cycles

Walk cycles are frequently used in animation. This section shows how to animate both a biped walk and a quadruped walk.


Both the Biped and CAT features can generate walk cycles for you, but creating a walk cycle by hand is a traditional exercise for animators, and doing so can help you understand how two-footed and four-footed creatures move about.

## Animating a Freeform Walk Cycle

While 3ds Max has a dedicated method (Footstep mode) for creating quick and easy walking animations, you can also create walk cycles with freeform animation.


In this lesson, you'll use animated pivot points and IK blend keys to constrain the feet to the ground plane.

Skill level: Intermediate to Advanced
Time to complete: 1 hour and 10 minutes

## How a Biped Walks

If you don't use Biped to create a walk for you, it helps to know that a human walk cycle is defined by two steps: left foot to right foot, followed by right foot to left foot (or vice versa). The two steps break down into four states:


## Left to right:

1. Contact
2. Down
3. Passing
4. Up
5. Contact again (same as 1 , but with legs reversed)

1 Contact: Both feet are on the ground. At this point, the stride is at its longest: this is known as an extreme pose.

2 Down or "Recoil": After contact, the weight goes down on the front leg. The body lowers, and both legs bend.

3 Passing or "Breakdown": The front leg straightens and the back leg passes it. The body raises to a point that is higher than in the contact position.
4 Up or "High Point": The back foot is now the front one, and is about to make contact. The other foot pushes up and forward, raising the body to its highest position.

5 Contact: The same as pose 1, but with the opposite leg forward.
You can start animating the cycle at any of these poses. Animators often prefer to begin with the contact pose, as that pose (in general, any extreme pose) is a good reference to build from.
You have to decide how many frames the walk cycle will use. Twelve frames yield two steps per second: this is a natural pace, which we will use in this tutorial. Cartoonists sometimes use an 8 -frame cycle to create a fast, humorous walk. A 24 -frame cycle would give (for film) one step per second, suitable for
a slow-moving character. This tutorial uses a slightly slower 37 frames for the cycle.

## The First Step: Pivots and IK Keys

To use freeform animation for feet, yet keep those feet on the "ground" (the 3ds Max ground plane), you can use a system of pivot points and a few different kind of IK keys. This lesson introduces those features.

## Set up the scene:

1 Restart or reset 3ds Max.

2 On the


## Create a biped and load a FIG file:

1 Click to turn on Biped (Biped), and create a biped in the Front viewport.

2 Go to the Motion panel.

3 Turn on

* (Figure Mode), then click (Load File). 3ds Max displays the Open dialog.

4 Open the file tut_swimmer.fig. This file is in the folder \sceneassets $\backslash$ animations $\backslash$.
The biped takes on new structural elements stored in the FIG file. This simplified figure has one large toe on each foot and one large finger on each hand; its spine contains two segments instead of four.


NOTE You cannot animate in Figure mode.


## Set a key:

1 Change the Perspective viewport to Wireframe (press F3) and zoom in so the feet are clearly visible.

2 Select Bip01 R Foot.


3 On the
Motion panel $>$ Key Info rollout, click
(Set Key).
The foot is highlighted in white, and a key appears on the track bar at frame 0 . You have just started a freeform animation.


Track bar key at frame 0

## Set different types of keys at frame zero:

There are two ways to set character animation keys in 3ds Max. You can use the standard method of keyframing, which involves turning on Auto Key and transforming objects. It is quick and easy, but if you forget that Auto Key is on, you can set keys unintentionally.

The second method uses the Set Key buttons on the Key Info rollout. These buttons set several parameters at once. This is the method you'll use in the steps that follow.

1 On the Track Selection rollout, click

(Body Vertical).

This selects the biped's center of mass, Bip01, and activates the
 Move tool in one step. You've set a key for the foot, but there is a problem. The foot can go through the ground plane. See for yourself in the next few steps.

2 Right-click the Left viewport to activate it without changing the selection set.

3 With the Body Vertical track still active on the Track Selection rollout,

move the center of mass down in the Left viewport.
The biped moves down through the ground plane (as indicated by the grid in the Perspective viewport).

4 Press Ctrl+Z to undo the move.

## Set planted keys:

Now you'll set a planted key. A planted key does three things: It sets IK Blend to 1 , turns on Join To Previous IK Key, and also turns on Object Space.
Together, these three settings ensure that the foot will not pass through the ground plane.

For more information about IK Keys, refer to the "Key Info Rollout" topic in the 3ds Max Help.

1 In the Perspective viewport,

select Bip01 R Foot again.

2 On the Key Info rollout, click
$\square$ (Set Planted Key). The red pivot point becomes more pronounced.


3 On the Track Selection rollout, click
$\pm$ move the biped down in the Left viewport.
The foot stays on the ground plane, and the knee bends to accommodate the vertical movement of the biped.


Planted foot stays on ground.

4 Press Ctrl+Z again to return the biped to its previous position.

Now you've seen the effect of the planted key on the foot. You can use the same Set Key buttons on pivot points for the feet and hands. Next, you'll replace the key at frame 0 with a new one, changing the pivot point.

## Set pivot keys:

1 At frame 0, right-click the Perspective viewport, and

select Bip01 $R$ Foot.

It still has the planted key from before.
2 On the Key Info rollout, open the IK expansion bar and click Select Pivot.

All pivot points for the foot are now visible as blue and red dots. The pivot at the ankle is red, showing that this is the currently active pivot point.

TIP Wireframe mode lets you clearly see and select the pivot points.

3 Click the pivot point on the ball of the foot, at the base of the toes. The new pivot point is displayed in red.


NOTE You don't have to set a key each time you choose the pivot point. However, you should use the Set Key buttons if you want to change the Key parameters.

4 Advance the time slider to frame 5, and click


5 Right-click the foot and choose Rotate from the quad menu. On the main toolbar, make sure that Reference Coordinate System is set to Local.

6


Rotate the foot up approximately - 15 degrees about the local Z
axis to make the heel raise, and then click
(Set Planted Key).

The heel lifts off the ground, the foot rotates on the ball, and the toes stay on the ground.


Now you can animate the pivot point to the toes, as the ball of the foot lifts off the ground.

## Animate the pivot points:

1 Drag the time slider to frame 10, and then click (Set Key).
2 Click Select Pivot, and then click the pivot on the end of the toe.


3 Click (Set Sliding Key) to set a key for the pivot.

4 Click Select Pivot again, to turn it off.
5 In the Perspective viewport, right-click the foot and choose Rotate from the quad menu.

6


Rotate the right foot about -25 degrees around the Z axis so the heel continues to raise and roll off the toes.

 (Set Sliding Key) to keyframe the foot rotation.
The sliding key does not join to the previous key, but has IK Blend set to 1 , which keeps the foot above the ground plane. If you had set a planted key, the foot would jump to a different location as it attempted to join to the previous key.

## Save your work:



Save the scene as walkcycle_beginning.max.

## Next

Complete the First Step on page 975

## Complete the First Step

In this lesson, you complete the first step by moving the biped body forward and its right foot to the contact position.

## Set up the scene

- Continue from the previous lesson.


## Lift the foot off the ground:

When the foot lifts off the ground completely, you'll set a free key.
1 Drag the time slider to frame 15.
2 In the Left viewport, right-click the foot and choose Move from the quad
 Move the foot up off the ground and forward.


By moving the foot, you are seeing an example of Biped's IK system. You are creating rotations for the upper and lower leg links as you move the foot.

3 On the Key Info rollout, click (Set Free Key) to keyframe the lifted position of the foot.

4 Scrub the time slider back and forth to observe the animation so far.

## Lock down the opposite foot:

1 Drag the time slider back to frame 0 and

select Bip01 L Foot.

2 On the Key Info rollout, click
(Set Key).

3 Click (Set Planted Key) to set an initial key for the left foot at
This key locks down the foot for any subsequent movement in upcoming frames. If you were to grab the center of mass and move it down, both legs would bend instead of moving below the ground plane.

4 Turn on Select Pivot and pick the pivot point at the ball of the foot.


The left foot with a new pivot point.

5 Click Select Pivot to turn it off.

## Keyframe the center of mass:

事
1 On the Track Selection rollout, click (Body Horizontal). Bip01 is automatically selected.

2 At frame 0, click

(Set Key) for Bip01.
This creates a start key for the center of mass.
3 Drag the time slider to frame 15.

4 In the Left viewport, use the Move Transform gizmo to

move the center of mass so the torso shifts forward, and then set another key.


NOTE Because the center of mass is the root node, you can use only Set Key, not the specialized IK keys.

5 Use the Move Transform gizmo to
 move the center of mass down a little, so the left knee bends slightly, then set another key.
The left leg bends automatically as the center of mass moves down.


6


Select Bip01 L Foot.

7 On the Key Info rollout,
8 set a planted key for the ball of the foot.

8 Right-click the left foot and choose Rotate from the quad menu.

Rotate the foot so the heel is lifting up off the ground, and then set another planted key.
The heel is rotated off the ground.


9 Drag the time slider to frame 22, and click (Set Key).

10 Right-click the Perspective viewport, turn on Select Pivot, and then pick the pivot at the end of the toes of Bip01 L Foot.

11 On the Key Info rollout, click

(Set Sliding Key), then turn off Select Pivot.

12 In the Left viewport,
 rotate the left foot up a little more, and set another sliding key.


13 On the Track Selection rollout, click


Move the center of mass forward again, and
set a key.


## Keyframe the right heel hitting the ground:

1 At frame 22,
 select Bip01 R Foot and
 move it forward, then $\stackrel{-\mathbf{+}}{ }$ set a sliding key.


2 Turn on
(Select And Rotate), note the location of the gizmo intersection, and then turn on Select Pivot (this tuns off Select And Rotate). Pick the point at the ankle that lay at the gizmo intersection, and then set a sliding key.

3 Turn off Select Pivot. Rotate the foot so it's parallel to the ground, and then
 set a sliding key.


4 Turn on Select Pivot, and set the pivot to the heel. sliding key.


The pivot point moved to the heel.

5 Turn off Select Pivot. Drag the time slider to frame 27.

6 In the Left viewport,
 move the right foot forward a little. Notice that the foot moves away from the pivot point in the viewport.


Sliding Key lets foot move away from pivot.

7
Set a sliding key.
The pivot point in the viewport moves to the heel of the foot.

8


Move the right foot down so it touches the ground, and set another sliding key.


9 Turn on Select Pivot. Pick the pivot at the ball of the right foot.


The pivot moved to the ball of the right foot.

10 Click (Body Horizontal),

move the center of mass so
that it is over the heel of the right foot, and
H
 set a key.

12 Scrub the time slider and watch the animation of the foot and the pivot points.

## Save your work:

圆
Save the scene as walkcycle_1step.max.

## Next

Complete the Walk Cycle on page 987

## Complete the Walk Cycle

This lesson moves the biped forward and completes the walk cycle.

## Set up the scene:

■ Continue from the previous lesson.

## Continue the walk cycle:

1 At frame 27, click (Body Vertical) so you can move the center of mass.


Lower the body slightly, so the biped sinks a bit as the right foot flattens onto the floor. Set a key for the center of mass.

3 Drag the time slider ahead to frame 32.
 Move the center of mass
so it's over the ball of the right foot. Set a key for the center of mass.


Move and

rotate Bip01 L Foot so the heel swings above
the ground.


Set a free key.


Use this procedure throughout this exercise: Lock one foot by setting planted or sliding keys, move the center of mass, then move the other foot and set a key.

## Complete the walk cycle:

1 Drag the time slider to frame 37, and click


Move the center of mass forward, and (Body Horizontal). set a key.


2


Select Bip01 L Foot and

move it so the leg is extended in front of the biped. $\theta$ Set a free key.


3 upward.

Rotate the left foot so the heel is down and the toes point

Now the foot looks better.


4 With the left foot selected, click Select Pivot and select the pivot at the heel. Set a planted key for the pivot.

5 Turn off Select Pivot.

6 Go to frame 39, and
 rotate the left foot so it is flat on the ground.

7 With the left foot selected, click Select Pivot and select the pivot at the
heel. $\square$ Set a planted key for the pivot.

8 Set a planted key for the left foot.

9 Click
 so the body moves forward.

Set a key for the center of mass.
11 With the left foot selected, click Select Pivot and select the pivot at the heel. Set a planted key for the pivot.

12 At frame 41,
 rotate the left toes (Bip01 L Toe0) so they are flat on the ground.
 Set a planted key.


Select Bip01 R Foot and drag the time slider back to frame 30.
$\square$ Set a planted key.

14 At frame 32,
 rotate the right toes so they are flat, and set another planted key.

15 Drag the time slider to frame 37, and
 rotate the right foot up a little, then $\square$ set a planted key.

16 Scrub the time slider and review the motion. Add rotations for the toes as needed.

Save your work:

.Save the scene as walkcycle_completed.max.

## Next

Correct the Walk and Add Secondary Motion on page 994

## Correct the Walk and Add Secondary Motion

Although the walk cycle is now complete, you can make the biped's motion more realistic by adding secondary motion such as swinging the arms, as this lesson shows. This lesson also shows a way to correct biped motion by examining the biped's trajectory.

## Set up the scene:

Continue from the previous lesson.

## Display trajectories:

Biped has its own trajectory display. You can use it to observe the movement of the center of mass in the walk cycle. You can also edit the keys on the trajectory directly in the viewport.

1 On the Track selection rollout, click

(Body Horizontal).

## 2 On the Key Info rollout, turn on



A line appears on the viewports showing the COM's trajectory: the path it moves along during the animation.

WARNING Don't use the standard Trajectories functionality (the button near the top of the Motion panel) with Biped. Use the Trajectories button on the Biped rollout $>$ Modes And Display expansion bar $>$ Display group or on the Key Info rollout.

3 Scrub the time slider, and watch the biped center of mass moving along its trajectory.

4 On the main toolbar, turn on
 (Select And Move) toolbar. At the top of the

Motion panel, turn on Sub-Object, and then click any key on the trajectory.

| Bip01 |
| :--- |
| Selection Level: |
| Sub-Object Trajectories <br> Parameters Trajectories |$.$|  |
| :--- |

5 Use the Move Transform gizmo to

move the keys to correct the trajectory.


Edit keys in biped trajectory.

6 Turn off Sub-Object and Key Info rollout $N$ (Trajectories).

## Add arm swings:

The character is starting to look like it's walking, but it's still quite stiff. Adding arm swings will put some life in the animation.
The arms swing opposite to the legs. When the right leg is forward, the left arm is forward. Arms bend at the elbow on the forward swing, and stretch out straight on the backward swing.

1 Scrub the time slider to decide where to place the arm swings.
The right leg stretches out at frame 27, and you'll keyframe the left arm to swing there.

2 Turn on Auto Key (Auto Key).

3 At frame 0,
 move the left hand slightly, to set a key.

move the right hand slightly, to set a key.
4 At frame 0,

5 At frame 27,
 move the left hand so it swings forward. Position the arm so there is a slight bend at the elbow. Since Auto Key is on, you have keyframed the arm by moving it.

6 On the Track Selection rollout, click $\rightarrow \mathbf{4}$ (Opposite). The right hand is selected.

7


Move the right hand back slightly, so the arm is stretched out. Now the left arm is forward and bent a little, while the right arm is back and straight.


8 In the Front viewport, double-click Bip01 R UpperArm. The entire right arm is selected.


9 On the
Motion panel, open the Copy/Paste rollout and click
$\square$ (Copy Posture).

10 Click (Create Collection). Name the Collection walkcycle1.
11 Turn on Create Snapshot From Viewport, just above the Paste Options group.


12 Click (Copy Posture). Name the Copied Posture RArm back.

13 At frame 37, click
(Paste Posture Opposite).
The left arm swings behind the biped.
14 At frame 27, double-click Bip01 L UpperArm.
The entire left arm is selected.
15 On the Copy/Paste rollout, activate the Perspective viewport and click

(Copy Posture) again. Name the posture LArm forward.


16 At frame 37, click (Paste Posture Opposite).

The right arm swings in front of the body.

17 Turn off Auto Key (Auto Key).
18 Scrub the time slider back and forth to evaluate the animation.

## Add sway to the shoulders and hips:

You've animated the character by moving its hands and feet and center of mass. But the spine, hips, and head are still stationary. You'll add some rotations to the shoulders and hips to complete the walk cycle.

1


Select Bip01 Pelvis and drag the time slider to frame 15. The left foot is locked at this frame with a planted key.
Be careful where you add the hip rotations. Don't inadvertently disturb the work you've done on the feet so far.
As the legs extend and swing forward, the hips rotate slightly in the direction of the movement.

2


Rotate the pelvis about the Y-axis approximately -2 degrees,
and set a key.
The pelvis will not accept too much rotation. When you set the key, the pelvis corrects itself to account for the locked foot.


Rotation added to the hips from the Front view.

3 Drag the time slider back to frame 0.
degrees about the Y axis, and

Rotate the pelvis back 2
 set a key.

Rotate the pelvis back about -3 degrees about the $X$ axis, and
in set a key.


5 Drag the time slider to frame 32.


Rotate the pelvis about 4 degrees
around the $Y$ axis, then set another key

6 Go to frame 39 and

rotate the pelvis -2 degrees around the Y
axis again, then


The procedure is the same for the spine. At frame 27, the arms swing out in one direction. At frame 37, they swing in the opposite direction.

7


Select the biped spine object, Bip01 Spine.

8 At frame 27,
rotate the spine in the direction of the arm swing
set a key.
(about -6 degrees around the X axis), then


The spine can freely rotate about all three axes. You can make adjustments on each one. Rotate about the Z axis for a more stooped walk. Increase rotation about the X axis to make the walk loose and floppy.

NOTE Instead of animating the spine, you can animate the clavicles to raise or lower the shoulders.

## Twist links mode:

The Bend Links rollout includes tools you can use for animation. You can use either the Bend Links or the Twist Links to animate the bending and/or twisting of the spine.

1 Turn on (Figure Mode).
In the Structure Rollout, change Spine Links to 5.
You can have up to 10 spine links, but five is enough to observe the Twist Links effect.

2 Turn off $\underset{\sim}{ }$ (Figure Mode).

3 Turn on Auto Key (Auto Key).
4 On the Bend Links rollout, turn on Twist Links Mode.


5


Select the Bip01 Spine object. This is the lowest spine object in the biped.

6 Go to frame 0, and

rotate the object slightly about the X axis to add a key. Do the same about the Y axis.

7 Drag the time slider to frame 27, and

rotate approximately 10 degrees about the X axis so the spine rotates following the swing of the arms. The blue arm is swinging forward, so rotate the spine to match.

8 You can also
 rotate -1 degree about the Y axis.
The slight rotation of the first spine object results in a larger effect further up the hierarchy.

9 At frame 37, repeat the rotations but in the opposite direction, in order to match the swinging of the green arm outward.

## Save your work:

## Summary

You have animated a simple walk cycle using freeform animation and IK constraints.

You can use the footstep method of animation to create a walk cycle automatically. To learn about this technique, see Creating a Distinctive Walk on page 856 .

## Animating a Quadruped Walk

In these lessons, you'll animate a four-legged character, a dog, to walk in a continuous way. You'll use the ForeFeet option to make the fingers of the biped hands behave like toes on forefeet.


Skill level: Intermediate to Advanced
Time to complete: 1 hour and 50 minutes

## The Walk Cycle for Quadrupeds

A quadruped walk is essentially two biped walks on page 964 linked together, but out of phase with each other. When a biped walks, the shifting weight on the pelvis causes the up-down motion just described. For a quadruped, the same weight shifts occur for the pelvis and the shoulders.


Quadrupeds have different proportions than human bipeds. In particular:

- The rib cage is elongated downwards, unlike the flatter human rib cage.

■ The shoulder blades lie along the side of the rib cage, not on the back.
■ There are no collarbones.
The lack of collarbones gives the shoulder blades more freedom. This affects weight distribution on the front legs.
When you use Biped to animate a quadruped, its "clavicle" parts behave more like shoulder blades.

In spite of these differences, and some others we will mention later, a 3ds Max Biped can model a quadruped quite well. This tutorial uses a 24 -frame cycle, which comes to one step per second for each pair of feet.

## Set Up the Scene

The first steps are to configure animation for the walk cycle, and then to adjust the biped

## Set up the lesson:

- On the Quick Access toolbar, click


## E

(Open File), navigate to the \character_animation \quadruped folder, and open quadruped_walk_1.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

This file contains the biped used for the dog. It is posed on all fours, and has a tail.


If you prefer to start from scratch, you can duplicate this pose by rotating and moving the biped's pelvis, arms, and head.

## Configure time and Auto Key behavior:

1 Click (Time Configuration) to open the Time Configuration dialog.

This button is located among the animation playback controls.


2 In the Frame Rate group, choose Film. This sets the frame rate to 24 frames per second.


The rate of 24 fps is easier to work with, given our choice of a 12 -frame cycle for each pair of limbs. If later you want to output to NTSC video, which has a frame rate of 30 fps , you can change the rate before you render.

3 In the Animation group, change Start Time to 1 and End Time to 25.


This gives a 24 -frame animation, with an extra frame at the end so the walk cycle loops smoothly when you play it as feedback in 3ds Max viewports. When you're done, frame 1 and frame 25 will have the same pose. If you were using the walk cycle in another context (for example,
moving the walking dog along a path), you would trim off frame 25 and use the cycle of frames 1 through 24 in the larger animation.

4 Click OK to close the Time Configuration dialog.
5 Choose Customize $>$ Preferences, and go to the Animation tab. In the Auto Key Default Frame group, make sure On is turned on, and change the frame value to 1 .


This sets Auto Key to set an original-value key at frame 1, the first of this animation, when you create a key at a different frame.

## Set the biped to use ForeFeet.

1 Click any part of the biped to select it, then go to the
Motion panel.

2 On the Biped rollout, click (Figure Mode) to turn it on.

3 Open the Structure rollout, and then click ForeFeet to turn it on.
ForeFeet causes the biped fingers to behave like toes. You can think of this option as "Four Feet."

NOTE This biped has just one toe for each foot and one finger for each hand. For most quadrupeds, the toes move as a group when walking, so the simplest model works well.

4 Click (Figure Mode) again to turn it off.

5 Change the viewport to a Left view, then click

6 Select the biped's right finger, and

rotate it so it is parallel with the ground plane: about -30 degrees in the local Z axis.

(Select By Name) to select the biped's left finger (Bip01 L

Finger0), and

rotate it as you did the right finger.

TIP Another difference between the anatomy of humans and most quadrupeds (elephants are a notable exception), is that the hind legs appear to have an extra joint. Actually, this is because the foot is extended, and the weight rests on the ball of the foot. In Biped, you can add an extra joint or "link" to the leg, but increasing Leg Links to 4 causes Biped to generate additional animation keys that you might not want. It seems easier to leave Leg Links at its default of 3, and increase the length of the foot link, as has been done in this model.


Elongated hind foot in a familiar quadruped

## Save your work:

- Save the file as my_quadruped_adjusted.max.


## Next

Block the Steps for the Forelegs on page 1013

## Block the Steps for the Forelegs

Now that you've adjusted time settings and the biped itself, you're ready to block the basic walk cycle, working from pose to pose. This involves positioning the legs in space and time, giving the walk its overall tempo. You will begin with the quadruped's forelegs.

## Set up the scene:

- On the Quick Access toolbar, click

(Open File), navigate to the \character_animation \quadruped folder, and open quadruped_walk_2.max. This scene is the same as the one you just saved, but a set of reference poses has been set up on planes in the background.


## Configure character studio:

1 Use (Orbit) to change the viewport so you can see all four of the quadruped's feet.


2
Use Ctrl+click to select both hind feet and both hands (forefeet).

3 On the
Motion panel $>$ Quaternion/Euler rollout, choose Euler. Euler keys have tangent controls, which can be useful for this walk cycle exercise.

4 On the 3ds Max status bar, to the right of the Set Key button, choose

(Linear) as the Default In/Out Tangent type.
Sometimes blocking the animation is easier without extra interpolation (which you can add later).

5 Also on the
Motion panel, open the Key Info rollout and expand its IK group (click the plus-sign icon to the left of the IK label).
+IK

6 Finally, open the Copy/Paste rollout as well.
TIP To see both the expanded Key Info rollout and the Copy/Paste rollout, it might help to make the Command panel two columns wide: drag the left border of the Command panel to the left to make the Command panel wider.

7 Press Shift+Z to undo the viewport change and return to the Left view.
(Depending on how you adjusted the viewport, you might have to click Shift $+Z$ more than once to return to the Left view.)

## Begin posing the front legs:

1 Make sure you are at frame 1, then turn on Auto Key (Auto Key).

2 Use both

(Move) and

(Rotate) to position the arms (forelegs) and hands (forefeet) to match the reference sketch. This is the Passing pose. (The quadruped's hind legs are in the Down pose.)

TIP While a single biped (quadruped) part is selected, the PageUp and PageDown buttons move up and down the hierarchy.

You don't have to match the sketch accurately: a general idea of the pose is the goal.

TIP If you find it difficult to select a part of the arms by clicking, use (Select By Name).


Select the right hand (forefoot), then on the Key Info rollout,
click
(Set Sliding Key). Do the same for the left hand (forefoot).
NOTE Both Set Planted Key and Set Sliding Key set IK Blend equal to 1, but only Set Planted Key turns on Join To Prev IK Key. Join To Prev IK Key causes the limb to snap to the pivot set in the previous IK key. Set Sliding Key doesn't cause the pivot snap; this contributes to a more natural motion for the forelegs.

One advantage of the ForeFeet toggle is that it lets you set keys such as this for "hands" on the ground plane, as you do for feet.

NOTE The track bar shows sliding keys in yellow, planted keys in orange, and free keys in gray.

Double-click the right clavicle to select the entire arm (foreleg),
then on the Copy/Paste rollout, click
(Copy Posture).
5 In the Copy/Paste rollout > Paste Options group, under Auto-Key TCB / IK Values, choose Copied.

When Copied is chosen, IK info is pasted along with the new key. When Default is chosen, IK info is not pasted and the new key is a free key, FK rather than IK, which is not what you want for this animation.

6

味Go to the last frame (frame 25), and then click (Paste Posture).

7 Go to frame 13, and then click


Frame 13 is the midpoint of the walk cycle animation: frames 13 through 24 are essentially the same poses as frames 1 through 12 , but with the legs in opposite positions. (Frame 25 is the same as frame 1, so that the animation will play as a seamless loop when you preview it in viewports.)

8 Click the Point Of View (POV) viewport label, and choose Right to change the viewport to a Right viewport.

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9

## $10 \times 1$

 the left arm (foreleg).10 Click
 (Copy Posture).


Go to frame 25, then click
 (Paste Posture).

12 Go to frame 13, then click


Now the forearms/legs have the same posture in the extreme poses: the first and last frames of the cycle, and the mid frame.

TIP When you use Paste Posture Opposite, don't be alarmed that a key doesn't appear on the Track Bar: the original limb is still selected, so you won't see keys for the opposite limb.

13 Press Shift+Z to undo the viewport change and return to the Left view.

Add the other three poses:
Auto Key (Auto Key) is still on.
1 Make sure that

2 As in the previous procedure, use

(Rotate) to set up the transitional poses, as follows:

- Frame 4, Up


Frame 7, Contact


NOTE The sketches have a bit of perspective, so the left feet appear a bit raised from the ground plane, but as you're working in 3D, at contact both feet can rest on the ground.

Frame 10, Down


3 Also as earlier, after you create each pose,

select the right forefoot and click
(Set Sliding Key), then do the same for the left forefoot.

## Check your work by looking at trajectories:

1


Double-click the right clavicle to select all of the right foreleg.


2 On the Key Info rollout, click (Trajectories) to turn int on.

3 Scrub the time slider.
The elbow trajectory describes an arc, and the foot trajectory describes a rough trapezoid.


4


Double-click the left clavicle to see the trajectories for that limb, as well.

## Copy poses to the second half of the cycle:

1 Go to frame 4.


Double-click the right clavicle to select the entire foreleg, then click W (Copy Posture).

2 Go to frame 16, and click (Paste Posture Opposite).

3 foreleg in frame 7 to the left foreleg in frame 19, and from the right foreleg in frame 10 to the left foreleg in frame 22.

4 Repeat the previous three steps, but copying the left foreleg poses to the right foreleg at the same three frames.

## Preview your work:

1 Click (Play) to see the animation.
The quadruped's forelegs now move in a plausible walk cycle.

Save your work:

Save the file as my_quadruped_forelegs.max.

## Next

Block the Steps for the Hind Legs on page 1023

## Block the Steps for the Hind Legs

Creating steps for the hind legs essentially repeats the work you did for the forelegs.

Set up the scene:

- Continue from the previous lesson.

Start with the Down frames:

1 Go to frame 1. Use
 (Move) and
 (Rotate) to pose the hind legs in the Down pose, using the reference sketch as a guide.


2


Set a sliding key for each foot.

3


Double-click the right thigh to select the whole hind leg, then click
$\square$ (Copy Posture).

4 Go to frame 25, then click
 (Paste Posture).

5 Go to frame 13, then click

(Paste Posture Opposite).
6 Repeat steps 3 to 5 for the left leg.

## Add the intermediate poses:

1 Use

(Move) and
(Rotate) to pose the legs at the intermediate frames, as follows:
■ Frame 4, Passing


Frame 7, Up


- Frame 10, Contact


NOTE For now, don't worry if the front and hind feet overlap in space at the hind legs' crossing pose. You will fix this later.

2


Set sliding keys for the feet.

## Copy poses to the second half of the walk cycle:

 them to the opposite hind leg in the second half of the walk cycle, as follows:

- Frame 4 to frame 16
- Frame 7 to frame 19

■ Frame 10 to frame 22

## Preview your work:

1


- Click Play to see the animation.

Now all the legs move in a plausible walk cycle. The effect is still a bit stiff and mechanical: you will correct that in the following lesson.

TIP If the animation looks too jerky at points, you can stop playback, adjust poses (Auto Key should still be on), and scrub the time slider to see how it appears. The goal is a smooth-looking walk, but it doesn't have to be perfect.


Click Stop.

## Save your work:



Save the file as my_quadruped_alllegs.max.

## Next

Add Weight Shifts and Spine Movement on page 1028

## Add Weight Shifts and Spine Movement

For a more realistic walk, the quadruped's hips and shoulders need to move up and down as the weight of the animal shifts from leg to leg. You will create a layer that contains this animation. Using a new layer allows you to compare the original animation with the newly created keys. When you are satisfied with the new animation, you can collapse layers to integrate the old and new animation.

Set up the scene:

- Continue from the previous lesson, or navigate to the
\character_animation \quadruped folder, and
 quadruped_walk_3.max.


## Create a layer for the hip and shoulder motion:

1


Select any part of the quadruped, go to the Motion panel, and open the Layers rollout.

2 On the Layers rollout, click 1. 1 Center of Mass \& Spine.


3 Also on the Layers rollout, in the Retargeting group, turn on the

retargeting buttons for all four legs. Turn on IK
Only as well.


These controls preserve the IK constraints from the animation on the base layer. Without them, moving the quadruped's center of mass (COM) would simply translate the entire quadruped, disregarding the sliding keys you created earlier to control the feet.

4 Click Update.

If you select a foot, you can see that the sliding keys now appear in the Track Bar for this layer.

## Create movement for the hips:

1 On the
Motion panel, open the Track Selection rollout. Click
$\ddagger$ (Body Vertical) to turn it on. This selects the COM, as well.
Because the quadruped is walking in place, you need to adjust only the vertical position of the COM.

2 Go to frame 1. Turn on Auto Key (Auto Key), then
 COM down slightly (frame 1, as you might recall, is a Down pose).

NOTE When you work with layers, the viewport feedback isn't fully interactive: as you move the COM, the feet descend below the ground plane. After you release the mouse, 3 ds Max recalculates IK and the feet snap into the position where they should be.


Lowered COM for the Down pose

As you animate on the Center of Mass \& Spine layer, viewports show the original animation as a red stick figure with a box for a head.

3 On the Track Bar Shift+drag the new COM key to make a copy of it at frame 13 and frame 25, the other two Down frames in this cycle.

4 Go to frame 7, the Up state, and
 move the COM to a point that is higher than the original animation.


Raised COM for the Up pose

IMPORTANT When you raise the COM, try to make sure that the limbs are not extended too far: if they are fully extended, then Biped tends to generate abrupt motion, which doesn't look good or natural.

5 Shift+drag the new key from frame 7 to create a copy at frame 19.

6 Go to frame 10, the first Contact pose for the hind legs, and
 move the COM to a vertical position midway between its heights for the Down and Up poses.


7 Shift+drag the new key from frame 10 to create a copy at frame 22. If you scrub the time slider or play the animation, you can see that the hips now bob up and down in a more convincing version of a walk. The shoulders and spine still seem rigid.

## Create movement for the shoulders:

1 Go to frame 1. Make sure
(Auto Key) is still on.


Select the lowest spine link, Bip01 Spine, and

rotate it up a bit (not too much).

3


Select the next spine link, Bip01 Spine 1, and

rotate this link down a bit.

The goal is to have the outline of the spine match the contour of the dog's body in the reference sketch.


4 Shift+drag to copy the new key from frame 1 to frames 13 and 25.

5 Go to frame 7, the Contact pose for the forelegs, and

repeat these adjustments to the lower two spine links. Again, you want to have the spine follow the dog's body in the sketches. At Contact for the forelegs, the dog's weight shifts from the pelvis to the shoulders.
In this step, you might want to adjust the third spine link, Bip01 Spine 2, down a little bit, as well.
After you adjust the spine, if the forefeet don't appear to be reaching the ground plane properly, go to the Layers rollout $>$ Retargeting group, and click Update.


6 Shift+drag to copy the new key from frame 7 to frame 19.
If you scrub the Time Slider, you can see that the spine already has a more fluid movement.

7 Go to frame 4, the Up pose for the forelegs. Again,

rotate the spine links to follow the dog's body. For this pose, the spine should be a bit higher than the pelvis.


8 Shift+drag to copy the new key from frame 4 to frame 16.
With the spine movement added, the quadruped looks less like a robot and more like an animal walking.

Add some head movement:

1 Go to frame 1, and

select the head of the quadruped.

2 On the Key Info rollout, click
$\square$ This sets a key for the head and the upper neck link, Bip01 Neck1.

3 Shift+drag the new key from frame 1 and copy it to frame 25, then copy it to frame 11 as well.

4
Select the lower neck link, Bip01 Neck, then click Key) to set a key for it as well.

5 Shift+drag the neck key to copy it to frames 11 and 25 , as you did for the head.

You've now set up a reference pose about which other head poses can move. Head movement is secondary motion. It's called "secondary" because the walk doesn't depend on it, and it doesn't affect the leg or body motion. However, secondary motion can add a great deal of life to an animation.

6 Go to frame 7. Make sure Auto Key (Auto Key) is on, then
 rotate the neck and head upward slightly.


The idea is that in general, the dog looks where it is going when it's forelegs are in the Contact position.

7 Shift+drag the new key to copy it to frame 19.

8 Go to frame 11
Rotate the neck links so they are roughly parallel to the ground, and then rotate the head so it is looking slightly down.


As you probably noticed, frame 11 comes one frame after the Down pose at frame 10. Secondary motion tends to lag a little behind primary motion. Also, setting keys slightly out of phase in this way helps keep the animation from appearing too mechanical.

9 Shift+drag the new key to copy it to frame 22.

## Save your work:

$\square$
Save the file as my_quadruped_legs_spine_head.max.

## Next

Polish the Walk Cycle on page 1039

## Polish the Walk Cycle

## Set up the scene:

- Continue from the previous lesson, or navigate to the
\character_animation \quadruped folder, and
 quadruped_walk_4.max.


## Collapse the layers:

1


Select any part of the quadruped, then go to the Motion panel.

2 On the Layers rollout, click
$\square$沓

Now the scene contains only a single layer of Biped animation: the keys you created on the Center of Mass \& Spine layer are transferred to the main timeline.

## Smooth out the trajectories:

2 On the main toolbar click

(Curve Editor (Open)).
3 If you need to, pan the Controller window until you can see the tracks for all four feet. Expand the hierarchy if you need to, and Ctrl+click to select all four Transform tracks.

4 On the Track View status bar, turn on

(Filter - Selected Tracks Toggle).

This simplifies the Controller window display by showing only selected tracks.

5 Make sure you can see all keys in the Function Curves window.


6 Drag a selection box to select all the keys in the animation.


7 On the Track View toolbar (the Key Tangents toolbar), click
 Tangents To Smooth).
Smooth tangents give the animation a more organic feel, making it less abrupt.


8 Close Track View.


Trajectories of the dog's right forefoot and knee before smoothing


Trajectories of the dog's right forefoot and knee after smoothing

- Play the animation.

The dog's walk is now much smoother, and feels more "integrated": more a single movement, and less a collection of individual movements.

## Give the shoulder blades more freedom:

1 Turn on Auto Key (Auto Key). Go to frame 1, select the dog's shoulder blade (Biped01 R Clavicle), then
 rotate it up about 35 degrees in the local Z axis.

2 Make sure only the shoulder blade/clavicle is selected, then on the Copy/Paste rollout, click
 (Copy Posture).

3 Click
(Paste Posture) to paste the shoulder blade posture at frame 13.

4 At frame 25, don't paste the posture, but rotate the shoulder blade up about 30 degrees.
Pasting the pose lifts the dog's foot off the ground, and we don't want that to happen.

5 Click
(Paste Posture Opposite) to paste shoulder blade posture onto the left shoulder blade at frames 1,13 , and 25.

6

四
Switch to display all four viewports before you preview the animation.

We have been working mostly in the Left viewport, but this is a three-dimensional animation, and it helps to look at the motion from other points of view.
With more movement in the shoulder blades, the quadruped walk has more of a loping feel to it: a gait that we associate with wolves and larger dogs.

Add some side-to-side movement to the pelvis:

1

Maximize the Top viewport.

2 Make sure
Auto Key (Auto Key) is on.

3 On the main toolbar, turn on

(Angle Snap Toggle). Then at frame 1,

rotate the pelvis to the dog's right, 15 degrees in the local Y axis.


4 Go to frame 13.
Rotate the pelvis to the dog's left: - $\mathbf{3 0}$ degrees in the local Y axis.


5 Finally, go to Frame 25, and

restore the pelvis back to its frame 1 position: 30 in the local Y axis.
You can preview the animation, but the pelvis movement is really a basis for the spine movement, which you will add next.

## Add side-to-side movement to the spine:

1 Make sure
Auto Key
(Auto Key) and

(Angle Snap Toggle) are both on.

2 Activate the Top viewport, if it isn't active already.

3 At frame 1,

select the lowest link of the spine, Bip01 Spine.

4


Rotate Bip01 Spine to the dog's right, 15 degrees in the local Y axis.


Notice that Biped maintains the head facing forward, which is what you want it to do.

5 Also at frame 1,
 rotate Bip01 Spine02 - $\mathbf{1 0}$ degrees in the local Y axis, and then rotate Bip01 Spine03 (the shoulders) - $\mathbf{1 5}$ degrees in the local $Y$ axis.


The spine describes an S-curve as the dog walks, with the shoulders rotating in the opposite direction from the hips.

WARNING Don't use Page Up or Page Down to select spine links. This select other biped parts as well, such as arm and leg links, and will generate unwanted animation.

6 Go to frame 13.


Rotate the three spine links in the opposite direction: -15 degrees in the local Y axis for Bip01 Spine; 10 degrees for Bip01 Spine02; and 15 degrees for the shoulders, Bip01 Spine03.


Because of other Biped keys, the spine returns to a straight posture by frame 5 , so you don't have to "overcompensate" the rotation value as you did for the hips.

7 Finally, go to frame 25 and
 rotate the spine to its frame 1 position: $\mathbf{1 5}$ degrees in the local Y axis for Bip01 Spine; - $\mathbf{1 0}$ degrees for Bip01 Spine02; and -15 degrees for the shoulders, Bip01 Spine03

The last bit of movement to add is, appropriately, the tail, which mirrors the spine movement in a similar S-curve. Like head movement, tail movement is a secondary motion that doesn't affect the mechanics of the walk, but does give it greater realism.

Add side-to-side movement to the tail:

1 Make sure Auto Key (Auto Key) and $\hat{0}+$
(Angle Snap Toggle) are both on.

2 Activate the Top viewport, if it isn't active already.

3 At frame 1,
 select the lowest link of the tail, Bip01 Tail.

4


Rotate Bip01 Tail to the dog's left, $\mathbf{- 1 5}$ degrees in the local Y axis.


Rotate the remaining three tail links in the opposite direction, to counter the side-to-side motion of the spine.


6 Go to frame 13 and as you did for the spine,

rotate the tail links to mirror the frame 1 pose.


7 Go to frame 25 and
 restore the tail to its frame 1 pose.


## Correct the intersecting feet:

The last bit of "polish" to add to the dog's walk is to remove the intersecting feet that was a result of simple footstep blocking.

1 Click (Maximize Viewport Toggle) so you can see all four
2 Drag the time slider to frame 10. At this point, the right forefoot intersects the right hind foot.


3 In the Left viewport,
 move the foot up and out of the way of the hind foot, and then click $\stackrel{-4}{(\text { Set Sliding Key). }}$


Now the forefoot lifts out of the way before the hind foot steps down. Scrub the time slider to make sure you've corrected the intersection: the forefoot should lift from the ground just before the hind foot descends.

4 Drag the time slider to frame 22.
Here there is the same problem with the left feet intersecting.

5 As you did for the right forefoot,
 move the left forefoot up and away from the descending hind foot, and then click
 (Set Sliding Key).
Now neither the right nor left feet intersect during the walk.

## Preview your work:

- Now you've finished animating the dog's walk.


Switch to all four viewports, and


Stop playback when you're done.

## Save your work:

Save the file as my_quadruped_completedwalk.max.

To see a completed version of the animation,
 quadruped_walk_completed.max.

## Summary

In essence, a quadruped walk cycle combines two biped walk cycles. This tutorial demonstrated the ForeFeet toggle that enables hands to behave as feet, with sliding keys on the ground plane. It also showed one way to smooth tangents for a better-integrated animation.

## Notes on Looping and Reloading Biped Animation

To loop the quadruped walk (or other Biped animation), 3ds Max doesn't allow you to use Parameter Curve Out-Of-Range Types, but you can use the Motion Mixer to loop a walk cycle.

Also, when you have rotated the COM as you did for the quadruped, if you save the motion as a BIP file you should save a FIG file as well as a BIP file. Then the method to use depends on how you are loading the BIP file:

- If you load the BIP file motion onto a new Biped, then after you click

(Load File) on the Motion panel, in the Open dialog, turn on Restructure Biped To Match File.

■ If you use the Motion Mixer to add the BIP file to the animation, then first
go into Figure Mode and
 load the FIG file onto your Biped. The FIG file saves the COM rotation data, so you need to load it before loading the BIP animation: Otherwise, the orientation of the motion will not match the rest of the scene.

## Materials and Mapping Tutorials

Materials are like paint. With materials, you make apples red and oranges orange. You put the shine in chrome and the polish on glass. By applying maps, you can add images, patterns, and even surface texture to objects. Materials are what make your scenes look real.

Mapping is a method of projecting pictorial information (materials) onto surfaces. It is a lot like wrapping a present with wrapping paper, except the pattern is projected mathematically, with modifiers, rather than being taped to the surface.

This tutorial introduces the Material Editor, the master design studio for materials and maps. In the following tutorials, you will learn how to assign materials to objects, how to create basic materials, and how to apply textures.


## Features Covered in This Section

- Using the 3ds Max Material Editor to create, edit and apply materials.
- How mapping coordinates work, and how to manipulate them using 3ds Max modifiers.
- How to layer multiple texture maps onto a surface to create a composite image.
- How to map textures onto curved surfaces.

■ How to apply multiple sub-maps similar objects to give each their own unique identity.

## Introduction to Materials and Mapping

To introduce materials, you will work with a scene that shows an army compound: a field headquarters that has been built around a farmhouse.


A rendering of the field headquarters after you have completed the tutorial
In this tutorial, you will learn how to:
■ Create basic materials.

- Assign materials to objects in the scene.
- Create and adjust mapping coordinates.

■ Use texture, opacity, and bump mapping.
■ Use 3D procedural materials.

Skill level: Basic to Intermediate
Time to complete: $11 / 2$ hours

## Applying Materials and Textures

You begin with a scene that has only a few materials in it.

## Set up the lesson:

- On the Quick Access toolbar, click
 \scenes \materials_and_mapping \intro_to_materials $\backslash$ and open army_compound.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

Except for the vehicles, the jeeps and helicopter, this scene contains no materials. The buildings and terrain have a featureless, plastic look to them that is typical of newly created geometry in 3ds Max.


The field headquarters before you apply materials

You'll begin by adding textures to the utility containers in the fenced area at the rear of the compound.

## Isolate the utility containers:

1 On the main toolbar, open the Named Selection Sets drop-down list, and choose the Utilities selection set.


3ds Max selects the various containers.
2 Right-click the viewport to display the quad menu, and choose Isolate Selection.

This command is in the upper-right, Display quadrant.


3ds Max displays the utility containers in the center of the viewport, and hides the other scene geometry.

TIP You might have to move the Warning: Isolated Selection dialog to see the geometry clearly.

Warning: Isolated Selec... $\quad$ K

Exit Isolation Mode

3 Use

(Orbit) to adjust the view so you can see all five containers clearly.


The isolated set of containers

Now you're ready to begin creating materials for these objects.

## Apply a basic material to the oil tanks:



2 Click an empty area of the viewport to deselect the Utilities set, and then click OilTank01 (the front cylindrical object on the right) to select it.

3 Ctrl+click OilTank02 and OilTank03 to select them as well.

4 On the main toolbar, click Material Editor.
(Material Editor) to open the Slate


TIP If this is the first time you are using the Slate Material Editor, you might need to resize it so you can easily see all three of the columns in its interface.

Also, to see changes in the viewport, it will help to minimize the Slate Material Editor while you work, and then restore it when you need to work on materials some more.

The Material Editor is a sort of workbench for creating, adjusting, managing, and applying materials to objects. The main portions of its interface are:

■ On the left, a Material/Map Browser panel where you can choose material and map types (or ready-made materials) to add to the scene.

- In the middle a View panel where materials and maps appear as nodes that you can wire together.
- On the lower right, a Parameter Editor where you can edit the material and map controls.

TIP If the Compact Material Editor opens instead, then on the Material Editor menu bar, choose Modes > Slate Material Editor. The Compact Material Editor has a smaller window, with conspicuous sample slots near the top of its interface.

5 On the Material/Map Browser panel at the left, locate Materials > Standard $>$ Standard, then drag the Standard entry from the Browser and drop it in the active View (the large panel labeled View1 in the center of the Editor).


A node for the Standard material appears in the active View.


6 Double-click the Standard material node to display parameters for the material in the Parameter Editor on the right side of the Slate Material Editor.

7 In the material Name field, near the top of the Parameter Editor, enter Oil Tanks as the material name.


Notice that as you enter the name in the Name field, the name in the title bar of the node also updates.

It is good to get in the habit of naming a material as soon as you create it. In a complex scene, intelligible material names are useful.

8 On the Blinn Basic Parameters rollout, below the Name field, click the color swatch that is labeled Diffuse.

3ds Max opens a Color Selector dialog.
Use the Red/Green/Blue controls on the Color Selector to choose a yellow color. Set Red $=\mathbf{2 0 0}$, Green $=200$, and Blue $=0$.


The diffuse color of a material is the color that appears under diffuse, or scattered, light. It is what we usually think of as "the" color of a material, and what you will set first, when you create a basic material such as this one.

9 Click OK to close the Color Selector.

10 On the Slate Material Editor toolbar, click
 Selection).
In the viewport, the oil canisters turn yellow.
11 Look at the material preview in the title bar: it now has angled corners. Double-click the preview to make it larger so you can get a better look.


Angled corners on a material preview mean that the material has been applied to at least one object in the scene. When the angled corners are solid white, as they are in this case, the material is said to be hot. When you make changes to a hot material, the scene changes immediately, and usually the viewport display shows the material changes you have made.

You will take advantage of adjusting a "hot" material in the next set of steps.

## Make the oil tanks shiny:

Make sure that the three oil tanks are still selected, and that the Oil Tanks material is still active.

1 On the Blinn Basic Parameters rollout, in the Specular Highlights group, change the value of Specular Level to 90.
Bright highlights appear on both the sphere in the preview, and the oil tanks in the viewport.

2 Also in the Specular Highlights group, change the Glossiness value to 32.


Specular Highlights
Specular Level: $\sqrt{90} \mid$ ⿻ㅡㄱ $\square$
Glossiness: $\sqrt{32} \mid \stackrel{\Delta}{v} \quad \square$
Soften: $\sqrt{0.1} \mid \stackrel{\rightharpoonup}{-}$

Left: Preview with the oil tank material

Right: Specular highlight controls with Glossiness = 32

As you can see the preview and in the graph to the right of the Specular Highlight and Glossiness controls, the highlight is now narrower. Specular Level controls how bright highlights are, while Glossiness controls highlight width. In general, shinier materials have smaller highlights.

You have used basic material controls, Diffuse color, Specular Level, and Glossiness, to create a simple material that has the appearance of a moderately shiny paint. This completes the material for the oil tanks.


The oil tanks with their material

## Apply a texture map to the ammunition canister:

For the ammunition canister, you will use a bitmap. Bitmaps are a versatile way to add visual detail to scenes, and we use them extensively in this scene. When a bitmap is used to provide an object's color, it is also known as a texture map. The texture map you apply to the canister shows a section of metal plating with a "checkered" pattern.


Texture map for the ammunition canister

1 In the Slate Material Editor > active View, move the Oil Tanks node to one side.

2 Drag another Standard material node into the active View. Double-click the node to display the material parameters, then in the Name field, change the name of the material to Canister.

3 In the Slate Material Editor > Material/Map Browser panel, at the left, locate Maps > Standard $>$ Bitmap, and drag this map type into the active View.
3ds Max opens a file dialog.
4 In the file dialog, click to highlight the file metals.checker.plate.jpg (it is in the project folder \sceneassets $\backslash i m a g e s \backslash$, like all the maps for the tutorials), and then click Open.
3ds Max adds this Bitmap node to the active view.


5 Drag from the Bitmap node's output socket (the circular control at the right of the node). When you drag, 3ds Max creates a wire.


Drop the wire on the input socket for the Canister node's Diffuse Color component.
The Bitmap is now wired to the material.


After you wire the Bitmap, 3ds Max also adds a Controller node (you could use this, if you wanted, to animate the Bitmap's Amount value).

6 Click the new Bitmap node to highlight it.

7 On the Slate Material Editor toolbar, click
 (Show Map In Viewport) to turn it on.
A red diagonal shape appears in the Bitmap title bar, to indicate that Show Map is active.


8 Click the Canister node to highlight it again.
9 Move the Slate Material Editor window so you can see both the objects in the viewport, and the Canister node in the active View. Make sure that none of the utility objects is selected, then drag from the output socket of the Canister node (the output socket is the round control at the right of the node), drag to the viewport, and then release the mouse over the blue canister in the middle of the group.


Dragging from the output socket of the Canister material

3ds Max applies the Canister material to the ammunition canister.
Dragging and dropping from the output socket of a material node is an alternative to using

## Adjust the metal plate mapping:

If you
 zoom in, you can see that the mapping is not as good as it could be. The top and sides of the canister look all right, but there is streaking where the top of the canister has beveled faces.


Streaks in the texture when using the default mapping

To fix this, you use a modifier called UVW Map.

1


Select the canister object, which is named Ammo, and go to the


Modify panel.
2 Open the drop-down Modifier list, and choose UVW Map from the list.
TIP Once you open the list, you can press $U$ a couple times until the list highlights UVW Map, and then press Enter.


3 In the Parameters rollout > Mapping group, choose Box.
The radio buttons at the top of the Mapping group (Planar, Cylindrical, Spherical, and so on) tell the UVW Map modifier how to project the map onto the object. Box mapping projects the map from all six sides, so the texture display is more uniform.

4 Also in the Mapping group, set Length $=$ Width $=$ Height $=\mathbf{2 . 0 m}$.
Now the mapping is uniform and looks good from any angle.


The texture corrected using UVW Map

## Clean up the Slate Material Editor interface:

1 In the Slate Material Editor $>$ active View, click a node to select it, then press Ctrl+A to select all nodes in the View.

2 Press Delete.
Deleting nodes from the active View simply cleans up the View for further work. It does not remove the materials from the scene: You can still see the materials you created (as well as in the Material/Map Browser Scene Materials group.


If you need to edit a material again, you can drag it from this group and into the View as an instance.

NOTE You also have the option of maintaining multiple Views of the materials for your scene. See the 3ds Max help for more details.

## Apply a 3D material to the generators:

Finally, for the generators, you will use a 3D procedural map. A bitmap is simply a digital image such as a scan or a photograph. A 3D map, on the other hand, is generated by 3ds Max.

1


Select Generator01 and Generator02, the large boxy objects to the left.

2 In the Slate Material Editor, drag another Standard material node into the active View. Double-click the node, then name the material Camouflage.

3 Drag a Noise map from the Material/Map Browser panel into the active view, and wire it to the Camouflage material's Diffuse Color component.

4 Double-click the Noise node to display its parameters. On the Noise Parameters rollout, click the color swatch labeled Color \#1.
3ds Max opens a Color Selector.
5 Change Color \#1 to a dark green: Red $=0$, Green $=175$, Blue $=0$.
6 Click the color swatch labeled Color \#2. On the Color Selector, change Color \#2 to a tan: Red $=\mathbf{2 0 0}$, Green $=155$, Blue $=0$.

7 Click OK to close the Color Selector.

8 Click the Camouflage material node again to make it active.

9 Click

(Assign Material To Selection), and then click Map In Viewport) to turn it on.
The map appears in the viewport, but the camouflage pattern isn't very apparent.

10 On the Noise Parameters rollout, change the Noise Threshold values. Set High $=\mathbf{0 . 5 1}$ and Low $=\mathbf{0 . 4 9}$. In addition, change the Size value to $\mathbf{1 8 . 0}$. Now the generator casings have a recognizable camouflage pattern. A bonus of the procedurally generated 3D Noise texture, is that the pattern is not quite the same on either generator. (This effect is more apparent when you render the scene: In viewports, both generators look much the same.)

You now have a reasonably realistic texture for all of the containers in the utilities area of the compound.


Utility containers with their textures

## View the entire scene again:

■ In the Warning: Isolated Selection dialog, click Exit Isolation Mode.


Exit Isolation Mode

The viewport shows the entire scene once again.

## Apply a texture map to the terrain:

For the last step in this lesson, you will apply a texture to the terrain beneath and surrounding the compound.


Terrain texture for the army compound

1 In the Slate Material Editor, drag another Standard material node into the active View. Double-click the node to display the material parameters, then in the Name field, change the name of the material to Terrain.

2 In the Slate Material Editor > Material/Map Browser panel, at the left, locate Maps $>$ Standard $>$ Bitmap, and drag this map type into the active View.

3ds Max opens a file dialog.
3 In the file dialog, choose terrain.jpg, and then click Open.
4 Wire the new terrain texture to the Terrain material node's Diffuse Color component.

5 Click the new Bitmap node to make it active, and on the Slate Material

Editor toolbar, click
(Show Map In Viewport) to turn it on.
6 Drag from the Terrain material node's output slot, and in a viewport, release the mouse over the Ground object.

The Ground object turns brown, but it doesn't show the texture map. This is a sign that the object doesn't have mapping coordinates.
Primitive objects such as boxes and spheres have default mapping coordinates, but editable geometry such as Ground, which is an Editable Poly, does not. You have to assign mapping coordinates by applying UVW Map.

7


Select the Ground object, and go to the Modify panel.

8 Use the Modifier List to apply a UVW Map modifier.
For the terrain, the default Planar projection works fine, and the map terrain.jpg is already the right size for the scene, so your work in this lesson is now complete.


Army compound with textured utility containers and terrain

## Save your work:

■ Save the scene as my_fieldhq_containers_and_terrain.max.

## Add Detail to Some Outbuildings

Next, you will add materials to the barracks. Materials for the barracks use texture maps, as the ammunition canister does, but they also use bump mapping to create a more three-dimensional appearance.

## Set up the lesson:


open army_compound01.max.

## Isolate the barracks:

1 On the main toolbar, open the Named Selection Sets drop-down list, and choose the barracks selection set.


3ds Max selects the barracks buildings.
2 Right-click the viewport to display the quad menu, and choose Isolate Selection.
3ds Max displays the barracks in the center of the viewport, and hides the other scene geometry.

3 Use

(Field-Of-View) to adjust the view so you can clearly see the barrack walls.

Texture the barrack walls:

1 Turn on

(Select Object), then click an empty area of the viewport to deselect the barracks set.

2 If it is not already visible,
 display the Material Editor.

TIP Besides the toolbar button, another way to display the Material Editor, or to restore it if it is minimized, is simply to press M .

3 On the Slate Material Editor menu bar, choose Options > Propagate Materials To Instances to turn it on. (When this option is turned on, a check mark appears before its name.)

Like the oil tanks and generators, the barracks objects, roof, walls, and floors, are instances of each other. By turning on this option, you can apply a material to all the objects of one type by dragging and dropping to only one object.

4 In the Slate Material Editor, drag another Standard material node into the active View. Double-click the node to display the material parameters, then in the Name field, change the name of the material to BarracksWalls.

5 In the Slate Material Editor > Material/Map Browser panel, at the left, locate Maps > Standard > Bitmap, and drag this map type into the active View.

3ds Max opens a file dialog.
6 On the file dialog, choose planks.jpg, and then click Open.
7 Wire the new planks texture to the BarracksWalls material node's Diffuse Color component.

8 Click the new Bitmap node to make it active, and on the Slate Material

Editor toolbar, click
 (Show Map In Viewport) to turn it on. The BarracksWalls material now has an image of the planking.


Planks texture for barracks walls

9 Drag the BarracksWalls node output socket to the leftmost barrack walls. All three barracks now show the BarracksWalls material.

The planks texture shows dirt at the bottom of the wall, but with default mapping coordinates, the dirt appears just above each doorway, instead.


Planks texture appears on the walls, but is not aligned correctly.

## Use UVW Map to adjust the planks:



Select Barracks01-Walls, and then go to the


Modify panel.
2 Use the Modifier List to apply a UVW Map modifier.
3 In the Parameters rollout > Mapping group, change the projection type to Box. Also set Length $=$ Width $=$ Height $=4.0 \mathrm{~m}$.

Now the planking texture is correctly aligned with the walls.


After applying UVW Map, the planks on the walls are aligned correctly.

Add a bump map to the planks material to improve realism:
If you take a closer look at the barracks, you can see that the texture looks good, but it also has a flat appearance, smoother than aged wood typically appears.


## Barrack walls with a texture alone, and no bump mapping

You can improve the appearance of the plank walls by using bump mapping. Bump mapping makes an object appear to have a bumpy or irregular surface.

1 In the Slate Material Editor > Material/Map Browser panel, at the left, locate Maps $>$ Standard $>$ Bitmap, and drag another Bitmap node into the active View.
3ds Max opens a file dialog.
2 On the file dialog, choose planks.bump.jpg,, and then click Open.
3ds Max adds the node to the active View.
This map is simply a black-and-white version of the planks.bmp map itself.


Black-and-white planks texture for bump mapping

Bump mapping uses intensities in the map to affect the surface of the material when you render it: white areas appear higher, and black areas appear lower. This is why the bitmap you use for bump mapping is often a black-and-white version of the map you use for texture.

3 Wire the node to the Bump component of the BarracksWalls material.


As it did for the other Bitmap nodes, 3ds Max adds a Controller node for the bump map's Value.

TIP Pressing L tells the Slate Material Editor to lay out nodes in the active View.

4 Bump mapping isn't displayed in the viewports, so click

- (Render Production) to see the effect of the new map.


The barrack walls with bump mapping

To get an even more weathered look, you can increase the bump mapping Amount.

5 Double-click the main BarracksWalls material node, and then on the Maps rollout, increase the Bump Amount to 75.

NOTE You might notice a couple of user-interface changes that happened when you assigned the map for bump mapping: a check box indicates that bump mapping is turned on, and the Bump button now shows the name of the map: planks.bump.jpg.

6 Click - (Render Production) again.
Now the planks appear extremely weathered.


The barrack walls with increased bump mapping

Texture the barrack roofs:
You will use a similar method for the roofs and floors of the barracks.


Left: Texture map for the barrack roofs

Right: Bump map for the barrack roofs

1 Increase the
 Field-Of-View so you have a good view of the barrack roofs.

2
Select Barracks01-Roof.
3 Clear the Slate Material Editor $\boldsymbol{>}$ active View.
4 In the Slate Material Editor, drag another Standard material node into the active View. Double-click the node to display the material parameters, then in the Name field, change the name of the material to BarracksRoof.

5 In the Slate Material Editor > Material/Map Browser panel, at the left, locate Maps $>$ Standard $>$ Bitmap, and drag this map type into the active View.

3ds Max opens a file dialog.
6 On the file dialog, and then choose metal_plate.jpg as the texture map.
7 Wire the new Bitmap node to the Diffuse Color component of the BarracksRoof material.

8 Click the BarracksRoof material node again to make it active.

9 Click ${ }^{1}+$ (Assign Material To Selection), and then click (Show Map In Viewport) to turn it on.
In the viewport, the map appears on the barrack roofs. However, it is oriented the wrong way: the corrugated plates should lie along the slope of each roof instead of lengthwise.

TIP The map should be applied to all three roofs. If it isn't, Propagate Materials To Instances was not on. Choose Options > Propagate Materials To Instances to turn this option back on, and try applying the map again.

10 Double-click the Bitmap node with the metal_plate.jpg texture. On the Coordinates rollout, change the W Angle to $\mathbf{9 0 . 0}$ degrees.

11 Go to the
Modify panel, and use the Modifier List to apply a UVW Map modifier.
At first this appears to lose the W-Angle correction you just made, but changing the modifier alignment will fix that.

12 In the Parameters rollout $>$ Alignment group, choose Y as the alignment axis.

## Alignment:



Fit
Center

## Bitmap Fit Normal Align

## View Align Region Fit

## Reset

 AcquireNow the metal plates are oriented correctly again.
13 Also on the Alignment rollout, click Fit.
This sets the Width to its correct value of 7.04 meters.
14 In the Parameters rollout > Mapping group, change Length to also equal 7.04m.
(Make sure you leave the UVW Map projection set to Planar, the default.) The roof texture now has the correct size and orientation.

15 In the Slate Material Editor > Material/Map Browser panel, at the left, locate Maps > Standard $>$ Bitmap, and drag another Bitmap node into the active View.

3ds Max opens a file dialog.
16 On the file dialog, choose metal_plate.bump.jpg as the texture.
17 Wire the new Bitmap node to the Bump component of the BarracksRoof node.

18 Double-click the new Bitmap node to display its parameters. On the Coordinates rollout, change the W Angle to $\mathbf{9 0 . 0}$ to match the texture.

19 Double-click the BarracksRoof material node. On the Maps rollout, increase the Bump Amount to 90.

20 Click ( Render Production) to see the effect.


The barrack roofs with bump mapping

At the eaves of the roofs, the texture "slops over" a bit. In this scene, it isn't a problem because usually you will render the barracks from a distance. Of course, the bump mapping isn't too apparent at a distance, either. Whenever you texture a scene, bear in mind how much detail you want to use to make the scene believable.

## Texture the barrack floors:

Texturing the barrack floors should now be a familiar process


Left: Texture map for the barrack floors
Right: Bump map for the barrack floors


Select Barracks01-Floor.
2 Add a new Standard material node to the active View, double-click it, and name the material BarrackFloors.

3 Add a new Bitmap node, choose wood_batten.jpg as the texture, then wire it to the Diffuse Color of BarrackFloors.

4 Click the BarrackFloors material node again to make it active.

5 Click $+\square$ (Assign Material To Selection), and then turn on
 (Show Map In Viewport).

6 Add another Bitmap node, choose wood_batten_bump.jpg as the texture, then wire it to the Bump component of BarrackWalls.

7 Double-click the BarrackFloors material node, and on the Maps rollout, change the Bump amount to 90.

8


Apply a UVW Map modifier to Barracks01-Floor. Leave the projection set to Planar. Set Length $=$ Width $=4.0 \mathrm{~m}$.
You don't need to adjust the orientation of the floorboards.

Now the barracks are completely textured.


Close-up of one barrack with textures for roof, walls, and floor

## Use the Barrack Materials for the Sentry Box

Now that you have textured the barracks, you can use the same materials for the sentry box. The trick is to use the same materials and the same UVW Map settings.

## Change the view:

1 Minimize the Slate Material Editor.
2 In the Warning: Isolated Selection dialog, click Exit Isolation Mode to return to a general view of the scene.

3 Click the Point Of View (POV) viewport label, and choose Cameras Camera02.
This gives you a view of the completed barracks, and the unfinished sentry box.

The new view lets you see the roofs, walls, and floors of the completed barracks, and also the roof, walls, and floor of the sentry box, which doesn't yet have materials applied.


Camera02 view with finished barracks to the right, unfinished sentry box to the left.

4 Click the Point Of View (POV) viewport label, and choose Perspective. Changing to a perspective view doesn't change what appears in the viewport, but in the perspective view, you can navigate without changing the camera settings.

## Copy the barracks floor material:



Click one of the BarracksOX-Floor objects to select it.

2


Ctrl+drag the UVW Mapping entry in the floor object's modifier stack, and drop this modifier instance over the floor of the sentry box. (Before it has a material, the floor appears blue.)
The sentry box floor now has the correct mapping, but it still needs its material.

3 Press M to open the Slate Material Editor, then drag from the output socket of the BarrackFloors material to the sentry box floor.
Now the floor has both the material and the correct mapping.

## Copy the roof and wall materials:

- For the roof and walls of the sentry box, follow the same steps you did for the sentry box floor: First select a barracks roof or wall, Ctrl+drag UVW Mapping from the modifier to the corresponding sentry box object, then wire the appropriate material to the roof or walls.
If the material is no longer visible in the active View of the Material Editor, then on the Browser panel open the Scene Materials group, drag the material into the active View, and choose Instance.


The sentry box with the same materials as the barracks

NOTE The order in which you apply the material and the mapping doesn't matter. The important thing is to assign the material and the UVW Mapping, so that the materials render correctly.

## Create a new, 3D material for the sentry bar:

For the sentry bar, which blocks or permits vehicle access to the compound, you can use a simple material with a procedural map named Gradient Ramp.

1 On the main toolbar, open the Named Selection Sets drop-down list, and choose the sentrybox selection set.
3ds Max selects the sentry box.
2 Right-click the viewport, and choose Isolate Selection from the quad menu.

3 Use (Field-Of-View) to adjust the view so the sentry bar is clearly visible.

Isolated sentry box with a view of the bar

## 4



Select the sentry-bar object.
5 In the Slate Material Editor, drag a new Standard material node to the active View, double-click the node, and name the new material SentryBar.

6 From the Material/Map Browser $>$ Maps $>$ Standard group, drag a Gradient Ramp node into the active View. Wire this node to the Diffuse Color component of the SentryBar material.

7 Click the new SentryBar material node to highlight it, then click

(Assign Material To Selection) and (Show Map In Viewport).

8 Double-click the Gradient Map node to see its parameters.

Gradient Ramp is a 3D procedural material like the Noise material you used for the generator casings.


9 In the Gradient Ramp Parameters rollout, change the Interpolation type to Solid.

The gradient display changes to two solid colors, one of them black.
10 Double-click the arrow-shaped slider at the middle of the gradient display. This slider controls the color to its right (you could use the first slider on the left to adjust the black color.)


## Gradient Ramp with solid colors

Double-click the middle slider (shown in green) to change the color to the right of the slider.

3ds Max opens a Color Selector.
11 On the Color Selector, change the second gradient color to orange: Red $=255$, Green $=150$, Blue $=0$.

12 Click OK to close the Color Selector.
13 On the Coordinates rollout, change the U Tiling value to $\mathbf{1 0 . 0}$. The material changes from two color areas to multiple stripes.

14 Also in the Coordinates rollout, change the W Angle value to - $\mathbf{- 2 . 5}$. Now the stripes have an angle to them.


Isolated sentry box with the completed sentry bar

## View the entire scene again:

1 In the Warning: Isolated Selection dialog, click Exit Isolation Mode.
2 Click the viewport label and choose Cameras > Camera01.
3 Click the viewport label again and choose Perspective.

## Save your work:

■ Save the scene as my_fieldhq_barracks.max.

## Using Opacity Mapping for the Fences

The fences are a bit of a special case, because the chain-link parts of them should be partially transparent. You accomplish this the way you did bump mapping: by the use of bitmaps.

Set up the lesson:

■ Continue from the previous lesson, or

open army_compound02.max.

## Select the fences:

> On the main toolbar, open the Named Selection Sets drop-down list, and choose the fence selection set.

This step is mainly to show you what and where the fences are. There is the main fence around the compound and the smaller fence that encloses the utility containers.

NOTE Incidentally, the main fence includes two gates, left and right. Each gate can move along its own local X axis to open or close the compound.

## Use a basic material for the fence supports:

Each fence component, including the gates, actually includes two objects: a "structure" component for the fence's supportive piping, and a "wire" component for the actual chain link.

1 In the Material Editor, drag a new Standard material node to the active View, double-click it, and name the material, FenceSupport.

2 In the Blinn Basic Parameters rollout, click the Diffuse color swatch to display the Color Selector, and then assign the material a light gray color: Red $=$ Green $=$ Blue $=188$.

3 Click OK to close the Color Selector.
4 Click the FenceSupport material node again to make it active.

5 Press H to display the Select From Scene dialog. Highlight the structure objects for all the fences: Fence-Structure, Gate-left-structure, Gate-right-structure, and Fence-sml-Structure. Click OK to select these four objects.

6
 (Assign Material To Selection).

Use a texture map for the chain link:
The chain link itself uses a bitmap with a chain-link pattern.


Chain-link texture for the fence

1 In the Material Editor, drag a new Standard material node to the active view, double-click it, and name the new material FenceChainLink.

2 On the Shader Basic Parameters rollout, turn on 2-Sided.
3 Drag a new Bitmap to the active View. On the file dialog, assign sitework.chainlink.jpg as the texture.

4 Wire the new Bitmap node to the FenceChainLink material's Diffuse Color component.

5 Click the FenceChainLink material node again to make it active.

6 Press H to display the Select From Scene dialog. Highlight the wire objects for all the fences: Fence-Wire, Gate-left-wire, Gate-right-wire, and Fence-sml-Wire. Click OK to select these four objects.

7 Click $+\square$
(Assign Material To Selection) and then turn on (Show Map In Viewport).
The fence texture appears in viewports as a gray pattern on a black background. It isn't yet to scale, so you need to adjust it with UVW Map.

NOTE Because the mapping isn't yet right, some fence surfaces might appear gray even if you turned on 2-Sided. The UVW Map adjustments will fix this.

8 With all four objects still selected, go to the


Modify panel and apply a UVW Map modifier.

9 Change the mapping projection type to Box, and then set Length = Width $=$ Height $=\mathbf{0 . 5 m}$.
Now the mapping and the scale of the chain link are correct; but of course, the fences still appear to be solid objects.

## Use the chain-link texture to create transparency and opacity:

Just as in bump mapping, where black areas of a map appear recessed and white areas appear prominent (with gray values having an intermediate effect), in opacity mapping, black areas appear transparent and white areas appear opaque (while gray values create some degree of translucency).

Because the chain-link map is already black-and-white, it should work effectively both as a texture and as an opacity map.

1 In the active View, drag a second wire from the Bitmap node with the chain link pattern. This time, wire it to the FenceChainLink material's Opacity component.


Bitmap controlling both color and opacity

2 Click the main FenceChainLink material node, then click to turn on
 (Show Map In Viewport).
Now, in the viewport, the chain-link portions of the fence appear partially transparent.


Viewport display of fence with opacity mapping

The one thing missing from this view is transparency in the fence shadows. Depending on your graphics card, viewports might not display opacity mapping just as they don't display bump mapping. If this is the case, you must render to see the effect of opacity mapping on shadows.

3 Click - (Render Production).
In the rendering, the shadows convincingly match the transparency of the fence.


Rendering of opacity-mapped fence

Save your work:
■ Save the scene as my_fieldhq_fencing.max.

## Texturing the House: More Mapping Techniques

The house is of stone, not of wood, but for the most part, the mapping techniques you use should be familiar from previous lessons. This lesson introduces a couple new techniques that can be useful.

## Set up the lesson:

- Continue from the previous lesson, or
 open army_compound03.max.


## Texture the walls of the house:

The walls of the house present familiar techniques.
1 On the main toolbar, open the Named Selection Sets drop-down list, and choose the house selection set.
3ds Max selects the farm house.
2 Right-click and choose Isolate Selection from the quad menu.

3


Click an empty area of the viewport to clear the selection, and then click the House object to select the walls.

4 In the Slate Material Editor, drag a new Standard material node to the active View, double-click it, and name the new material Masonry.

5 Drag a new Bitmap node to the active View, choose masonry.fieldstone.jpg as the texture, and wire it to both the Diffuse Color and Bump components of the Masonry material node.


Texture for the house walls

6 Double-click the Masonry material node to see its parameters. On the Maps rollout, change the Bump amount to 90.
(Assign Material To Selection), and then turn on (Show Map In Viewport).

8


Apply a UVW Map modifier to the house walls. Change the map projection to Box, and set Length $=$ Width $=$ Height $=5.0 \mathrm{~m}$.


House walls with a masonry texture

## Use a Mapscaler to texture the roof:

The roof, on the other hand, presents a problem. With its two gables, there is no straightforward way to map the pattern using UVW Map.


Shingle texture for roof of house

With default mapping (you don't need to go through these steps, yourself), the texture doesn't look right. Even if you were to adjust the scale or change the projection type, the shingles wouldn't conform to the direction of the gables.


Default texture mapping for the roof

The solution is to use a different modifier, Mapscaler, to handle the texture mapping.

1


Select the House-Roof object.
2 In the Slate Material Editor, drag a new Standard material node to the active View, double-click it, and name the new material HouseRoof.

3 Drag a new Bitmap node to the active View, choose shakes.weathered.jpg as the texture, then wire the new Bitmap to the HouseRoof material node's Diffuse Color component.

4 Click the HouseRoof material node to make it active.
 (Show Map In Viewport).

6 Go to the
Modify panel. From the Modifier List, choose MapScaler.

NOTE Be sure to choose "MapScaler" from the list, and not "MapScaler (WSM)". The world-space (WSM) version of MapScaler has a similar effect, but is not quite the same.

The MapScaler modifier maintains the map scale relative to the object (in this case, the roof), and by default it wraps the texture so the shingles follow the angles of the roof.


Shingle texture mapped using MapScaler

TIP Not all game engines recognize the MapScaler modifier, but if you apply MapScaler and then collapse the object to an Editable Mesh or Editable Poly, the texture mapping will be "baked in" to the model, and game engines will recognize the mapping.

## Texture the windows:

The windows use another small feature to ensure correct mapping.
1 In the Warning: Isolated Selection dialog, click Exit Isolation Mode.

2


Click one of the purple windows to select it. The windows are a single grouped object named Windows.

3 Right-click the viewport, and choose Isolate Selection from the quad menu.

4 In the Slate Material Editor, drag a new Standard material node to the active View, double-click it, and name the new material HouseWindows.

5 In the Shader Basic Parameters rollout, click to turn on Face Map. When Face Map is on, a texture map is applied to each face of an object individually.

6 Drag a new Bitmap node to the active View, choose window.jpg as the texture, then wire the new Bitmap node to the Diffuse Color of the HouseWindows material node.


Bitmap for the window texture

7 Click the HouseWindows material node to make it active.

8 Click $1+\square$ (Assign Material To Selection), and then turn on (Show Map In Viewport).

9 In the Warning: Isolated Selection dialog, click Exit Isolation Mode.

## Texture the front door:

Like the walls, the front door of the house is a straightforward texture mapping.

1


Click to select the Door object.
2 In the Slate Material Editor, drag a new Standard material node to the active View, double-click it, and name the new material WoodBoards (you will use it elsewhere in the scene).

3 Drag a new Bitmap node to the active view, choose wood.boards.jpg as the texture, then wire the new Bitmap to the Diffuse Color of the WoodBoards material node.


Left: Texture for the wood boards that make the house door

Right: Bump map for the wood boards

4 Drag a second Bitmap node to the active View, choose wood.boards.bump as the texture, and wire this Bitmap to the Bump component of the WoodBoards material node.

5 Double-click the WoodBoards node so you can see its parameters, then on the Maps rollout, increase the Bump Amount to 70.

6 Click

(Assign Material To Selection), and then turn on (Show Map In Viewport).

7


Apply a UVW Map modifier to the door. Change the map projection to Box, and set Length $=$ Width $=$ Height $=4.0 \mathrm{~m}$.

This completes your texturing of the house.


The house with all its textures

Save your work:
Save the scene as my_fieldhq_farmhouse.max.

## Mapping the Barn

The army compound scene is nearly complete. The walls and doors of the barn use the same material you just created for the door, while the floor of the barn is the same as the barracks floors. The only difference is the roof of the barn: This also uses the WoodBoards material, but with a slightly different mapping.

## Set up the lesson:

■ Continue from the previous lesson, or

open army_compound04.max.

## Use the front-door texture for the walls and doors of the barn:

1 Click the Perspective viewport label, and choose Cameras > Camera03. Camera03 shows a view of the barn.

2 Click the viewport label again, and choose Perspective, so any navigation you do won't change the camera position or settings.

3 From the Material Editor, drag from the output socket of the WoodBoards material onto the barn walls and barn doors: the objects Barn, Barn-Door-right, and Barn-Door-left.

4 Press H to display the Select From Scene dialog. Select the Door object,
then


Ctrl+drag its UVW Mapping from the modifier stack to the barn walls and doors.

## Use the barracks floor material for the floor of the barn:

1 From the Material Editor, drag from the output socket of the BarrackFloors material onto the barn floor.

2 Press H to display the Select From Scene dialog. Select one of the barracks floor objects, then Ctrl+drag its UVW Mapping from the modifier stack to the barn floor.

## Texture the roof of the barn:

1 From the Material Editor, drag from the output socket of the WoodBoards material onto the barn roof.

2
Select the barn roof and
apply a UVW Map modifier to it. Leave the map projection set to Planar. In the Alignment group, change the alignment axis to Y. In the Mapping group, change Length $=$ Width $=4.0 \mathrm{~m}$.

Now the army compound scene is completely textured.

## Render the completed scene:

1 Right-click the viewport label and choose Cameras
Camera01.


The fully textured field headquarters

## Save your work:

■ Save the scene as my_fieldhq_finished.max.
You can see a version of the finished scene in army_compound_completed.max.

## Summary

This tutorial has introduced a variety of methods for applying materials to objects. Among the methods shown were:

■ Applying a basic material to change an object's color or shininess (the oil tanks and the fence piping)

- Applying a 3D procedural map to create a patterned material (the generators and the sentry bar)
- Applying a Diffuse or "texture" map to give an object a photorealistic pattern (the ammunition canister, the terrain, and almost all of the building surfaces)

■ Using the UVW Map modifier to control the projection, orientation, and scale of texture mapping
We also showed how to copy UVW Map from one object to another when the objects share the same material.

■ Using bump mapping to give a 3D appearance to a textured material (most of the materials on the buildings)

■ Using opacity mapping to make a material partially transparent (the chain-link fence)

■ Using the object-space Mapscaler modifier to project a map onto a complicated shape (the roof of the house)

## Normal Bump Mapping

Normal bump mapping is a technique that lets you simulate high resolution surface detail on low resolution polygonal models.

Normal bump mapping is similar in some respects to regular bump mapping, but it conveys more complex surface detail. Normal bump maps store not only the depth information used in regular bump mapping, but also information on the direction normal of the surface, to produce more life-like results.

The practical benefits of normal bump mapping were first seen in real-time gaming platforms. The ability, however, to create more realistic detail with fewer polygons is desirable in all areas of digital content creation. 3D artists of every specialty should therefore be familiar with two normal bump mapping techniques: the planar projection method and the cage projection method. In this section, each technique is presented in its own tutorial.

IMPORTANT Before you begin these tutorials, you should make sure that 3ds Max is set to use the Direct3D display driver; otherwise, you will not be able to see the bump effect in your viewports. From the main menu, choose Customize - Preferences, and in the Viewports tab > Display Drivers group, make sure Direct 3D is the selected driver. If you need to change the driver, you also need to restart 3ds Max. If Direct3D hardware shading is not available on your workstation, then skip these tutorials.

## Planar Projection Method

Normal bump mapping involves two objects: a high resolution, polygonally detailed object as the source for the normal bump map information, and a low resolution target to receive the map and use it to appear more finely detailed than it really is.

The objective in this tutorial is to assign the target object, a simple two-dimensional plane, the complex surface detail of the source: a tile of mortared stones.

The texture to be baked onto the plane will consist of a normal bump map, together with a diffuse map. You will then add a height map to give the plane the appearance of depth, and render it with the mental ray renderer.


In this tutorial, you will learn how to:

- Set up the map projection using the render to texture controls.
- Define diffuse, normal bump, and height maps, and bake the resulting texture onto a destination object.
- Preview the baked result in a viewport.

Skill level: Intermediate
Time to complete: 1 hour

## Creating a Normal Bump Map

First, you use the Render To Texture feature to create the normal bump map.

## Set up the lesson:

> On the Quick Access toolbar, click

(Open File) and from the \materials_and_mapping \normal_bump_map folder, open pavers.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene consists of a source object, a tile of spheres sculpted to resemble rocks set in mortar. Directly above is the target object, a simple two-dimensional plane.

## Unwrap the plane object:

1 In any viewport,

select the target plane object, Proj-Plane, and go to the


Modify panel.
2 From the Modifier List drop-down, choose Unwrap UVW.
This modifier sets out the mapping coordinates of the plane object, so that the textures of the source object can accurately be projected onto it.

On the Parameters rollout > Channel group, notice that the mapping coordinates are automatically stored on Map Channel 1.


## Set up the projection:

Here, you will use the Render To Texture tool to define various projection setup parameters.

1 With the plane object still selected, from the main menu, choose Rendering $>$ Render To Texture.

TIP The default keyboard shortcut for the Render To Texture dialog is 0 .

2 In the Render To Texture dialog
General Settings rollout > Output group, define the output path where you want to save the diffuse, normal bump, and height map textures you are about to create.

## Output

Path: ts\3ds Max 2011 Tutorialslsceneassetslimages ...
$\square$ Skip Existing Files $\quad$ Rendered Frame Window

By default, the output is saved to the \3dsmax \sceneassets \images folder of your 3ds Max project, but you might want to specify a different storage location.

3 In the Objects To Bake rollout > Projection Mapping group, turn on Enabled. Since the plane object you will bake the texture to consists of only a single flat surface, turn off Sub-Object Levels.

## Projection Mapping

| $\nabla$ Enabled (No Projection Modifier | Pick... Options... |
| :--- | :--- | :--- |
| $\nabla$ Object Level | Sub-Object Levels |
| - Put to Baked Material | Put to Baked Material |

© Full Size $\bigcirc$ Proportional

If you wanted to bake textures of objects onto multiple surfaces (for example, onto each face of a box), you would keep Sub-Object Levels turned on.

4 Click the Pick button to display the Add Targets dialog.


Here, you choose which objects you want to bake onto the plane object.
5 Click the first item in the list, then Shift+click the last item in the list to choose all the rocks and the mortar. Click Add.

The drop-down list in the Projection Mapping group changes from (No Projection Modifier) to Projection, indicating that a new Projection modifier, containing the items you just selected for projection, has been placed on the stack for the plane object.

6 Click the Options button to display the Projection Options dialog.


The height map defines the stone and mortar topography of the source object. To generate the map, you must determine both the farthest and closest points between the source and plane object.

7 Activate the Top viewport, and
 zoom in slightly until you can see the mortar regions clearly.

In the next two steps, be sure that you are directly above the plane. Height selection will work only if you are above the target object.

8 In the Height Map group, click the eyedropper button to the right of the Min Height field. Click through the plane, above the mortar between the rocks. The value of Min Height changes to -100 .

## Height Map

Min Height: $\sqrt{-100.0}$ Buffer min Height: 0.0
Max Height: 10.0 Buffer max Height: 0.0

9 Click the eyedropper button next to the Max Height field and then click through the plane, over the highest rock in the scene. This is Rock10, along the upper-right edge of the plane in the Top viewport. Try to find a value between -40.0 and -20.0 . dialog $>$ Objects To Bake rollout $>$ Mapping Coordinates group, choose Use Existing Channel, if it is not already chosen.

## Mapping Coordinates



Clear Unwrappers

The Use Existing Channel option indicates that you want to use the texture-mapping coordinates you created from the UVW Modifier at the beginning of this lesson, rather than letting 3ds Max create new texture-mapping coordinates on the fly.

## Define the texture to be baked:

Now that the projection method has been defined, the next step is to add the diffuse, normal bump, and height maps that, when combined, will form the texture to be baked onto the plane object.

1 On the Render To Texture dialog, scroll down to the Output rollout, click Add and from the Add Texture Elements dialog, click to highlight DiffuseMap, then click Add Elements.


A new Diffuse entry appears in the Output rollout $>$ Selected Element Common Settings group. The file name of the diffuse map to be created displays in the File Name and Type field.


2 Make sure that the Target Map Slot has changed to Diffuse Color. If it hasn't, choose Diffuse Color from the drop-down list.

3 Click the $512 \times 512$ Width/Height button. This sets the output resolution of the diffuse map to 512 by 512 pixels.


4 On the Output rollout, click Add again and from the Add Texture Elements dialog, click to highlight NormalsMap, then click Add Elements.


A new Normals entry appears on the Output rollout, below the Diffuse map entry.

5 Make sure that the Target Map Slot has changed to Bump. If it hasn't, choose Bump from the drop-down list.

6 Click the $512 \times 512$ Width/Height button to set the output resolution of the normals bump map.

7 In the Selected Element Unique Settings group, turn on Output Into Normal Bump, so that the result shows up properly both in the viewport and in the rendered frame.

## Selected Element Unique Settings

## $\checkmark$ Output into Normal Bump

hender Height Map into Alpha Channel

8 On the Output rollout, click Add and from the Add Texture Elements dialog, click to highlight HeightMap, then click Add Elements.


A new Height entry appears on the Output rollout.
9 Leave the Target Map Slot empty. This information is not needed here. You will assign the map later, using the mental ray renderer.

10 Click the $512 \times 512$ Width/Height button to set the output resolution of the height bump map.
At this point, you have defined all the basic elements and settings for creating diffuse, normals bump, and height maps.

11 Activate the Perspective viewport.
12 With the plane object selected, press Alt+X to exit X-ray (See-Through) mode. This mode lets you see behind the selected object. With this mode
now turned off, you will be able to see the results when the plane is rendered.

13 At the bottom of the Render To Texture dialog, click Render to render the selected plane.
3ds Max displays a warning.

## Missing Map Targets

The following elements do not specify a Target Map slot:

```
Proj-Plane: HeightMap
```


## Continue

Cancel
Don't display this message again

Click Continue to dismiss the Missing Map Targets message box. We deliberately left the height map unassigned, because in the next lesson, you will assign it separately.

If the Files Exists dialog displays, click Overwrite Files.


The rendering shows only the information from the diffuse map. The normal bump and height maps have also been baked into the texture of the plane, but they are not visible. In the next lesson, you will use the Material Editor to display the complete projected texture in the viewports.

14 $\square$ Close the rendered frame window.

## Save your work:

Save the scene as my_paver_elements.max.

## Visualizing the Projection

With DirectX shading, you can view the effect of normal bump mapping in viewports.

## Set up the lesson:

- Continue from the previous lesson, or from the
\materials_and_mapping \normal_bump_map folder,
 open pavers_view.max.


## Preview the normals bump map:

## 1

Select the plane object. Right-click it, and choose Isolate Selection from the quad menu.
Next, you will hide the plane's selection cage, which was generated by the Projection modifier you added earlier.


2 On the
Modify panel, open the Modifier List and apply a Poly Select modifier. This adds the modifier to the top of the plane's modifier stack and hides the selection cage.

3 Open the

4 Click (Pick Material From Object), and click the plane object to display its material in the active View.

5 Double-click the Proj-Plane_mtl [Proj-Plane] / Shell material node (the one at the right) to display the Shell material parameters.

$\left[\right.$| Shell Material Parameters |  |  |
| :---: | :---: | :---: |
| Original Material: | Viewport | Render |
| orig_Proj_Plane_mtl (Standard) | $\odot$ | 0 |
| Baked Material: |  |  |
| baked_Proj-Plane_mtl (Standard) | © | $\bigcirc$ |

As the rollout shows, the Shell material contains two types of material: the originally assigned plane material, which displays only when rendered, and the baked material obtained from the source object, which displays only in viewports.

6 On the Slate Material Editor, click $\llcorner$ (Zoom Extents) to see the whole material tree.


TIP You might want to change the size of the Slate Material Editor window, and use some of the other navigation tools, to get a view you can read easily.

At the right is the top-level node, the Shell material you just inspected. Next to the left are the two sub-materials: The original, renderable material is above, and the baked, hardware material is below. The baked material has a Bitmap node and a Normal Bump map node (each of these has an associated Controller node). Finally, the Normal Bump node uses the NormalsMap bitmap you rendered in the previous lesson.

7 Double-click the Bitmap node for the Normal Bump map. This is the node at the far left.

8 In the Bitmap parameters rollout > Cropping/Placement group, click View Image.

```
Cropping/Placement
```



3ds Max displays the normal bump map you created earlier, which now is applied to the plane object.


The colors in the map are significant. The reason normal bump maps convey so much more detail than ordinary bump maps is that normal bump maps use the entire RGB spectrum for surface detail information, whereas ordinary bump maps only use a single grayscale. The blue channel conveys vertical depth information, and the red and green channels enhance this information by providing a direction vector for the orientation of the surface normal at each point. This results in higher realism.
 Close the Rendered Frame Window.

## Use hardware shading to display the map:

1 In the Slate Material Editor, double-click the baked_Proj-Plane_mtl/ Standard material node to display its parameters.

2 On the Slate Material Editor toolbar, open the Show Standard/Hardware Map In Viewport flyout, and choose Show Hardware Map In Viewport.


3 On the Parameter Editor panel, open the Maps rollout, and increase the Bump amount to 90.


4 Minimize the Slate Material Editor.

5 In the Perspective viewport,
 zoom in to get a closer view of the plane.
The flat surface of the plane object takes on a greater, three-dimensional degree of detail.


Next, you will add a standard Omni light to the scene to see how effectively the normal bump map, when combined with a standard Omni light, provides a sense of depth to the object.

## Visualize the 3D effect

1 On the


Create panel, turn on

(Lights). Choose Standard from the drop-down list, then click Omni to turn it on.


2 In the viewport, click anywhere above the plane object to place the light.

You might need to move the light vertically as well, to position it above the plane.


Even though this object is a flat plane, notice how the light and shadow play across the stones as if the geometry was a raised surface.

## Try rendering with both renderers:

1 Delete the light object.
2 Restore the Slate Material Editor (press M), and move the window so you can see all of it, again.

3 Double-click the Proj-Plane_mtl [Proj-Plane] / Shell material node (the one at the right) to display the Shell material parameters.

4 On the Shell Material Parameters rollout, set the Baked Material to be visible in the rendered output.

$\left[\right.$| Shell Material Parameters |  |
| :--- | :---: |
| Original Material: | Viewport |
| orig_ProjPlane_mtl (Standard) | Render |
| Baked Material: |  |
| baked_Proj-Plane_mtl (Standard) | o |
|  |  |

5 Minimize the Slate Material Editor.

6 In the Perspective viewport, , orbit so the plane is almost horizontal, then press F 9 to render the plane.

Notice how the edges of the plane still appear straight and two-dimensional.

The 3D relief you've achieved so far with the diffuse and normals bump maps is usually acceptable when you model for games development. For other uses, such as cinematics, you might need to take things one step farther.

To complete the effect, you will use the height map you created earlier and render it with the mental ray renderer. $\stackrel{+}{\square}$ Common tab, scroll down to the Assign Renderer rollout, then click
$\because!$
(Choose Renderer) for the Production renderer.


8 In the Choose Renderer dialog, choose "mental ray Renderer," then click OK.

9

- Render the plane again.

10 In the rendered frame window, click
 Window), then minimize the two frames.

## Render the height map

Now you will add the Height map to the rendering.


Select the plane object.
2 Press M to restore the Slate Material Editor.

3 Double-click the baked_Proj-Plane_mt/ / Standard material node to display its parameters.

4 In the mental ray Connection rollout > Extended Shaders group, click the
 lock button for Displacement to unlock Displacement and enable its controls.


5 From the Material/Map Browser panel at the left of the Slate Material Editor, locate Maps $>$ mental ray $>$ Height Map Displacement, and drag this map type to the Active View.

6 In the active View,
 zoom so you have a good view of both the baked_Proj-Plane_mtl / Standard material node and the new Height Map Displacement node.


7 On the baked_Proj-Plane_mtl / Standard material node, click the plus-sign icon (+) to open the "mr Connection" group, and then wire the Height Map Displacement node to the "mr Connection: Displacement" component of the baked material.


8 On the Material/Map Browser panel, locate Maps > Standard > Bitmap, and drag this map type to the active View.

3ds Max opens a file dialog.
On the file dialog, choose proj-planeheightmap.tga.
Like the Diffuse and Normal Bump maps, this file should be located in \sceneassets \images, or in the folder you specified earlier on the Render To Texture > General Settings rollout.

9 Wire the new Bitmap node to the Height Map component of the Height Map Displacement node.


10 Double-click the Height Map Displacement node to display its parameters, and on the Height Map Displacement rollout, set Minimum Height to 0.0.

TIP An easy way to do this is to right-click the spinner arrows.

| Height Map Displacement Parameters | 入 |
| :---: | :---: |
| Minimum Height . . . . . . . . . . . . . . . . 0.0 |  |
| Maximum Height . . . . . . . . . . . . . . . . 10.0 |  |
| Height Map . . Map \#14 (Proj-PlaneHeightMap.tga) |  |



12 Restore the view of the rendered frame you cloned earlier, and compare the renderings.


The geometry has been pushed up based on the displacement map generated by the mental ray engine and added to the rendering.

## Summary

This tutorial showed you how to project complex surface detail from a source object onto a simple, two-dimensional plane. Detail is derived
from the source by including normal bump, diffuse, and height maps in the projection, then rendering them as a texture to the simple plane.

## Cage Projection Method

Normal Bump Mapping using cage projection also involves a source and target object.

In this tutorial, you will create a cage object and form it to fit the contours of the target, a low-resolution model of a human head. You will then use the cage to receive the diffuse and normal bump map information from the source, a high-resolution version of the model.


Model of a warrior with diffuse map only (left) and with normal map applied (right)

In this tutorial, you will learn how to:

- Use Render To Texture to create a normal bump map.

■ Use the Projection modifier to "steal" detail from a high-resolution mesh.
■ Use the Normal Bump map type to render the effects of a normal bump map.

Skill level: Intermediate/Advanced
Time to complete: 1 hour

## Creating a Normal Bump Map

You use Render To Texture to create the normal bump map for the warrior head as well, but you also adjust the cage before you render the map.

## Set up the lesson:

On the Quick Access toolbar, click

(Open File), navigate to
 warrior_head_lores.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.


The only visible object is an editable mesh model of the head of a warrior. This is the low-resolution target object, consisting of roughly 750 polygons, to which you will apply normal bump maps. Its surface is smooth, and it has a checkered texture map applied to it. This checker map was used as a visual guide in setting up the texture mapping of the surface. An Unwrap UVW modifier has already been applied.

## Inspect the mapping:

1
 Select the model, go to the rollout, and click the Edit button.


3ds Max opens the Edit UVWs dialog, which shows how the Unwrap UVW modifier has already been applied to the target object, and how the texture coordinates have been mapped to the surfaces of the model. This layout was designed to facilitate painting, which can be necessary for "touching up" texture mapping.

2 In the Selection Modes group, turn on Select Element, then click to turn

(Face Sub-Object Mode). In the main window, select geometry elements to see how they correspond to the model in the Perspective
viewport.


In order to extract the high-resolution information from the source model, you will now need to merge it with the low-resolution version.

## Merge the high-resolution model:

1 From the


Application menu, choose Import Merge, and on the file dialog, navigate to the folder that contains your scene files. Select the scene that contains the high-resolution model warrior_headhires.max, then click Open.

3ds Max opens a Merge dialog.

## (G) Merge - warrior_head_hires.max



## Find Case Sensitive Sort

(O) Alphabetical

By Type
By Color

| List types |  |
| :--- | :--- |
| $\nabla$ Geometry | All |
| $\nabla$ Shapes | None |
| $\nabla$ Lights | Invert |
| $\nabla$ Cameras |  |
| $\nabla$ Helpers |  |
| $\nabla$ Space Warps |  |
| $\nabla$ Groups/Assemblies |  |
| $\nabla$ Bone Objects |  |

All None Invert Influences

Display Subtree Display Influences

Select SubtreeSelect Influences

2 On the dialog, click to highlight War_Head_HiRes, then click OK. The two models are now visible. Both are the same size and are precisely aligned.


3 To view the high-resolution model on its own, make sure the
high-resolution model is selected,

select a non-checkered part of the head, right-click, and from the quad menu choose Isolate Selection.


This model, at approximately 96,000 polygons, shows a much greater amount of detail.

4 Click Exit Isolation Mode to return to the merged view and then
 click a checkered region of the model to select the low-resolution model.

To make sure you have the low-resolution model selected, check that the Name And Color rollout displays War_Head_LoRes.
Now you will proceed to create the normal bump map based on the high-resolution model.

## Set up Render To Texture (RTT):

To generate the normal bump map, you will use the Render To Texture tool.
1 From the main menu, choose Rendering $>$ Render To Texture.
2 In the Render To Texture dialog $>$ General Settings rollout $>$ Output group, define the output path where you want to save the diffuse and normal bump map textures you are about to create.

```
Output
Path: ts\3ds Max 2011 Tutorials\sceneassets\images\(\ldots\)\(\square\) Skip Existing Files \(\quad\) Rendered Frame Window
```

By default, the output is saved in the \sceneassets \images folder of the current project, but you might want to specify a different storage location.

3 In the Objects To Bake rollout > Projection Mapping group, turn on Enabled, then turn off Sub-Object Levels, since no sub-selections exist in this particular model.

```
Projection Mapping
| Enabled (No Projection Modifier - Pick... Options...
    \square Object Level 琼-Object Levels
    (0) Put to Baked Material Chut to Baked Material
    (O) Full Size Proportional
```

4 Click the Pick button to display the Add Targets dialog, choose War_Head_HiRes, then click Add.


The drop-down list in the Projection Mapping group has changed from (No Projection Modifier) to Projection, indicating that a new Projection modifier has been placed on the stack for War_Head_HiRes.

Projection Mapping

| $\nabla$ Enabled Projection | $\square$ | Pick... Options... |
| :--- | :--- | :--- |
| $\nabla$ Object Level | $\square$ Sub-Object Levels |  |
| OPut to Baked Material | 〇Put to Baked Material |  |
|  | ○ Full Size | Proportional |

Also, a rough wireframe cage appears around the high-resolution head object in the viewport. The cage shows a considerable amount of irregular geometry, but this is usual when it is first applied. The problem is easy to correct.


5 On the Modify panel $>$ Cage rollout, click Reset.


The cage resets itself to fit tightly around the target low-resolution model.
The shape of the cage is correct, but it is important that the cage fully encompass the source high-resolution model. Where the source geometry lies outside the cage, the result will be ray intersection misses, which in turn will cause flaws in the normal bump map.

6 On the Cage rollout > Push group, set Amount to 1.1.


After the value is applied, it resets to 0.0 and the cage balloons outward slightly so that the entire War_Head_HiRes object, with all its bumps and protrusions, fits within it.


7 In the Render To Texture dialog $>$ Objects To Bake rollout $>$ Mapping Coordinates group, choose Use Existing Channel.

## Mapping Coordinates

Object: Use Existing Channel Yuse Automatic Unwrap

Channel:


This is where you specify that you want to use the pre-assigned texture-mapping coordinates you viewed at the beginning of this lesson, rather than letting 3ds Max create new texture-mapping coordinates on the fly.

8 Scroll down to the Output rollout, click Add, and in the Add Texture Elements dialog, click to highlight Normals Map, then click Add Elements.


A new NormalsMap entry appears on the Output rollout of the Render To Texture dialog.

9 On the Selected Element Common Settings group > Target Map Slot drop-down list, choose Bump, then click the $512 \times 512$ Width/Height button, which sets the output size to 512 by 512 pixels.


10 On the Selected Element Unique Settings group, turn on Output Into Normal Bump, so that the result shows up properly both in the viewport and in renderings.

## Selected Element Unique Settings

Qutput into Normal Bump:
乌Render Height Map into Alpha Channel

At this point, you have defined all the basic elements and settings for generating a normal bump map.

## Render and fine-tune the normal bump map:

1 At the bottom of the Render To Texture dialog, click Render to render your normal bump map.


The rendered map shows an unwrapped diffuse rendering of the high-resolution model. Assorted red patches are visible, indicating where the bump map projection rays did not properly capture the underlying geometry. This is because the cage created by the Projection modifier did not completely cover the high-resolution model in these spots.
This would create problems if you applied the normal bump map to the low-resolution target. You will resolve this problem by applying neutral normal values to these red patches so they blend with their surrounding areas.

2 Make sure the War_Head_LoRes object is selected and on the Render To Texture dialog > Objects To Bake > Projection Mapping group, click Options to display the Projection Options dialog.

| (6) Projection Options | - | 回 | $\Sigma 3$ |
| :---: | :---: | :---: | :---: |
| Objects and Sources |  |  |  |
| War_Head_LoRes (0 SO Outpu | puts) | Synch All |  |
| Filtering Options |  |  |  |
| $\square$ Crop Alpha Gla | Global Supersampler: None Setup... |  |  |
| Method |  |  |  |
| O Raytrace $\bigcirc$ UV Match | ( Use Cage Offset: 10.0 |  | $\stackrel{\mid}{\text { v }}$ |
| Resolve Hit |  |  |  |
| Closest Furthest |  |  |  |
| $\square$ Hit Only Matching Material ID |  | $\checkmark$ Ray miss check |  |
| $\square$ Include Working Model |  | Ray miss color: |  |
| Normal Map Space |  |  |  |
| $\bigcirc$ World $\bigcirc$ Screen | © Local XYZ (O) Tangent |  |  |
| Orientation: Red: $\bigcirc$ Left $\bigcirc$ | Right Green: <br> Down <br> Up |  |  |
| Height Map |  |  |  |
| Min Height: $\sqrt{-10.0}$ \| 4 | 7 Buffer min Height: | -22.437 |  |
| Max Height: 10.0 | B Buffer max Height: | 1.095 |  |

3 In the Resolve Hit group, turn off Ray Miss Check, then
 close the dialog.
With Ray Miss Check turned off, the red patches in the rendered normal bump map will be replaced by a neutral blue background with a normal value of 0 , a value that will permit the regions to blend effectively with the normal map that will be created.

4 At the bottom of the Render To Texture dialog, click Render to render your normal bump map once again.
Click Overwrite Files when you are prompted to overwrite the previous rendered file.

The rendered result shows that the previous ray misses now appear as black, the neutral element background.


Now you will take a look at the actual normal bump map image file to see the blending result.

5 From the main menu, choose Rendering > View Image File. In the file dialog that displays, navigate to the image file location, which by default is \sceneassets $\backslash i m a g e s$.

6 Select the file war_head_loresnormalsmap.tga, then click Open.


The blue channel conveys vertical depth information, and the red and green channels enhance this information by providing a direction vector for the normal orientation of the surface at each point. This conveys more information than an ordinary grayscale bump map.

7


Close the normal map image.

## Save your work:

■ Save the scene as my_warrior_normal_map.max.

## Applying Normal Bump Maps to Objects

In this lesson, you will apply the normal bump map you created in the previous lesson to the low-resolution model of the warrior.

## Set up the lesson:

1 Continue from the previous lesson, or from the
\materials_and_mapping \normal_bump_map folder,
 warrior_head_b_map.max.

2


Select the low-resolution version of the head by clicking a
checkered portion of the model, then go to the
 Modify panel.

3 To hide the projection cage, open the Modifier List and apply a Poly Select modifier.

## Apply a texture to the head:

1 With the low-resolution head selected, right-click and from the quad menu, choose Isolate Selected. The high-resolution model is now hidden.

2 Open the


3 From the Material/Map Browser panel on the left, drag a Standard material to the active View.

4 Double-click the Standard material node to display its parameters. In the name field, name the material Head.

## Material it el (Standard) <br> x

```
Head
``` Selection).

6 From the Material/Map Browser panel, drag a Bitmap into the active View. 3ds Max opens a file dialog.
On the file dialog, choose head_diffuse.jpg (this file is in the \(\backslash\) sceneassets \(\backslash i m a g e s\) folder).

7 Wire the new Bitmap node to the Diffuse Color component of the Head material.


When you wire the Bitmap, 3ds Max adds a Controller node for the bitmap's Value.

8 Double-click the Bitmap node to display its parameters.

9 On the Bitmap Parameters rollout, click View Image to display the bitmap in a larger format.


This image file is a previously created diffuse bitmap of the warrior's face, based on the unwrapped model.

\section*{10}
 Close the image window.

11 On the Slate Material Editor toolbar, click

(Show Map In Viewport) to see the material in viewports.


The result is fairly flat and lacking in detail. The normal bump map you will now apply should improve things considerably.

\section*{Use a Normal Bump map to apply the normal map:}

1 Drag a Normal Bump map from the Browser into the active View.
2 Wire the Normal Bump map node to the Bump component of the Head material node.


3 Drag another Bitmap from the Browser into the active View. 3ds Max opens a file dialog.
On the file dialog, choose war_head_loresnormalsmap.tga, (this file is in the \sceneassets \(\backslash\) images folder).
(If you like, you can use the version of this map that you rendered yourself in the previous lesson.)

4 Wire the new Bitmap node to the Normal component of the Normal Bump map.


Now the normal bump map will be visible in renderings. To make the normal bump map visible in viewports, you need to go through a few more steps.

\section*{Use hardware shading to display the normal bump map:}

1 Double-click the Head material node to see its parameters.
2 On the Slate Material Editor toolbar, open the Show Standard/Hardware Map In Viewport flyout, and choose Show Hardware Map In Viewport.


3 On the Parameter Editor panel, open the Maps rollout, and increase the Bump amount to 90.
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|r|}{Maps} \\
\hline Amount & Map \\
\hline \(\square\) Ambient Color . . . 100 & None \\
\hline \(\checkmark\) Diffuse Color . . . \(\sqrt{100}\) 빅 & (proj_plane_diffusemap.tga) \\
\hline \(\square\) Specular Color . . \({ }^{100}\) & None \\
\hline \(\square\) Specular Level . . 100 & None \\
\hline \(\square\) Glossiness . . . . \(\sqrt{100}\) & None \\
\hline \(\square\) Self-Illumination . 100 & None \\
\hline \(\square\) Opacity . . . . . . \(\sqrt{100}\) & None \\
\hline \(\square\) Filter Color . . . \(\sqrt{100}\) & None \\
\hline V Bump . . . . . . . 90 ] | & Normal_Bump (Normal Bump) \\
\hline & \\
\hline
\end{tabular}

4 Minimize the Slate Material Editor.
5 The model suddenly takes on a new level of detail. The low-resolution model is now picking up the normal information from the high-resolution mesh object.

If you like, try adding an Omni light to the scene and moving the light object across the face: first with the diffuse map selected, then with the normal bump map selected. See how much of a difference a normal bump map can make.
Compared to the head that doesn't use the normal bump map, the difference is dramatic.


\section*{Save your work:}

■ Save the scene as my_warrior_head_normal_map.max.

\section*{Summary}

This tutorial showed you how to use a projection cage to receive texture from a high-resolution model, then apply the result to a low-resolution version of the same model. This technique is an effective way to assign complex surface detail to low-polygon objects. This can be a useful technique when you prepare a model for a game engine. It can help improve render time, as well.

\section*{Composite Mapping}

A composite map layers two or more texture maps onto one another, in order to produce a more detailed image.

The end result is determined by the level of transparency defined for each layer. Transparency can be global (applied to the entire surface of the layer), derived from the layer's alpha channel, or based on a mask. To fine-tune the image, the pixels of each layer can also be blended with one another in a number of different ways.

In this tutorial, you will create a complex texture map of a steel shutter for a pawn shop. The map will consist of five layers of images composited together using various transparency settings and blending techniques.


\section*{A render of the steel shutter composite map after completing this tutorial}

In this tutorial, you will learn how to:
- Create a composite layer
- Color correct a layer
- Define layer transparency and contrast
- Create a layer defined by a mask
- Rearrange the order of layers
- Blend layers
- Add bump information to layers

Skill level: Intermediate
Time to complete: 45 minutes

\section*{Creating a Composite Map with Alpha Values}

You will create the base layer of the composite map by choosing a bitmap of a steel shutter, then assigning its diffuse, or color, values to an Arch \& Design material. You will then add two more image layers, using alpha values to define how each are superimposed over the base layer.

\section*{Set up the lesson:}

1 On the Quick Access toolbar, click (Open File), navigate to
 composite_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene consists of a pawnshop located in a rough part of town. The storefront is missing one important element: a steel shutter that protects a plate-glass window. Your task is to create a convincing composite map of the shutter.

2 From the main menu, chose Customize > Preferences > General panel - Texture Coordinates group and turn off Use Real-World Texture Coordinates, if it is not already off. Click OK.


\section*{Create a base layer and color correct it:}

1 Open the

\section*{Slate Material Editor.}

2 In the Material/Map Browser panel on the left, locate the Sample Slots group.
The first sample slot contains an Arch \& Design material called Shop-Door. This material has already been applied to the roll-up shutter object (door-sec).

3 Drag the Shop-Door material from the Browser into the active View. In the Copy/Instance map dialog, make sure Instance is chosen, then click OK.


4 On the Slate Material Editor toolbar, click
(Show Map In Viewport) so that later you will be able to view the Composite map in the viewports. Now you will add a composite map to the material's diffuse color component.

5 Drag a Composite map from the Browser into the active View (in the default groups, Composite is a Standard map), then wire the Composite map node to the Diffuse Color component of the Shop-Door material.


6 Double-click the Composite map node to see its parameters. Initially, the Composite map contains a single layer.


\section*{Specify the first layer of the Composite map:}

1 Drag a Bitmap from the Browser into the active View.
3ds Max opens a file dialog.
On the file dialog, choose shutters.jpg, and then click Open.
2 Wire the new Bitmap node to the Layer 1 component of the Composite map.

On the Layers 1 rollout for the Composite map, the Texture button now shows the shutters.jpg texture. This texture will be the base layer of the Composite map.


3 Right-click the title bar of the Shop Door material node, and choose Open Preview Window.


The preview helps you monitor the appearance of the map as you add more layers and make further adjustments.

NOTE A preview window takes more time to render than the small preview in the title bar of the material node.

4 Right-click the title bar of the Shop Door material node, and choose Preview Object Type > Box.


3ds Max changes the sample sphere to a cube, which is a better preview of the shutter geometry.

5 Drag a corner of the preview window to make it larger.


6 Move this preview so you can see all of the Shop Door node and the controls in the Parameter Editor.

\section*{Add a rust tone to the first layer:}

The shutter door material is uniformly gray in color. Let's add a little rust to give the shutter a more run-down appearance.

1 On the Layer 1 rollout, click (Color Correct This Texture). This button is at the left of the rollout.

3ds Max displays Color-Correction controls in the Parameter Editor, and it inserts a Color Correction map node between the Bitmap and the Composite map.


TIP In the active View, press L to rearrange the layout and see this node more clearly. Use other navigation tools to move among nodes in the View.

2 On the Color rollout, click the Hue Tint color swatch.


3ds Max opens a Color Selector.
3 Enter the following values in the RGB fields:
- \(\mathrm{R}=0.25\)
- \(G=0.15\)

■ \(\mathrm{B}=\mathbf{0 . 0 7 5}\)


Click OK to close the Color Selector.
4 On the Color rollout, drag the Saturation slider to about 17.0, then in the Strength field, enter 100.0.


Now the Shop Door material shows a brownish tint.


\section*{Use alpha values to add a layer of graffiti:}

Next, you will add a second layer to your composite map, one that contains the bold strokes of a graffiti artist (or more than one).

1 Double-click the Composite map node to see its parameters again.

2 At the top of the Composite Layers rollout, click Layer).
3ds Max adds a new Layer rollout to the display of the Composite map parameters.


Also, in the active View, the Composite map node now shows a new Layer 2 component.


3 Drag a Bitmap from the Browser to the active View, just below the Bitmap node for Layer 1.
3ds Max opens a file dialog.
On the file dialog, make sure Files Of Type is set to All Formats, choose graffiti.png, and then click View.
3ds Max opens a file viewer that shows the graffiti.png texture.


Graffiti bitmap used as the second layer in the composite map

In addition to red, green, and blue (RGB) information, the bitmap includes alpha channel information in its .png file format. This channel provides the level of opacity needed to superimpose the graffiti image over the base image.

4 On the file viewer toolbar, click
\(\square\)
The viewer displays a black-and-white version of the image, showing the file's alpha information.


Alpha channel of the graffiti bitmap

Black regions of the bitmap will be completely transparent in the composite map. White regions, representing the graffiti strokes, will be completely opaque and fully visible in the composite map. Gray regions will be semi-transparent and provide partial visibility, giving a blurred edge to the graffiti.

NOTE Other bitmap formats that can contain alpha channel information include .tif, .tga, and .exr.

5 \(\square\) Close the graffiti.png viewer, then on the file dialog, click Open.
3ds Max adds the Bitmap node to the active View.
6 Wire the new graffiti Bitmap to the Layer 2 component of the Composite map.


The Layer 2 rollout now shows the graffiti.png texture, and the material preview shows the composited graffiti.


Composite map with the graffiti layer composited on the shutter layer

Adjust the alpha and color levels:
If you look at the Shop Door material in a viewport (you will have to move or minimize the Slate Material Editor), you can see that the default values for compositing graffiti.png make the graffiti appear to float above the corrugated texture of the door.


You will fix this by adjusting some of the alpha settings for this layer.
1 On the Layer 2 rollout, change the value of Opacity 90.0, then press Enter.


This slightly increases the overall transparency of Layer 2, so that a small portion of Layer 1 is visible beneath it. The result is a more convincing blending of the graffiti onto the shutter surface.

The graffiti layer still needs to stand out a little more: you will use the color correction tools to achieve this effect.

2 Drag a Color Correction map from the Browser to the active View, and drop it on the wire between the Bitmap and the Composite map, when the cursor shows you can insert a map.


3ds Max inserts a Color Correction node between the graffiti bitmap and the Composite map. This is another way to add a Color Correction map.

3 Double-click the new Color Correction node so you can see its parameters.
4 On the Lightness rollout, drag the Brightness slider to the right until the Brightness field shows a value of about 15.0.


The graffiti colors are now brighter. On the other hand, the change in Brightness affects the semitransparent portion of the alpha channel as well, creating a halo effect around the graffiti strokes, which we don't want.


Halo surrounding graffiti strokes

You will correct this problem by increasing the contrast level.
5 Drag the Contrast slider to the right until the box displays a value of about 25.0.


Now the graffiti looks more like it is painted on the door.


\section*{Use a mask to add a sticker:}

Now you will add a third layer to your composite map, one that features a sticker.

1 Double-click the Composite map node to see its parameters once more.

2 At the top of the Composite Layers rollout, click
 (Add A New Layer).
3ds Max adds a new Layer rollout to the Composite map parameters, and a new Layer 3 component to the Composite map node in the active View.

3 Drag a Bitmap from the Browser to the active View. 3ds Max opens a file dialog.
On the file dialog, choose \(c\)-sign.jpg, and then click Open.

4 Wire the new Bitmap node to the Layer 3 component of the Composite map.


3ds Max displays the new Bitmap on the Layer 3 rollout and in the preview window.


The \(c\)-sign bitmap applied as a top layer in the composite map

Bitmaps saved in .jpg format have no alpha channel information. By applying the \(c\)-sign.jpg image directly as a top layer, you have completely obscured all layers beneath it. You can correct this by adding a mask. (You could easily create your mask in a paint program, but a mask image has already been prepared for you.)

5 Drag a another Bitmap from the Browser to the active View.
3ds Max opens a file dialog.
On the file dialog, choose c-sign-msk.jpg, and then click Open.
6 Wire the new mask Bitmap node to the Layer 3 (Mask) component of the Composite map.


The mask is a black-and-white image that acts as a "custom" alpha channel to the color map.. Black areas of the mask allow the underlying layers to show through, white areas are opaque, and gray areas are partially transparent.


Bitmap used to create a cutout of the poster for layer 3

Now on the Layer 3 rollout, the texture with the sticker appears at the left, and the mask bitmap appears at the right.


In the preview, the "CAUTION" sticker appears by itself, with the rest of the door now visible.


Layer 3 with the mask applied

One small problem remains. You want the graffiti to cover the sticker, not the other way around.

7 Drag the label of the Layer 2 rollout to a point just above the new Layer 3 rollout. Release the mouse when 3ds Max displays a blue line just above the Layer 3 rollout label.


3ds Max reorders and renumbers the layers accordingly. (Layer 3 becomes Layer 2, and vice versa.)

Now the graffiti appears on top of the sticker about closure.


NOTE In the active View, 3ds Max rewires the nodes to reflect the change in the order of the layers, so you might want to press \(L\) in the active View to update the layout of the nodes.

\section*{Save your work:}

Save the scene as my_shop_door_3layers.max.

\section*{Blending Layers}

In the previous lesson, you added layers to the Composite map while in Normal mode. In this mode, no blending between layers takes place: Visibility is determined solely by each layer's alpha channel.

With the blending modes, you can produce interesting composite effects by choosing how pixels in the top layer interact with those underneath. In this
lesson, you will use two blending techniques to add more layers to the composite map.

\section*{Set up the lesson:}
- Continue from the previous scene.

\section*{Add dirt to the bottom of the door with Multiply blending:}

1 Double-click the Composite map node so you can see its parameters.

2 At the top of the Composite Layers rollout click \(\square\) Layer).

3 Drag a Bitmap node from the Browser to the active View.
3ds Max opens a file dialog.
On the file dialog, choose dirt-bottom.jpg, and then click Open.
This file shows dirt at the bottom of the door.


Bitmap used in the first blend operation

4 Wire the new Bitmap node to the Layer 4 component of the Composite map.

This file is a .jpg image that has no alpha channel. It completely obscures all layers beneath it.


5 On the Layer 4 rollout, open the Blending Mode drop-down list.


In addition to Normal mode, which we have been using so far, there are a variety of other methods for blending layers.

6 Experiment with blending techniques by choosing a few options from the list.

The options resemble those available in such paint programs as PhotoShop and Combustion. Refer to the 3ds Max Help for a description of what each blending option does.

7 Choose Multiply from the list.


First blend operation using Multiply

This option multiplies the color value of all layers in the composite. The non-white color channels have a value of less than 1.0, so the multiplication tends to produce darker colors, a condition you will now correct.

8 On the Layer 4 rollout, change the Opacity value to 80.0, and then press Enter.


The reduced opacity of the top layer results in a lighter overlay of grime.


Add dirt to the top of the door with Linear Burn blending:

1 At the top of the Composite Layers rollout, click
\(\square\) Layer).

2 Drag a Bitmap node from the Browser to the active View. 3ds Max opens a file dialog.

On the file dialog, choose dirt-top.jpg, and then click Open. This file shows dirt at the top of the door.


Bitmap used in the second blend operation

3 Wire the new Bitmap node to the Layer 5 component of the Composite map.
This file is also a .jpg image that completely obscures all layers beneath it.


4 On the Layer 5 rollout, choose Linear Burn from the Blending Mode drop-down list.


Linear Burn blending combines the new dirt map with underlying layers.


Second blend operation using Linear Burn

Linear Burn combines the color of pixels in the top layer with colors from the underlying layers. The darker the Layer 5 color, the greater the effect: As a result, the default blending is too dark.

5 On the Layer 5 rollout, change the Opacity value to 70.0, and then press Enter.


Now the dirt at the top of the door, like the dirt at the bottom, blends well with the other textures.


\section*{Add bump information to the composite:}

1 Minimize the Slate Material Editor.

2 Activate the Camera01 view, then on the main toolbar, click \(\omega\) (Render Production).


The shutter shows good detail, but in a rendering with shadows, its corrugated surface lacks depth. You will correct this by adding bump information from the shutters.jpg map.

3 On the rendered frame window, click

(Clone Rendered Frame Window).

4 Restore the Slate Material Editor (press M).

5 In the Slate Material Editor, click \(\llcorner\) (Zoom Extents) to display the entire material tree, and press \(L\) to arrange the layout.


6 Wire the original Bitmap node, the one that contains shutters.jpg (it is at the upper left), to the Bump Map component of the Shop Door material node.


7 Double-click the Shop Door material node so you can see its parameters.
8 Expand the Special Purpose Maps rollout. The buttom for Bump mapping should show that shutters.jpg has been assigned. Change the amount value (the numeric field just to the right of the Bump toggle) to 3.0.


The effect in the preview is rather exaggerated.

\(\square\)
- Render the Camera01 viewport again and compare the result with the cloned rendered frame.


The fully composited shutter door, rendered with bump mapping

The shutter has lost its flat look and appears more three dimensional.

\section*{Save your work:}

1 Save the scene as my_pawnshop_composite.max.

If you like, you can
 your work with a completed scene file of this tutorial.

2 If you turned off the Use Real-World Texture Coordinates option at the beginning of this tutorial, then from the main menu, go to the Customize > Preferences \(\boldsymbol{>}\) General panel \(\boldsymbol{>}\) Texture Coordinates group and turn the option back on.

\section*{Save your work:}

Save the scene as my_shop_door_completed.max.

\section*{Summary}

In this tutorial, you learned how to create a composite map consisting of multiple layers of images. You used alpha channel information and a mask to control image transparency, then you used blending modes as an alternate way to specify how layers are composited.

\section*{Spline Mapping}

This tutorial shows you how to map a material to a curved surface, such as a road or a garden hose.

You will start with the same pawnshop model featured in the Composite Map tutorial, and use a spline to map a brick-like material onto the building's arched entrance.


In this tutorial, you will learn how to:
- Choose a mapping method for an object
- Create a spline and use it as a guide when mapping a texture to the object

■ Adjust the mapping through manipulation of the object's UVW coordinates

Skill level: Intermediate
Time to complete: 1 hour

\section*{Prepare the Scene}

In this lesson, you choose a brick material to map to the building arch, and specify the Unwrap UVW modifier as the mapping method. Then you create a spline object and use it as a guide to the mapping process.

\section*{Set up the lesson:}

■ On the Quick Access toolbar, click
 \(\backslash\) scenes \(\backslash\) materials_and_mapping \(\backslash\) spline_mapping \(\backslash\) and open splinemap_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

Choose the material and apply the mapping method:



Arch door object with no material applied

\section*{2 Open the}


Slate Material Editor. Locate the Sample Slots group. A material called brick-soldier has already been prepared for the arch object.


3 Drag the brick-soldier material from the Browser > Sample Slots group into the active View. In the Instance (Copy) Material dialog, make sure Instance is chosen, and then click OK.


4 In the active View, make sure the brick-soldier node is selected, then on
the Slate Material Editor toolbar, click

(Assign Material To

Selection). Also click to turn on
(Show Map In Viewport).
The arch turns a dark gray. It shows no further detail because no mapping coordinates have yet been specified for the Arch-Door object.

5


Close the Slate Material Editor.

\section*{Assign mapping coordinates (a first approximation):}

The common way to assign mapping coordinates is to use a UVW Map modifier, but if you look at the various options this modifier has for orienting
a map (Planar, Cylindrical, Spherical, Shrink Wrap, Box, Face, and XYZ To UVW), you can see that none of them corresponds to the curved shape of the arch.

\section*{Mapping:}
(O) Planar

Cylindrical \(\square\) Cap
Spherical
Shrink Wrap
© Box
- Face

OYZ to UVW

1 Go to the
Modify panel. From the Modifier List, choose Unwrap UVW.
Unwrap UVW is often used to map images onto complex objects. Unwrap UVW is better equipped to handle mapping of complex geometry, because it breaks that geometry into sections, and applies planar mapping to each section.

2 Right-click the arch object in the viewport and from the quad menu, choose Hide Unselected to isolate the object.


Arch object with brick material mapped to its surface

3 On the modifier stack, click the plus-sign icon (+) next to the Unwrap UVW modifier to expand its hierarchy, then click to go to the Face sub-object level.


At this level, you can map the brick material onto each selected face of an object.

4 In the viewport,

select a face on the arch object.
A yellow gizmo displays, representing a planar projection of brick material onto the selected face.


Planar projection of brick material onto an arch face

\section*{5}


Select another face on the arch object.
Notice how the yellow gizmo resets onto the newly selected face.
On the Map Parameters rollout, there are a number of controls available that can help you use Unwrap UVW to map specific types of objects. Some of these are similar to the UVW Map options. The Cylinder button, for example, displays controls used to map materials onto cylindrical
objects, such as a human arm or a lamp post. Others have more special purposes: You can use the Pelt button to map a material onto fabric such as a pair of trousers, or a curtain.
In this scene, you will use the Spline option, which is useful for mapping curved objects with a cylindrical or square cross-section such as a snake, or a ventilation duct.
Before you use this option, you will create the spline object itself.

\section*{Create the spline shape to use as a map path:}

1 On the modifier stack, click Face to exit the Face sub-object level.
The spline you create needs to be centered in the arch object. You could use the Line tool or the Rectangle tool to draw the spline, but you would need to enter the precise arch object coordinate values to do so. A more convenient alternative is to derive the spline from the existing object geometry.

2 On the stack, click the Editable Poly entry. Click Yes to dismiss the warning message that 3ds Max displays.

3 On the Selection rollout, click
 level.


Click and Ctrl+click to select all the outer edges of the arch object.
Be sure to leave the bottom and inside edges unselected.


Arch object with all outer edges selected

5 On the Edit Edges rollout, click Create Shape From Selection.


6 On the Create Shape dialog Curve Name box, name the shape Arch-Door-Spline, make sure Shape Type is set to Smooth, then click OK.


7 Click

(Edge) again to exit the Edge sub-object level, then press H to open the Select From Scene dialog.

8 Choose Arch-Door-Spline from the list to select the newly created spline. Click OK.

\section*{Select From Scene}

Select Display Customize

Find:
Selection Set:

Name
Camera01.Target
Arch-Door
Arch-Door-Spline

9 Press F3 to switch to wireframe mode.
10 From the Modifier List, expand the Editable Spline modifier, then and click Spline.


11 On the Geometry rollout, scroll down so you can see the Outline button, and then click it.


12 In the viewport, click the original spline and drag inward so the outline spline is positioned roughly at the midpoint between the outer and inner edges of the front face of the arch.


Outline spline centered on the front face of the arch object

The outline spline position does not have to be perfectly centered: You will align it more precisely in a moment.

13 On the modifier stack, click Segment.


14


Click and Ctrl+click to select the line segments at the base of the arch (they connect the original spline to the outline spline), then press Delete.


Spline segments at the base of each arch column

15 On the modifier stack, click Spline again, select the outer, original spline, then press Delete.

16 On the modifier stack, click Spline again to exit the Spline sub-object level.

Align the spline with the arch:
1 On the main toolbar, choose the Local coordinate system.


2 Make sure the spline is selected, then on the main toolbar click
 (Align), and then click the Arch-Door object.

3 In the Align Selection dialog > Align Position (Local) group, turn off X Position and Y Position, turn on Z Position, and in both the Current Object and Target Object subgroups, choose Center. Click OK.


The spline is now properly placed in the center of the Arch-Door object, ready to be used as a guide to map the brick material.

\section*{Apply the spline as a guide for the mapping:}

1 Press F3 to return to a shaded view.

2
Select the Arch-Door object.
3 On the modifier stack, in the Unwrap UVW modifier hierarchy, click Face to go to the Face sub-object level.

4 On the Selection Parameters rollout, turn off Ignore Backfacing.


If you leave Ignore Backfacing turned on, only the polygons facing you in the viewport will be included in a selection. Polygons hidden on the other side of the model will remain unselected.

5 Starting just above the base column to the left, click and drag diagonally upward across the arch object to region-select all the faces except for those on the underside of each column base.


Arch faces selected

6 On the Modify panel, scroll down to the Map Parameters rollout and click Spline.
Map Parameters \(\hat{\star}\)
Preview Quick Map Gizmo
\(x\)
Y
Z
(O) Averaged Normals
Quick Planar Map
Tweak
\begin{tabular}{|c|c|}
\hline Planar & Pelt \\
\hline Cylindrical & Spherical \\
\hline \hline Box & Spline \\
\hline
\end{tabular}

7 On the Spline Map Parameters dialog, click Pick Spline.


For now, leave the Spline Map Parameters dialog open.
8 Press H and on the Pick Object dialog, choose Arch-Door-Spline from the list, then click Pick.
The arch object is enveloped by a cage gizmo, which shows the outline and cross sections of the mapping.


Arch object enveloped by the cage gizmo

Now you need to correct the base of the cage gizmo, which is too narrow for the arch geometry.

Adjust the mapping gizmo:

1
 the base of the arch.


Bottom of arch, showing that the cage gizmo is too narrow

2 On the main toolbar, click \(\quad\) (Select And Uniform Scale), For each base of the arch, click to select the base of the gizmo, then drag the Scale gizmo along its Y axis until the cage is at least as wide as each face at the base of the arch.


Cage gizmo after resizing each base

You do not need to be precise at this point: In the next lesson, you will specify the cage more precisely by using the Unwrap UVW controls.

3 On the Spline Map Parameters dialog, click Commit to accept the changes made to the spline mapping so far.


\section*{Save your work:}

Save the scene as my_arch_spline_mapping.max.

\section*{Fine-Tune the Mapping}

With the introduction of the spline as a guide, now the brick material can properly follow the contours of the arch object. However, in the present state of mapping, the bricks are too large and they are mapped vertically up the arch columns instead of horizontally across them. In this lesson, you use the Edit UVWs dialog to adjust the mapping visually so that the bricks map properly.

\section*{Set up the lesson:}
- Continue from the previous lesson.

Set up the Edit UVWs dialog, and inspect the brick map:
1 On the Parameters rollout, click Edit.
3ds Max opens the Edit UVWs dialog.


Arch object displayed as grid of UVW faces and vertices

The window in the Edit UVWs dialog shows a flattened representation of the arch object. There are four red vertical panels made up of UVW faces and vertices. The panels represent the inner, outer, left, and right face of the arch.

2 Move the Edit UVWs window so you can see the arch object in the Orthogonal and Perspective viewports. If you need to, adjust the size of the Edit UVWs dialog so you can see all of the arch faces. Use the Edit

UVWs window
 zoom tool to zoom out slightly.
The surface of the arch object is currently mapped to a single tile of the brick-soldier material.

The square occupied by the flattened arch object corresponds to the dark square in the next diagram, which shows the coordinate system of the Edit UVWs window.


The texture you apply to the arch object will be mapped to this area, whose coordinate system ranges from 0,0 to 1,1 .

3 On the main menu, choose Rendering > View Image File, and on the View File dialog, navigate to the folder \sceneassets \images \\, click to highlight brick_soldier-diff.jpg and click Open.

3ds Max opens an image file viewer, showing that brick-soldier-diff.jpg is a square image. At present, it is mapped on a one-to-one basis using UVW coordinates that range from 0 to 1 . Outside of the square bounded by the 0 to 1 values, the same image is tiled two more times in each direction.

4


Close the image file viewer.

5 In the Edit UVWs window, open the texture drop-down list at the right of the toolbar, and choose the entry for "(brick_soldier-diff.jpg)" to display the map itself in the window.


6 In the Selection Modes group at the lower right of the Edit UVWs dialog, click Options.


3ds Max opens a further Bitmap Options group that appears below the Soft Selection group.

7 In the Bitmap Options group, change the value of Brightness to 0.75, then press Enter .


The bitmap in the Edit UVWs window becomes brighter and easier to see.

\section*{Correct vertical distortion:}

1 In the Selection Modes group, click \(\stackrel{\left[\begin{array}{c}+++ \\ +++ \\ ++ \pm\end{array}\right.}{ }\) (Vertex Sub-Object Mode).
Selection Modes


By switching to the Vertex sub-object mode, you can see how the Unwrap UVW modifier has slightly warped the contours of the arch object. You need to straighten out these contours.

NOTE The contours in your unwrapped arch object might be slightly different to the one shown in the next illustration, depending on how you resized the cage gizmo in the previous lesson.


Warped contours of the unwrapped arch object

2 On the Unwrap UVWs toolbar, click \({ }^{++\boldsymbol{+}}\), (Move), and region-select all the vertices of the left outside edge.


For these vertices to be properly aligned with the image map, they must all have the same \(U\) value of zero.

3 In the U coordinate field (on the toolbar at the lower left of the main dialog), type 0.0, then press Enter.


This gives the the horizontal map coordinate for each selected vertex a \(U\) value of 0 , thereby aligning all the vertices vertically at their origin (0) as shown in the next diagram.


4 Region-select all the vertices at the right outside edge of the arch object.
5 In the U coordinate field, type 1.0, then press Enter.
This aligns each selected vertex vertically at a horizontal value of 1 .


6 Select in turn, from left to right, the remaining columns of vertices for each inside edge. Give each inner edge a \(U\) value of \(\mathbf{0 . 2 5}, \mathbf{0 . 5}\), and \(\mathbf{0 . 7 5}\) respectively.


UVW vertices after alignment

The UVW map now covers the surface of the arch object much better. But as you can see in the window, there remains an obvious problem. The bricks are mapped vertically, whereas they need to be mapped horizontally. To make this change, you need to rotate the mapping by 90 degrees.

\section*{Correct the orientation of the bricks:}

1 Press Ctrl+A to select all the vertices.
i+i!
2 On the Edit UVWs toolbar, click
(Freeform Mode).


3 Position your cursor over a vertex at the midpoint of any side, and drag the whole UVW grid until the rotation indicator displays 90.


Now the bricks on the arch are oriented horizontally. Notice, however, that the bricks are still too large for the area they cover.


Arch object with bricks oriented horizontally

You need to resize the UVW grid over the map so that the bricks are better distributed.

Align the edges of the bricks and the arch:
Specifically, the current vertical scaling of the bricks means that the edges of bricks are not aligned with the edges of the arch: The UVW grid spans five bricks, when it should span only four.


Edges of bricks not aligned with the vertical edges of the arch
> Hold down the Shift key to constrain scaling to a single axis, then click on the left or right corner of the UVW grid and drag down until the grid is resized vertically (along the V axis) to fit over four rows of bricks.


UVW grid resized vertically to cover four rows of bricks, one row per face

Now the edges of the bricks and the edges of the arch line up.


Along the U axis, the bricks are still too large.

Increase the number of bricks along the length of the arch:

1 In the Edit UVWs window,
 zoom out and Sir
pan so you can see all of the brick-soldier-diff.jpg image.

2 In the Bitmap Options group, change the value of Tiles to 2.


Now the brick-soldier-diff.jpg is tiled twice in each direction.
NOTE The Tiling value affects the display of the map in the Edit UVWs window. It does not affect the mapping of the object, which is managed by the Bitmap controls. When Tiling=0, the map appears only in the unit square; when Tiling=1 (the default), the map is tiled 3 times in both U and V ; when Tiling=2 (as you just set it), the map is tiled 5 times in both U and V .

3

pan again so you can see all of the brick-soldier-diff.jpg tiles.


Two image tiles surround the UVW grid in every direction

4
Col
Region zoom in again so you can clearly see the UVW grid and the right edge of the bricks map.

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II
(Freeform Mode).
5 On the Edit UVWs dialog main toolbar, turn on Make sure all the vertices are still selected, then Shift+drag the top-right corner vertex all the way to the right-most edge of the map.


Shift+drag the top right corner of the UVW grid to resize it horizontally

Because the UVW guides have been stretched horizontally to cover three map tiles (from 0 to 3 along the U axis), now three times as many bricks are mapped along the length of the arch.


Correct the bulging appearance of bricks at the top of the arch:
If you look closely at the top of the arch, you can see that the bricks appear to bulge out.


Bricks in arch show deformation

This deformation is because the number of divisions in the arch object's polygon mesh does not match the number of bricks mapped onto them.

1 On the Edit UVWs dialog, click (Zoom Extents) to zoom in to the
 select only those vertices in the center that UVW guides, then correspond to the top of the arch.


UVW grid with arch vertices selected

There are 14 divisions in the polygon mesh that define the arch, but there are 16 bricks in the underlying map. You need to resize the UVW guides so that the mesh divisions match the number of bricks in the map.

2 With the
\(i+1\)
Freeform tool still active, Shift+drag the top-left corner vertex of the selection to the right by one brick.

3 Shift+drag the top-right corner vertex of the selection to the left by one brick.


The number of arch polygons now matches the number of bricks in the map.


Bricks at the top of the arch no longer appear to bulge.

\section*{Correct the scaling of bricks in the column:}

If you look at the whole archway, you can see that the fix you just made to the top of the arch, makes the bricks at the top appear larger than the bricks in the two columns.


Arch bricks are larger than the column bricks.

1 In the Edit UVWs window,

\(\dot{\dagger}+\)select only the vertices that correspond to the left-hand column of the arch (which is on the right in the Edit UVWs window and the viewport).


Left column vertices

2 Shift+drag the top-right corner vertex of the selection to the left by two bricks.


Left column after being resized two bricks to the left

3 Repeat the previous two steps for the arch object's right-hand column, dragging the UVW guides to the right by two bricks.



All bricks mapped to the arch object, both on the columns and the arch, now appear to be equal in size. The result is a properly mapped archway, with the bitmap convincingly following the contours of the object's geometry.


Arch object with bricks of equal size

\section*{Render the arch:}
\(1 \quad \mathrm{X}\) Close the Edit UVWs dialog and on the modifier stack, click Vertex to exit the Vertex sub-object level, then click any empty part of the viewport to deselect the arch.

2


Minimize the Orthographic viewport.

3 Right-click the Camera01 viewport and from the quad menu, choose Unhide All.

4 On the main toolbar, click \(\quad\) (Render Production) to render your work.


Rendered view of brick material mapped to the pawnshop entrance

Now your brick material is mapped to the archway properly.

\section*{Save your work:}

■ Save the scene as my_arch_spline_mapping_completed.max.

\section*{Summary}

In this tutorial, you learned how to use the Unwrap UVW modifier combined with a spline object to map a material onto a curved object. You also learned how to manipulate the object's UVW lattice in the Edit UVWs dialog to specify how the material's bitmap image is projected onto the target surface.

\section*{Using the Multi/Sub-Map}

You can apply multiple Multi/Sub-Maps to objects in a scene whenever you need to give similar objects in a group their own unique identity.

In this tutorial, you will assign an assembly of stadium seats a common material, then use a variety of Multi/Sub-Maps to assign each seat its own set of stains and discolorations.


You can distribute Multi/Sub-Maps among objects randomly, by object, or by material ID. Each sub-map can be based on a color, a bump map, or an image, among other components. You can distribute sub-maps individually, or composited with other maps to produce a more nuanced effect.

Multiple sub-mapping differs from mapping at a sub-object level, where you apply a material on a one a one-to-one basis to individual components of a single object.

The next illustration provides an example of sub-object mapping where five materials have been mapped to a door consisting of five sub-objects. In this technique, you select the polygon of each component, assign it a material ID, and apply a unique material to each ID.


The next illustration provides an example of multi/sub-mapping where multiple sub-maps have been applied to a material. The jeep surfaces are a composite of two layers: a layer of army green material and a layer of three sub-maps. Each sub-map is a bitmap image of a serial number, and is assigned to a jeep according to the vehicle's object ID number.


You can use any map channel in a sub-map. The next illustration shows three objects whose materials share the same diffuse color and specular highlights, but a sub-map with a slight variation of the bump channel has been assigned to each material to give each urn a unique surface texture.


In this tutorial, you will learn how to:
- Assign ID numbers to objects in a scene

■ Create sub-maps based on multiple diffuse values
■ Create sub-maps based on multiple bitmap images
- Create a material from two composited layers of sub-maps

NOTE In this tutorial, you will be creating composite maps. If you are not familiar with this technique, it is recommended that you complete the Composite Mapping tutorial on page 1176 first.

Skill level: Intermediate
Time to complete: 30 minutes

\section*{Create the Multi/Sub-Map Material}

In this lesson, your objective is to divide the seating in the stadium scene into four distinct groups, and use multi/sub-mapping to assign each group its own color, with red representing the most expensive seats and green the cheapest.

\section*{Set up the lesson:}
- On the Quick Access toolbar, click

(Open File), navigate to


NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK. If a Missing External Files dialog opens, click Continue.

\section*{Choose mental ray and group objects by ID number:}

1 On the main toolbar, click

(Render Setup).
2 On the Render Setup dialog \(>\) Common tab \(>\) Assign Renderer rollout, make sure the Production field is set to mental ray Renderer.


The Multi/Sub-Map is a mental ray feature. It is available only when you choose mental ray or the Quicksilver Hardware renderer as your renderer.

3 \(X\) Close the Render Setup dialog.

4 Right-click an empty area of the main toolbar and from the pop-up menu, choose Layers.


3ds Max opens the Layers toolbar.


5 On the Layers toolbar, open the layers list and click to hide all layers except Seats.


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Now only the seats objects are visible, making their selection much easier.
6 Close the Layers toolbar and
choose Object Properties.

\section*{Object Properties}

\section*{? \(\quad x\)}

General Adv. Lighting mental ray User Defined

Object Information
Name: Seat1088
Dimensions: \(X: 1^{\prime} 43 / 32^{\text {²}}\) Material Name: None
Y: \(1^{\prime} 622 / 32^{\text {² }}\) Layer: Seats
Z: \(1^{\prime} 226 / 32^{*}\)
Vertices: 158 Parent: Scene Root
Faces: 156 Num. Children: 0

\section*{0 In Group/Assembly: None}
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|l|}{Interactivity} \\
\hline \multicolumn{2}{|l|}{\(\square\) Hide} \\
\hline \multicolumn{2}{|l|}{\(\square\) Freeze} \\
\hline \multicolumn{2}{|l|}{Display Properties} \\
\hline \multicolumn{2}{|l|}{\(\square\) See-Through By Layer} \\
\hline \multicolumn{2}{|l|}{\(\square\) Display as Box} \\
\hline \multicolumn{2}{|l|}{\(\square\) Backface Cull} \\
\hline \multicolumn{2}{|l|}{\(\checkmark\) Edges Only} \\
\hline \multicolumn{2}{|l|}{\(\square\) Vertex Ticks} \\
\hline \multicolumn{2}{|l|}{\(\square\) Trajectory} \\
\hline \multicolumn{2}{|l|}{\(\square\) Ignore Extents} \\
\hline \multicolumn{2}{|l|}{\(\checkmark\) Show Frozen in Gray} \\
\hline \multicolumn{2}{|l|}{\(\square\) Never Degrade} \\
\hline \multicolumn{2}{|l|}{Vertex Channel Display} \\
\hline Vertex Color & Shaded \\
\hline Map & ) 1 \\
\hline
\end{tabular}

Rendering Control
Visibility: 1.0 븍 By Layer
\(\checkmark\) Renderable
VInherit Visibility
\(\checkmark\) Visible to Camera
\(\square\) Visible to Reflection/Refraction
\(\checkmark\) Receive ShadowsCast ShadowsApply Atmospherics
\(\square\) Render Occluded Objects

\section*{G-Buffer}

Object ID: 0
Motion Blur
Multiplier: 1.0 |考 By Layer
Enabled
None (O) Object Image

Notice that in the Object Properties dialog \(>\) General tab \(>\) G-Buffer group, the Object ID displays as 0 . All objects when they are first created are assigned an ID of 0 . Later on, you will change this number in order to assign certain groups of seat objects their own material variations.

8 Click Cancel to close the dialog, then on the main toolbar, choose the Lasso tool from the Select Object flyout.


9 Use the Lasso tool to select the seats shown in white in the next illustration.

Be sure to hold down the Ctrl key when you select additional seats.
TIP If you select unwanted seats, use the Alt key to deselect them.


10 Right-click, choose Object Properties from the quad menu, and in the Object Properties dialog \(>\) General tab \(>\) G-Buffer group, change the Object ID to 1. Click OK.

11 Use the Lasso tool to select the seats shown in the next illustration.


Be sure to hold down the Ctrl key when you select additional seats.
12 Right-click, choose Object Properties from the quad menu, and in the Object Properties dialog > General tab > G-Buffer group, change the Object ID to 2. Click OK.

13 Select the seats shown in the next illustration.


14 Right-click , choose Object Properties, and in the Object Properties dialog > General tab > G-Buffer group, change the Object ID to 3. Click OK.

15 Select the seats shown in the next illustration, and give them an object ID of 4.


Now all the stadium seats have an object ID of \(1,2,3\), or 4 . With this in place, each seat is ready to receive its own material variation and sub-object maps.

\section*{Create a material for the seats:}

1 Continue from the previous procedure, or open the file multi_maps_01.max.

2 Press \(M\) to open the Slate Material Editor.
TIP If the Compact Material Editor opens instead, then on the Material Editor menu bar, choose Modes > Slate Material Editor.

3 From the Material/Map Browser panel on the left, drag an Arch \& Design material into the active View (View1), the empty area in the center of the Slate Material Editor window.

In the Browser, the Arch \& Design material is in the Materials \(>\) mental ray group.
A node for the Arch \& Design material appears in the active View.


4 Double-click the Arch \& Design material node to display its parameters in the Parameter Editor panel on the right.

5 Change the name of the material to seats.
\begin{tabular}{|c|c|}
\hline Waterial iftos (Arch \% Design) & x \\
\hline seats I & \\
\hline Templates & 人 \\
\hline A (Select a template) & \(\checkmark\) \\
\hline
\end{tabular}

6 On the Templates rollout, open the drop-down list and choose Matte Finish.


7 In the Top viewport,

select all the seats, then on the Slate

Material Editor toolbar, click \(\qquad\) (Assign Material To Selection). The matte-finish seats material is assigned to all the seats.

Now you will add multiple sub-object maps to the seat material's diffuse color channel.

\section*{Define a multi/sub map for the seats:}

1 On the Slate Material Editor, drag a Multi/Sub-Map from the Material/Map Browser panel to the active View.

You can find the Multi/Sub-Map entry in the Maps > mental ray group. A node for the Multi/Sub map appears in the active View.


2 Drag from the output socket of the Multi/Sub-Map node (the round control at the right of the node). 3ds Max creates a wire. Drop the end of the wire on the input socket for the Diffuse Color Map component of the seats material node.


3 Double-click the Multi/Sub map node to display its parameters.
4 On the Multi/Sub-Map Parameters rollout, set the Number Of Colors/Maps To Use to 4.


By default, Switch Color/Map Based On is set to Object ID, meaning that the sub-maps will be distributed among the objects by their ID number. You have already set up the object IDs.

The Default/Out-Of-Range Color is set to red. This means the material of any object in the scene with an ID other than 1 to 4 will display in red. Red is one of the seat colors we are using, so click this color swatch and use the Color Selector to change this color to a neutral gray.

NOTE If you were to turn on the Repeat option, all objects with IDs higher than 4 would display the color sequence assigned to objects with IDs 1 to 4.

5 Click the color swatch labeled Color/Map \#1.


6 On the Color Selector, change the color to a bright red: Red \(=\mathbf{0 . 8}\), Green \(=0.0\), Blue \(=0.0\), then click OK .

7 Click the color swatch labeled Color \#2 and change the color to a blue: Red \(=\mathbf{0 . 2 7 5}\), Green \(=\mathbf{0 . 5 3 4}\), Blue \(=\mathbf{0 . 8 1 4}\), then click OK.

8 Click the color swatch labeled Color \#3 and change the color to a yellow: Red \(=0.867\), Green \(=0.808\), Blue \(=0.231\), then click \(O K\).

9 Click the color swatch labeled Color \#4 and change the color to a green: Red \(=\mathbf{0 . 1 5 8}\), Green \(=\mathbf{0 . 5 8 3}\), Blue \(=\mathbf{0 . 1 4 1}\), then click OK.
These colors will not show up in the viewports, but they will be visible when you render the image.

10 Make sure the Top viewport is active, then on the main toolbar, click

- (Render Production) to render the scene. Keep the rendered frame window open.


The rendered image shows seats with their sub-map material clearly visible. Seats with an object ID of 1 show the red sub-map applied, seats with an object ID of 2 show the blue sub-map applied, and so on.

11 Activate the Camera-Seats viewport.
12 In the rendered frame window's Viewport list, make sure Camera-Seats is chosen, then click Render to render the scene again.

Camera-Seats, frame 0, Display Gamma: 2.2, RGBA



13
 Close the rendered frame window.

\section*{Save your work:}

Save the scene as my_stadium_submaps.max.

\section*{Next}

Composite Sub-Maps Onto Objects on page 1290

\section*{Composite Sub-Maps Onto Objects}

The seats you mapped in the previous lesson appear too uniform: They lack individual signs of wear and tear. Now you will introduce another level of randomness to the seat material by adding sub-maps that contain blemishes and other discolorations.

To accomplish this, you will composite two layers of sub-maps onto one another. One layer will contain the four diffuse colors you specified in the previous lesson, the other layer will contain sub-maps with a mixture of image maps of dirt patterns.

\section*{Set up the lesson:}
- Continue from the previous lesson, or

open multi_maps_02.max.

\section*{Create the composite layers:}

1 If the Material Editor is not already open, press \(M\) to open it.
2 In the Slate Material Editor active View, click \(\left.\square^{〔}\right]_{\text {(Zoom Extents) so }}\) you can see both the material node and the Multi/Sub map node.

3 Drag a Composite map (Maps > Standard > Composite) from the Browser. In the active View, drop the map on the wire that connects the Multi/Sub map and the seats material.
3ds Max displays a cursor that indicates you are inserting the map into the wire. Release the mouse when this cursor appears.


4 After you release the mouse, 3ds Max displays a pop-up menu. On the pop-up menu, click Layer 1.


This incorporates the Multi/Sub map as the base layer of the composite.
5 On the Slate Material Editor, press L to arrange the layout of the material tree.


Add a Multi/Sub map to Layer 2:
1 Double-click the Composite map node to display its parameters.


2 On the Composite Layers rollout, click

g

3 Drag a second Multi/Sub-Map (Maps > mental ray > Multi/Sub-Map) from the Browser into the active View, then wire the new Multi/Sub map to the Layer 2 component of the Composite map.


TIP Pressing L again can help you see all the nodes. So can the other Slate Material Editor navigation tools. After you've used a navigation tool such as Zoom or Pan, right-click an empty area of the active View so you can select material and map nodes once again.

4 Double-click the new Multi/Sub map node to display its parameters.
5 On the Multi/Sub-Map Parameters rollout, set Number Of Colors/Maps To Use to 6.

This time, rather than change colors, you will add six bitmap images to the sub-map.

\section*{Add the first dirt bitmap to the Multi/Sub map:}

1 Drag a Bitmap from the Browser into the active View. 3ds Max opens a file dialog.

2 On the Select Bitmap Image File dialog, highlight dirt1.jpg and turn off Sequence (otherwise, 3ds Max opens all the dirt files as an animated sequence!). Click Open.


The thumbnail at the bottom right of the dialog gives you an idea of what the dirt1.jpg image looks like.

3 Wire the new Bitmap node to the Color/Map \#1 component of the new Multi/Sub map.


4 Double-click the new Bitmap node so you can see its parameters.
5 On the Coordinates rollout, make sure Use Real-World Scale is turned off.


Add the other bitmaps to the Multi/Sub map:
> Repeat the previous procedure for the remaining bitmaps, dirt2.jpg through dirt6.jpg. Wire the Bitmap node for dirt2.jpg to the Color/Map \#2 component, dirt3.jpg to the Color/Map \#3 component, and so on.

Define how the two layers composite together:
1 Double-click the Composite map node to see its parameters.


The Operations drop-down list for each layer is set to Normal, which means that the layer with the highest number obscures all layers beneath it. You need to add an operation that will blend the layers together.

2 On the Layer 2 rollout, click to open the Operations drop-down list, and choose Multiply.


Now the Composite map combines the color and dirt map layers.
3 Make sure the Camera-Seats viewport is active, then press F9 to render the scene (leave the rendered frame window open).


Notice how each group of seats shows the same dirt map. The dirt1.jpg map is applied to all objects in the scene with an ID of 1. The dirt2.jpg map is applied to all objects in the scene with an ID of 2, and so on. You now need to distribute a random mix of all six dirt maps for all seats groups in the stadium.

\section*{Define the sub-map distribution method and fine tune the composite image:}

1 Double-click the Multi/Sub map node that contains the dirt bitmaps, so you can see its parameters. On the Multi/Sub-Map Parameters rollout, open the Switch Color/Map Based On drop-down list, and choose Random.


2 Click Render to render the scene again (still leaving the rendered frame window open).


Now, all six dirt maps appear at random for all seats groups in the stadium. The dirt patterns, however, stand out too clearly.

3 Double-click the Composite map node to see its parameters.
4 On the Layer 2 rollout, change the Opacity setting to \(\mathbf{3 5 . 0}\).


The dirt layer is reduced in visibility to 35 percent of its full opacity.
5 Click Render to render the scene once more.


The dirt maps appear more faded, giving the seats a subtle variation that appear more realistic.

\section*{Save your work:}

1 Save the scene as my_stadium_submaps_completed.max.
2 If you wish, open the file multi-maps_completed.max and render the Camera-Seats viewport to see a finished version of the stadium scene.


\section*{Summary}

In this tutorial, you learned how to give similar objects individual character by adding sub-maps to their base material.

\section*{Lighting Tutorials}

\section*{7}

The tutorials in this section show you how to set the mood and create dramatic lighting effects for scenes built in 3ds Max.


A midday scene of an army camp

\section*{Features Covered in This Section}

■ Creation of a Daylight system to illuminate a scene with geographic accuracy.
■ Daylight illumination of building interiors using the Sky Portal.
- Exposure control.
- Shadow creation and definition.
- Nighttime illumination using adjustable photometric lights.

\section*{Lighting and Rendering a Daylight Scene}

In this tutorial, you have a scene of an army compound that requires lighting conditions for early, mid-day and late-day illumination.

To accomplish this, you will create a Daylight system and customize it to match a specific scene location and time. Then you'll set scene exposure and combine the Daylight system with a mental ray Sky Portal object that will cast light into building interiors. You will fine-tune the late-day illumination by adjusting the aperture setting.

After completing these lessons, you will see how easy it is to use mental ray rendering options to create realistic daylight conditions.


Morning illumination


Mid-day illumination


Late-day illumination
In this tutorial, you will learn how to:
- Use a Daylight system to illuminate scenes set in the daytime.
- Set up illumination based on the scene's geographic location, orientation, and time of day.

■ Use the Sky Portal object to gather skylight and apply it to the interior of buildings.
- Adjust scene exposure.

Skill level: Intermediate
Time to complete: 1 hour

\section*{Adding Daylight Illumination}

Start by switching from the default 3ds Max renderer to the mental ray renderer.

\section*{Set up the lesson:}

■ On the Quick Access toolbar, click
 (Open File) and from the \lighting_and_rendering \army compound folder, open army_compound_lighting_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

Make the mental ray renderer active:

1 On the main toolbar, click

(Render Setup) to open the Render Setup dialog.

2 On the Common tab \(>\) Assign Renderer rollout, click \(\because\) (Choose Renderer) for the Production renderer (at present the label says Default Scanline Renderer).


3ds Max opens a Choose Renderer dialog.


3 In the Choose Renderer dialog, choose mental ray Renderer, then click OK.

4


Close the Render Setup dialog.

5 On the main toolbar, click \(\quad\) (Render Production).
TIP You can press F9 as a shortcut for clicking Render Production.


Rendered scene with no daylight system present

Default lights provide basic illumination in the scene, with textures and materials applied, but the rendered image appears flat and not very realistic. You need to add daylight to the scene. This will be generated by a Daylight system comprising two mental ray photometric light sources:
- mr Sun, which simulates direct light from the sun.
- mr Sky, which simulates indirect light created by the scattering of sunlight in the atmosphere.

These two light sources will be accompanied by the "mr Physical Sky" environment shader, which generates the physical appearance of the sun and sky.


Close the Rendered Frame Window.

\section*{Create the Daylight system:}

1 On the
Create panel, click
(Systems). On the Object Type rollout, click Daylight to turn it on.


2 3ds Max opens a Daylight System Creation dialog that prompts you to add an "mr Photographic Exposure Control" to the scene.
(0) Daylight System Creation

You are creating a Daylight system.
It is recommended that you use the mr Photographic Exposure Control set to an Exposure Value of EV = 15 . Exposure Control settings can be adjusted from the Environment \& Effects dialog.

Would you like to change this now?


Do not show this message anymore (for this session)

Click Yes to add the mental ray Photographic Exposure Control with the recommended Exposure value of 15 .

3 In the Top viewport, click anywhere over the compound and drag slightly in any direction to create a compass rose.

4 Release the mouse button.
As soon as the mouse button is released, a Daylight object, or "sun," is created.

5 Move the mouse upward to position the daylight object in the sky. You can watch the object's position in the Front viewport. The exact height of the Daylight object in the sky is not important.


6 Click once to set the Daylight object position, then right-click to end Daylight creation.

\section*{Set the time and location of the light source:}

Now you will reposition the Daylight object, or "sun," so its position in the sky corresponds to the geographic location of the scene.

1 With the Daylight object selected, go to the


Modify panel, and on the Daylight Parameters rollout, click Setup.
\(\left[\right.\)\begin{tabular}{ll}
\multicolumn{2}{c}{ Daylight Parameters } \\
\(\begin{array}{ll}\text { Sunlight } & \nabla \text { Active } \\
\text { Standard } \\
\text { Skylight } & \square \text { Active } \\
\text { Skylight } \\
\text { Position } \\
\text { Manual } \\
\text { Date, Time and Location } \\
\text { Weather Data File } \\
& \text { Setup... }\end{array}\) \\
\end{tabular}

3ds Max displays the
Motion panel.
2 In the Motion panel > Control Parameters rollout > Location group, click Get Location.


3 On the Geographic Location dialog, open the Map drop-down list, and choose South America.


4 On the map, click on Nicaragua, or choose Managua Nicaragua from the City list displayed to the left.


After you click OK, 3ds Max positions the Daylight sun object to simulate the real-world latitude and longitude of Managua.

The Control Parameters＞Time group displays controls that let you modify the date and time of day，which also affects the position of the sun．The first scene you will illuminate and render is morning at 9 AM ．

5 In the Time group \(>\) Hours spinner box，set the time to 9 ．

\section*{Time}


Time Zone：\(\quad \sqrt{-6} \mid\)｜⿻三丨⿱⿻土㇒丂\zh20
Daylight Saving Time

6 In the Location group，set the North Direction to 110 degrees．
Location
\begin{tabular}{l} 
Get Location．．． \\
\begin{tabular}{l} 
Managua，Nicaragua \\
Latitude：\(\sqrt{12.1}\) \\
Longitude：\(\sqrt{-86.3}\) \\
North Direction：\(\sqrt{110.0}\) I \\
Model Scale \\
Orbital Scale：\(\sqrt{23.803 \mathrm{~m}} \mid \stackrel{\Delta}{\nabla}\)
\end{tabular}
\end{tabular}

This adjustment reorients the north－south position of the scene so when you render the late－day version of the scene，the sun disc will appear over the barracks as it prepares to set in the west．

7 Right－click the Camera01 viewport and press F9 to render the scene．


Rendered scene with Daylight object positioned at 9am

Now objects are lit well, and they cast shadows, but the sky is still a blank.

8 With the Daylight object selected, go to the


Modify panel.
9 On the Daylight Parameters rollout, open the Sunlight drop-down list and choose "mr Sun."


10 Also on the Daylight Parameters rollout, open the Skylight drop-down list and choose "mr Sky."


3ds Max opens a dialog that asks if you want to add the "mr Physical Sky" environment map to the scene.

\section*{mental ray Sky}

\section*{X}


You are creating a 'mr Sky'!
It is recommended to also add a 'mr Physical Sky' environment map.
Do you want this to be done automatically?

11 Click Yes to add the "mr Physical Sky" shader as an environment map.


Rendered scene with mr Physical Sky shader added

Now the scene looks like a sunny morning. Notice, however, that the regions behind the barracks doorways remain unnaturally dark. One way to solve this would be to increase the number of ray bounces used for Indirect Lighting. An alternate way is to add Sky Portal objects to the scene. The next section describes this method.

Save your work:
■ Save the scene as my_army_compound_daylight.max.

\section*{Using Sky Portals and Photographic Exposure Control}

A Sky Portal is a light object that gathers the sky light (as opposed to direct sunlight) generated by the Daylight system, then directs the light flow to the interior of certain scene objects.

NOTE Sky Portals typically require less rendering time than the Global Illumination option. They are an effective alternative to quickly visualize a scene.

\section*{Set up the lesson:}

■ Continue working on your own scene file or in the \lighting_and_rendering folder,
 open army_compound_lighting_daylight.max.

\section*{Add the Sky Portal:}

1 On the


Create panel, click (Lights). Photometric should be chosen on the drop-down list.
On the Object Type rollout, click "mr Sky Portal," then turn on AutoGrid.
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|r|}{Object Type \(\hat{\text { a }}\)} \\
\hline \multicolumn{2}{|l|}{V. AutoGrid} \\
\hline Targetwight & Free Light \\
\hline mr Sky Portal & \\
\hline
\end{tabular}

2 In the Camera01 view, create the Sky Portal by dragging diagonally from the upper-right corner of the far-right barracks entrance to the lower-left corner, until the entire opening is covered.


Sky Portal object in front of the barracks door

The Sky Portal should not be much larger than the door.
3 Right-click to complete creating the Sky Portal.

4 Right-click the Top viewport and
 zoom into the scene until you can clearly see the barracks entrance where you created the Sky Portal object.

Reposition the Sky Portal so it lies just inside the barracks entrance.


If the Sky Portal is placed outside the entrance, the sides of the door frame attract unneeded illumination.

6 With the Sky Portal object still selected, go to the


Modify panel. On the "mr Skylight Portal Parameters" rollout, make sure the Sky Portal is On, then change the value of Multiplier to 8.0.


Typically you would specify a lower Multiplier value if Sky Portal objects were added to the other doors and windows of the barracks.

7

Zoom out and 8 pan in the Top viewport so you can see the front of all three barracks.

\section*{8}


Shift+copy the Sky Portal to the left to create two more instances of the Sky Portal object, one for each entrance to the two remaining barracks.


9 Activate the Camera01 viewport, then - render the scene.


Rendered scene with light channeled into the barracks interior

The result is much improved. The Sky Portal is now channeling sky light into the barracks.

10 Minimize the Rendered Frame Window.

\section*{Set the illumination for mid and late afternoon:}

1


Select the Daylight system (click the sun object, not the compass
rose), then go to the
 Motion panel. > Time group > Hour spinner box, set the time to 14 (2 PM).

2 Make sure the Camera01 view is active, then
- render the scene.


Rendered scene with Daylight object positioned at 2 PM
The shadow of the suspended light next to the jeep \({ }^{\circledR}\) indicates that the sun is almost directly overhead. However, for this time of day the Sky Portals are transferring too much light into the barracks.

Make a clone of the Rendered Frame Window.

\section*{4}


Select one of the Sky Portal objects, go to the


Modify panel, and on the mr Skylight Portal Parameters rollout, change the Multiplier value to 5.0.
The Sky Portals are instances, so any change you make to one Sky Portal will be passed on to the others.
- Render the Camera01 viewport again.


Rendered scene with Sky Portal multiplier reduced

Compare the latest rendered frame with the one you cloned earlier. The entrance illumination is subtle but more realistic.

Now you will generate a third rendered version of the scene, this one showing late-day illumination.

6


Select the Daylight system sun object, and in the
Motion panel Time group, change the Hour to 17 (5 PM).

- Render the Camera01 viewport.


Rendered scene showing late day illumination before Exposure Control adjustment

The rendering is too dark. You will use exposure control to adjust the illumination.

8 On the Rendering menu, choose Exposure Control. 3ds Max opens the Environment And Effects dialog.

9 In the "mr Photographic Exposure Control" rollout > Exposure group, choose Photographic Exposure, then set the value of Aperture (f-Stop) to 5.6.


- Render the Camera01 viewport again.


Rendered scene after exposure adjustment

The new f-stop setting compensates for the time of day.

You have created three distinct moods based on mental ray lighting techniques.

\section*{Save your work:}
- Save the scene as my_army_compound_evening.max.

\section*{Summary}

You can create a Daylight system to simulate real-world outdoor lighting conditions at any time of day, at any location on the planet. The mental ray renderer offers a range of presets that define proper exposure settings, which you can adjust manually as needed. You can add Sky Portal objects to channel daylight into structures through their doorways and windows, to improve interior illumination.

\section*{Lighting and Rendering a Nighttime Scene}

In this tutorial, you will illuminate the army compound so you can render it at night.

You will create photometric lights that replicate real-world lighting systems, then add a touch of realism using the mental ray Glare effect.


In this tutorial, you will learn how to:
- Place photometric lights in a scene and adjust light color.

■ Set shadow parameters so lights cast shadows properly.
■ Change the exposure for a nighttime scene.
- Use a bitmap image as the scene background and adjust its output to compensate for night lighting conditions.

Skill level: Intermediate
Time to complete: 1 hour

\section*{Adding Photometric Lights}

You will start by switching from the default renderer to the mental ray renderer, if you have not already done so. Then you will add photometric lights to illuminate the nighttime scene.

\section*{Set up the lesson:}

- On the Quick Access toolbar, click

(Open File) and in the \lighting_and_rendering \army compound folder, open army_compound_lighting_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

Make the mental ray renderer active:

1 On the main toolbar, click
 Setup dialog.
(Render Setup) to open the Render

2 On the Common tab \(>\) Assign Renderer rollout, click \(\because\) (Choose Renderer) for the Production renderer (at present the label says Default Scanline Renderer).


3ds Max opens a Choose Renderer dialog.


3 Choose mental ray Renderer and click OK.

4


Close the Render Setup dialog.

5 Activate the Camera01 viewport, and on the main toolbar, click 8 (Render Production).


Rendered scene with default lighting

This is the same starting point as the previous tutorial, with default lights providing basic illumination. Now you will add photometric light objects to illuminate the scene.

6 \(\square\) Close the Rendered Frame Window.

\section*{Set up the photometric lights:}

1 Activate the Top viewport and
next to the jeep01 object.


2 On the
Create panel, click
(Lights). If AutoGrid is on, turn it off. On the Object Type rollout, click Free Light to turn it on.


3ds Max opens a dialog that asks whether to add an "mr Photographic Exposure Control" to the scene.

You are creating a photometric light.
It is recommended that you use the mr Photographic Exposure Control. Exposure Control settings can be adjusted from the Environment \& Effects dialog.

Would you like to change this now?
\(\square\) Do not show this message anymore (for this session)

3 Click Yes to add the exposure control.
4 In the Top viewport, click once at the center of the lamp shade to create the light object.

5 Look at the Camera01 viewport. By default, the light object is created on surface plane of the scene.


6 Activate the Front viewport and
the new light. 7 Use (Select And Move) to move the light object on its Y axis
until it is just below the lamp light bulb.


Do not position the light object inside the bulb itself. If you do, the bulb object will cast unwanted shadows.

8 Go to the
Modify panel. On the Templates rollout, open the drop-down list and choose Street 400W Lamp (Web).


Next, you will adjust the color of the light to be cast. You have two ways to do this: You can specify color by the type of object that emits the light, such as an incandescent bulb or a fluorescent tube. Or you can specify light color by its temperature, in degrees Kelvin.

9 In the Intensity/Color/Attenuation rollout > Color group, open the drop-down list and choose Incandescent Filament Lamp.
\begin{tabular}{|c|c|}
\hline & Intensity/Color/Attenuation^ \\
\hline \multicolumn{2}{|l|}{Color} \\
\hline & D65 Illuminant (Refert \\
\hline \multicolumn{2}{|l|}{D50 Illuminant (Reference Whi} \\
\hline \multicolumn{2}{|l|}{O P655 Illuminant (Reference Whi} \\
\hline \multirow[t]{3}{*}{} & Fluorescent (Cool White) \\
\hline & te Fluorescent (Daylight) \\
\hline & Fluorescent (Lite White) \\
\hline \multirow[t]{2}{*}{} & int Fluorescent (Warm White) \\
\hline & Fluorescent (White) \\
\hline & Halogen \\
\hline \multicolumn{2}{|r|}{Halogen (Cool)} \\
\hline & Halogen (Warm) \\
\hline \multirow[t]{2}{*}{} & Din HID Ceramic Metal Halide (Coo \\
\hline & HID Ceramic Metal Halide ( \\
\hline \multirow[t]{2}{*}{} & HID High Pressure Sodium \\
\hline & ID Low Pressure Sodium \\
\hline \multirow{3}{*}{V} & HID Mercury \\
\hline & HID Phosphor Mercury \\
\hline & HID Quartz Metal Halide \\
\hline \multirow[t]{2}{*}{\(\square\)} & HID Quartz Metal Halide (Cool) \\
\hline & HID Quartz Metal Halide (Warn \\
\hline \multicolumn{2}{|l|}{Far HID Xenon} \\
\hline \multicolumn{2}{|l|}{\multirow[t]{2}{*}{}} \\
\hline & \\
\hline
\end{tabular}

The color swatch just below this list updates to match the color temperature of your light selection. The rollout also displays its corresponding value in degrees Kelvin.

- render the scene.


Scene exposure set too high for the light object

Even though 3ds Max added an exposure control to the scene, its default settings don't work with this light object.

\section*{Set scene exposure:}

1 On the Rendering menu, choose Exposure Control to open the Environment And Effects dialog.

2 In the "mr Photographic Exposure Control" rollout > Exposure group, choose Photographic Exposure, then specify a Shutter Speed of 1.0 (1/1.0


Rendered scene after adjustment to exposure

The rendering is much improved, but light is falling only on the central part of the compound. You need to add another overhead light.

3 X Close the Environment And Effects dialog.

\section*{Add another overhead light:}

1 Activate the Top viewport and
 zoom out until you can see the other overhead light fixture, to the lower right.



3 In the Object group, choose Instance to create an instance of the Free Light object, then click OK.

4 Activate the Camera01 viewport and
- render the scene again.


Scene illumination after second light added

The rear area of the compound is now illuminated, but objects in the scene cast no shadows.

Add shadows to the rendering:

1 With either light selected, go to the


Modify panel. In the General Parameters rollout > Shadows group, turn on Shadows.


2 Open the Shadow Map Params rollout (you might have to scroll down to see it). Reduce Bias to \(\mathbf{0 . 0}\) to set shadows closer to the shadow-casting object, and change Sample Range to 12.0.
Setting Sample Range to a value greater than zero generates soft-edged shadows.
\begin{tabular}{|c|c|}
\hline Shadow Map Params & 入 \\
\hline \multicolumn{2}{|l|}{Bias: \(\sqrt{0.0}\) 考 Size: \(\sqrt{512} \mid\) |} \\
\hline \multicolumn{2}{|l|}{} \\
\hline \(\square\) Absolute Map Bias & \\
\hline \(\square 2\) Sided Shadows & \\
\hline
\end{tabular}

3

- Render the Camera01 viewport again.


Objects in the scene now cast shadows

Notice the improvement that shadow casting has on the rendering of the jeep.

Next, you will add light objects to the light fixtures above each barracks doorway.

\section*{Add lights over the barracks doors:}

1 \(\square\) Close the Rendered Frame Window, activate the Top viewport, \(\stackrel{-1}{4}\) and zoom in to the light fixture above the entrance to the far left barracks.


2 On the
Create panel, click
(Lights). On the Object Type rollout, click Free Light to turn it on.

3 Click once on the center of the light fixture to create the light object.

4 Activate the Front viewport and use

(Select And Move) to move the light object on its Y axis until it is level with the light fixture.


5 In the Top viewport,

zoom out until you can see all three doorways, then Shift + drag the light to the right, creating two instances of the light, each positioned above one of the remaining two barracks entrances.


6 With any of the barracks doorway lights selected, go to the
 Modify panel. On the Templates Rollout, open the drop-down list and choose 100W Bulb.


Keep in mind that the light you choose in this list possesses the same properties as real-world lights do. In terms of light attenuation, for example, for every 10 meters distance travelled, light intensity from this bulb will drop off to \(1 / 100\) th of its initial strength.

7 In the Intensity/Color/Attenuation rollout > Color group, use light temperature to change the light color. You want the bulb to project a light blue color, so choose Kelvin, and then enter a value of \(\mathbf{8 0 0 0 . 0}\). In the range of degrees Kelvin, light color varies from 1000 (pink) to 20,000 (blue).


8 Activate the Camera01 viewport and
- render the scene.


Rendered scene with all light systems in place

All objects in the scene foreground look properly lit.

\section*{Save your work:}

■ Save the scene as my_army_compound_nighttime.max.

\section*{Next}

Adding a Background Image and Lighting Effects on page 1353

\section*{Adding a Background Image and Lighting Effects}

In this lesson, you take a daylight image of a desert landscape, adjust its output to resemble nighttime lighting conditions, then incorporate the result into the scene as a background. You'll add a Glare effect to enhance the appearance of the lights, then introduce a few more photometric lights to illuminate the interior of one barracks.

\section*{Set up the lesson:}
- Continue working on your own scene file or in the
\lighting_and_rendering\army_compound folder,
 army_compound_lighting_no_bkrnd.max.

\section*{Add a background image:}

1 Open the Rendering menu and choose Environment to open the Environment And Effects dialog. On the Common Parameters rollout, click the Environment Map button (at present, the text on the button says ("None").


3ds Max opens the Material/Map Browser.


2 On the Material/Map Browser, double-click the Bitmap map type. (Bitmap is in the Maps > Standard group.)
3ds Max opens a file dialog.

3 In the file dialog, navigate to the \sceneassets \images folder, click desert.jpg to highlight it, then click Open.
The image is a desert landscape, taken during the day.
4 On the Exposure Control rollout make sure Process Background And Environment Maps is off.


When this option is turned on, 3ds Max applies the exposure control to the background map itself. For most bitmaps (those that don't save a high dynamic range), in effect this makes the background and other environment maps invisible.

5 Make sure no object is selected, right-click a viewport, and from the quad menu, choose Hide Unselected.

6

- Render the Camera01 viewport.


With all objects hidden, 3ds Max has rendered only the background image. It is apparent that you will need to make the image darker so it suits the nighttime scene.
Leave the Environment And Effects dialog open for now.

\section*{Adjust the background image:}

1 Open the
 Slate Material Editor.

2 In the Material/Map Browser panel on the left, navigate to the Sample Slots group.

3 Drag the Environment Map button from the Environment And Effects dialog and drop it onto an unused sample slot. The sample slot shows a red bar across it when you are able to drop the map.


3ds Max asks if this should be an instance or a copy. Make sure Instance is selected, and then click OK.

4
 Close the Environment And Effects dialog.

5 Drag the sample slot with the environment map into the active View. Once again, 3ds Max asks if this should be an instance or a copy. Make sure Instance is selected, and then click OK.

6 In the active View, double-click the Bitmap node so you can see its parameters in the Parameter Editor panel to the right.

7 On the Output rollout, decrease the Output Amount to \(\mathbf{0 . 0 3 3}\).
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|c|}{Output} \\
\hline \(\square\) Invert & Output Amount: 0.033\(]\) \\
\hline \(\square\) Clamp & RGB Offset: 0 0.0 | \\
\hline \(\square\) Alpha from RGB Intensity & RGB Level: \(\sqrt{1.0}\) |考 \\
\hline \(\square\) Enable Color Map & Bump Amount: 1.0 \\
\hline
\end{tabular}

8
- Render the Camera01 viewport again.

The result is a heavily underexposed image, resembling a night sky: a digital version of filming "day for night."

Background bitmap heavily underexposed to suit night scene

9 Right-click any viewport, select Unhide All from the quad menu, then

- render the scene again.


Bitmap image added to scene background

The background adds depth and interest to the scene.
 Close the Slate Material Editor.

\section*{Add a Glare effect:}
mental ray provides a number of special effects designed to give light objects added realism. Here, you will add a Glare effect to the army compound lights, to simulate their interaction with dust particles and ambient humidity.

1 Click
(Render Setup). On the Render Setup dialog, go to the Renderer tab. In the Camera Effects rollout > Camera Shaders group, turn on the Output shader toggle.

\section*{Camera Shaders}
\begin{tabular}{|c|}
\hline None \\
\hline DefaultOutputShader (Glare) \\
\hline None \\
\hline
\end{tabular}

As the shader button shows, mental ray provides a Glare shader as a default shader for camera output, but by default this shader is turned off, so you have to enable it "by hand."

2 Open the


Slate Material Editor, and move it so you can see both dialogs.

3 In the Material/Map Browser panel on the left, navigate to the Sample Slots group.

4 Drag the Camera Shaders \(\boldsymbol{>}\) Output button from the Render Setup dialog and drop it onto an unused sample slot. The sample slot shows a red bar across it when you are able to drop the map.


3ds Max asks if this should be an instance or a copy. Make sure Instance is selected, and then click OK.

\section*{5}
 Close the Render Setup dialog.

6 Drag the sample slot with the Glare shader into the active View. Once again, 3ds Max asks if this should be an instance or a copy. Make sure Instance is selected, and then click OK.

7 In the active View, double-click the Glare node so you can see its parameters in the Parameter Editor panel to the right.

8 On the Glare Parameters rollout, change the value of Spread from 2.0 to 0.5 .
\begin{tabular}{|c|c|}
\hline Glare Parameters & 入 \\
\hline Quality . . . . . . . . . . . . . . . . . . . . . . . 2 & \\
\hline Spread & \\
\hline Streaks . . . . . . . . . . . . . . . . . . . . . . \(\square\) & \\
\hline Streak Image . glare_streaks_star_camera_filter.tif & \\
\hline Streaks Weight . . . . . . . . . . . . . . . . 0.5 & \\
\hline Resolution for Glare Processing . . . . . . . 500 & \\
\hline Replace Rendered Image with Glare Only . \(\square\) & \\
\hline
\end{tabular}

9 Close the Slate Material Editor.
\(\square\)
 clone of the existing rendered frame, then - render

10 Make a the scene.


Rendered scene with Glare effect added to light sources

Compare the two images to see the Glare effect. This effect is most pronounced on the suspended lamp over the jeep.


Add lights to the interior of the barracks on the right:



2 On the
Create panel, click
(Lights). On the Object Type rollout, click Free Light to turn it on.

3 Place the new light by clicking the apex of the barracks roof, near the entrance.


4 Activate the Front viewport,

right-hand barracks, then use \(\mathrm{C}^{ \pm}\)zoom to see the front of the light object on its Y axis until it is above the floor but below the roof, as shown in the illustration.


The interior barracks lights are fluorescent, so the new light object should be suspended about two feet (about 0.6 m ) from the ceiling.

5 Go to the
Modify panel. On the Templates rollout, open the drop-down list and choose 4ft Pendant Fluorescent (Web).


Now you will set the color the light will cast.
6 On the Intensity/Color/Attenuation rollout, make sure the preset Light radio button is chosen (as opposed to color temperature: "Kelvin"), then choose Fluorescent (White) from the Light drop-down list.
    Intensity/Color/Attenuation \(\hat{\text { 人 }}\)
    Color
    - D65 Illuminant (Refert
        D50 Illuminant (Reference Whi
        Pr65 Illuminant (Reference Whi
        Fluorescent (Cool White)
Filte Fluorescent (Daylight)
    Fluorescent (Lite White)
Int Fluorescent (Warm White)
    Fluorescent (White)
    Halogen
15 Halogen (Cool)
    Halogen (Warm)
Dir HID Ceramic Metal Halide (Coo
HID Ceramic Metal Halide (War
    HID High Pressure Sodium
    HID Low Pressure Sodium
    HID Mercury
    HID Phosphor Mercury
    HID Quartz Metal Halide
    HID Quartz Metal Halide (Cool)
    HID Quartz Metal Halide (Warn
    HID Xenon
Far Incandescent filament lamp

The scene calls for a standard fluorescent fixture consisting of four tubes. Rather than physically re-creating each tube, you can simply bump up the intensity of the single light object by a factor of four.

7 In the Intensity/Color/Attenuation rollout > Dimming group, change the value of Resulting Intensity to 400\% (percent).

Dimming
Resulting Intensity:
12800.0 lm
(v) 400.0\(]\) [ \(\stackrel{\Delta}{-} \%\)

Incandescent lamp color shift when dimming

8 In the Top viewport, make two instances of the fluorescent light. Distribute them evenly along the length of the barracks.


9 On the Shadows rollout, turn shadows On so the ceiling lights will cast shadows.


10 Activate the Camera01 viewport and


Rendered scene with interior lights added to the barracks on the right

The inside of the right-hand barracks is now illuminated, with light spilling out of the entrance.

\section*{Save your work:}

■ Save the scene as my_army_compound_nighttime_completed.max.

\section*{Summary}

In this tutorial, you learned how to use photometric lights to illuminate a night scene. You specified the color of the light source and defined how shadows were cast. You also learned how to take a background image, adjust its output, and apply it as a background to the night scene. Finally, you saw how a mental ray Glare shader can be applied to a light object to produce added realism.

\section*{Rendering Tutorials}

The lighting tutorials showed you ways in which to render your scene. The tutorials in this section cover additional aspects of rendering: Rendering large numbers of low-poly objects and proxies to reduce scene calculation time.


\section*{Features Covered in This Section}

■ Use a particle system to simulate large numbers of similar objects in a scene
■ Create mental ray proxy objects and use the Scatter utility to instance, then distribute them across a scene

\section*{Reducing Complexity in Your Renderings}

When you render a scene, the number of faces in the scene model directly affects rendering time: The greater the number of faces, the longer the rendering takes.

The tutorials in this section use trees as an example of objects with a high face count. They show you to ways to reduce that count: By turning trees into particles, a method you can use with either renderer; and by turning trees into mr Proxy objects, a method that applies to the mental ray renderer.


Trees set up as "particles" to render a wooded area in a short amount of time

\section*{Particle Trees}

In this tutorial, you learn how to use particles behaving as "billboards": Each particle shows a bitmap tree image that can render quickly, while a twinned particle casts the shadow of the tree.


Trees modeled using conventional 3D techniques can produce authentic results, but a single tree typically can include 20,000 polygon faces or more. If you need to duplicate the tree many times, to create a forest for example, you can be faced with a lengthy render involving millions of polygons.

However, there is a way to populate your scene with many life-like trees without sacrificing render speed. You can do this by using a particle system to generate a number of particles in the shape of two-dimensional planes, or "billboards." A map of a tree is then projected onto each billboard.

This particle method permits the mapping of different sizes and shapes of trees and is very economical to render. But it also raises several important issues.

Because the tree image is two-dimensional, it can be seen properly only when it directly faces the camera. If seen from an angle, it loses its realism.


\section*{Left: Particle tree facing camera}

\section*{Right: Particle tree at oblique camera angle}

For this reason, the flat plane on which the image is mapped must be continuously re-oriented toward the camera as the camera moves around the scene.


Particle tree continuously faces the camera

Another consideration is how your two-dimensional particle trees cast shadows. If the light source (usually the sun) does not directly face the billboard plane, the tree will cast an unrealistic oblique shadow, as shown in the next illustration.


Light source causes the particle tree to cast a shadow at an oblique angle
Therefore, you must generate a second set of particle tree planes. The first set should show the tree and no shadow, while the second set should show a shadow and no tree.


Left: Second particle tree oriented toward the light source, with its shadow visible Right: Second particle tree hidden, with only its shadow visible

The visible tree planes are oriented to continually face the camera, while the shadow-only tree planes continually face the light source. You define the tree and shadow orientation in the particle system parameter settings.

You should also introduce a degree of self illumination to the particle-based trees you generate. Otherwise, if the light source is behind the object in camera view, as shown in the next illustration, the object can appear darker that it should.


Left: Camera view of backlit particle tree with no self-illumination
Right: Camera view of particle tree illuminated directly by light source

In this tutorial, you will learn how to:
- Create tree objects and modify their material
- Create a particle system

■ Use operators to shape particle system events
- Map images to generated particles
- Set particle visibility
- Assign sub-materials to generated particles
- Rearrange particle placement in a scene

■ Use polygon selection to define the area in which to render the particles.

Skill level: Intermediate
Time to complete: \(11 / 2\) hours

\section*{Creating Billboard Tree Maps}

In this lesson, you will choose a tree from the 3ds Max library of ready-made plant objects and edit its material to resemble an elm in spring. You will save
this object as a .tif image, ready to be projected onto the billboards of your particle system.

NOTE In addition to the tree objects available in 3ds Max, there are a number of commercially available plug-ins, such as Forest from Itoo Software, or RPC from ArchVision, that offer a wide range of alternative tree species.

\section*{Create a tree:}

1 On the main toolbar, click
(Render Setup).
2 In the Render Setup dialog
Common panel 2
Common Parameters rollout \(>\) Output Size group, set Width and Height to 512.


Each particle, or billboard, you generate from the particle system will be perfectly square, so the resolution of the map you want to use for the tree must be square as well.
A value of \(1024 \times 1024\) or even higher is permissible, but the higher the resolution, the longer it will take to render the particle trees.

\section*{3}
\(\boxed{X}\) Close the Render Setup dialog.

4 On the
 drop-down list, and choose AEC Extended.


5 On the Object Type rollout, click Foliage and on the Favorite Plants rollout click American Elm.


6 Click anywhere in the Perspective viewport to place the tree.
7 Right-click to exit object creation mode.

\section*{Position the tree so it will render as a well-behaved billboard:}

1 Activate the Front viewport and press P to switch to a Perspective view.

2 Click 4 (Zoom Extents).
3 Click the Point-of-View (POV) viewport label and choose Show Safe Frames. Change the viewport shading mode to Smooth + Highlights (you can press F3).
The safe frame displays as a yellow square, indicating the extent of the rendering area.


Perspective view with the safe frame displayed

4 Use
(Pan) and

(Zoom) to reposition the tree until it fully occupies the safe area.


Tree repositioned to fill the safe area

Now you need to make sure the base of the tree trunk is centered precisely at the bottom midpoint of the frame. In doing so, you ensure that the trunk of this tree will be aligned with the tree shadow that you'll derive from this image.

5 Click the Perspective viewport's General label ("[+]") and choose Configure.

6 In the Viewport Configuration dialog \(>\) Safe Frames panel \(>\) Setup group, turn off User Safe Lock, then turn on User Safe.


7 Set the User Safe Horizontal spinner to 100.0, the Vertical spinner to 0.0, then click OK.


A purple vertical guide line displays in the viewport safe area. (This guide line is actually a rectangular safe-frame area that has no width.)


User safe area that acts as a guideline for centering the tree in the frame

8


Move the tree along its X axis until the center of the trunk base is aligned with the purple line.


The next procedure shows how to replace the tree with another one that might be more to your liking.

Find a tree configuration that you like:

1 Go to the


Modify panel. On the Parameters rollout, click the New button to the left of Seed until you see a tree you prefer.


2 If 3ds Max displaces the tree trunk,
 move the base of the tree along its X axis until it is aligned with the center line of the safe frame again.
This time, also make sure the tree base extends slightly below the bottom edge of the safe area. This will cause the particle tree to slightly sink in to the emitter object and form a solid connection with the ground. Also, make sure no leaves or tree branches extend beyond the safe area.


Base of the tree repositioned so it extends slightly into the safe area

\section*{Render the tree:}

1 On the main menu, choose Rendering > Gamma/LUT Setup.
2 3ds Max opens the Preferences dialog to the Gamma And LUT tab. Turn on Enable Gamma/LUT correction. Make sure that Gamma is chosen, and that the gamma value is set to 2.2 .

Turn on both options in the Materials and Colors group as well: Affect Color Selectors and Affect Material Editor.


Adding gamma correction improves the appearance of renderings.

3 On the main toolbar, click - (Render Production).


3ds Max renders the tree using the default render settings. The trunk color is not realistic, and the leaves are too uniform in color. To correct this problem, you will change their material diffuse values.

4 Minimize the Rendered Frame Window.

\section*{Change the material of the trunk:}

1 Open the


Slate Material Editor.

2 On the Slate Material Editor toolbar, click
(Pick Material From Object), then in a viewport, click any part of the tree.
3ds Max displays the BasicElm material in the Slate Material Editor active View.

3 In the Slate Material Editor, click \(\square^{\Gamma}\) (Zoom Extents).


The material tree looks complicated because BasicElm is a Multi/Sub-Object material, but it really is not as complicated as it looks.

4 Double-click the main BasicElm material node, the node at the right of the tree, so you can see the material parameters in the Parameter Editor panel at the right of the Slate Material Editor.


The Multi/Sub-Object Basic Parameters rollout shows how the BasicElm material contains five sub-materials, assigned separately to the trunk, branches, and leaves.

NOTE The Canopy sub-material is the material shown in viewports when the tree object is not selected.

Now you will change the Diffuse values of the Trunk sub-material to improve the appearance of the tree trunk.

5 In the active View, click to select the first sub-material at the top of the View, which is the node for the Trunk sub-material.

6 Click \(ᄂ\) (Zoom Extents Selected), and then 8 pan out in the View a bit so you can see the Trunk material node and the map and controller already assigned to it. When you're done, right-click an empty area of the View to return to selection mode.


7 In the Material/Map Browser panel at the left, locate the Noise map (it is in the Maps \(>\) Standard group), drag this entry into the active View, and then wire it to the Trunk sub-materials Diffuse Color socket.


8 Double-click the Noise map node so you can see its parameters.
9 On the Noise Parameters rollout, choose Fractal for the noise type, and set the Size spinner to 5.0.


10 Click the Color \#1 color swatch and choose a medium-dark brown color, (such as \(\mathrm{R}=77, \mathrm{G}=41, \mathrm{~B}=5\) ), then click the Color \#2 color swatch and choose a light tan or beige color (such as \(\mathrm{R}=146, \mathrm{G}=124, \mathrm{~B}=102\) ).


\section*{Render the tree to see the result:}

1 Minimize the Slate Material Editor.
2 Render the Perspective viewport to see the new diffuse values you set for the Trunk sub-material. If you are not satisfied with the result, feel free to make further changes to the material color.


With lighter, noise-mapped colors, the trunk looks more convincing and also more elm-like.

Next, you will copy the diffuse values of the trunk to the branches.

\section*{Use the new Trunk submaterial for the branches:}

1 Restore the Slate Material Editor window.

2 In the active View,


Pan downward in the View so you can see the Branch0 and Branch1 nodes. When you have finished panning, right-click an empty area of the View to return to selection mode.


3 Click the Branch0 sub-material node, then press Delete.
4 Delete the Branch1 sub-material node as well.


5 Wire the Trunk sub-material node to the main BasicElm (2) and (3) sub-material sockets that used to contain the Branch0 and Branch1 sub-materials.


6 With your cursor in the active View, press L to rearrange the layout of the material tree.


With only three sub-materials, the material tree is simpler than it was.
Now all the branches match the trunk, as you can see if you render the Perspective viewport again.


\section*{Change the material of the leaves:}

1 Double-click the Leaves sub-material node (now the second sub-material from the top) so you can see its parameters.

2 Drag another Noise map from the Browser into the active View, and wire the Noise map node to the Diffuse Color socket of the Leaves sub-material.


TIP After you add and wire the new Noise node, press L again to clean up the layout of the active View.

3 Double-click the new Noise map node so you can see its parameters.
4 On the Noise Parameters rollout, choose Fractal for the noise type, and set the Size spinner to \(\mathbf{3 . 0}\).


5 Also on the Noise Parameters rollout, set the Noise Threshold > High value to 0.7 and the Low value to \(\mathbf{0 . 3}\).


These values will increase the level of sharpness between the two colors you are about to choose.

6 Click the Color \#1 color swatch and choose a medium-dark green color, (such as \(\mathrm{R}=\mathbf{0}, \mathrm{G}=73, \mathrm{~B}=0\) ), then click the Color \#2 color swatch and choose a light green color (such as \(\mathrm{R}=175, \mathrm{G}=189, \mathrm{~B}=171\) ).


7 Minimize the Slate Material Editor.
8 Render the tree to see the new diffuse values for the leaf material.


Notice how the two-color combination makes for more realistic leaves.

\section*{Check the alpha channel:}

1 On the Rendered Frame Window, click (Display Alpha Channel)
to view the alpha channel of the tree object in the rendering.


Alpha channel of the tree object rendering

The alpha information provides the shape of the cutout for the particle trees you will generate later.
Now you now need to save the tree to an image file format that includes alpha information.

Save the "billboard" image of the tree in spring foliage:

1 On the Rendered Frame Window, click
 (Save Image).

2 In the Save Image dialog File Name field, type my_elm_spring.tif, then click Save.

3ds Max opens the TIF Image Control dialog. In the Image Type group, make sure that 8 -Bit Color is chosen, and Store Alpha Channel is on.


NOTE You can save your file in a format other than .tif, but be sure to choose a format that stores alpha information. Formats such as .png and .tga can include alpha, whereas .jpg and .bmp cannot.

The particle system you create in the next lesson can use this tree image to populate a forest. To introduce some variation to the scene, you will create a second tree image to be referenced by the particle system as well.

\section*{Create fall foliage for the tree, and save that image:}

1 In the Perspective viewport, select the tree object and on the
 Modify panel > Parameters rollout, click the New button to the left of Seed.

2 Continue clicking the button until you obtain a tree you like.
3 Set the Density spinner to 0.75 and press Enter.
\begin{tabular}{|c|c|}
\hline Parameters & 入 \\
\hline \multicolumn{2}{|l|}{Height: 360.0} \\
\hline \multicolumn{2}{|l|}{Density: 0.75 I} \\
\hline \multicolumn{2}{|l|}{Pruning: 00.0} \\
\hline New Seed: 1653428 & \\
\hline \multicolumn{2}{|l|}{\(\checkmark\) Generate Mapping Coords.} \\
\hline
\end{tabular}

This value reduces the number of leaves on the tree.

4 If you need to,

move the tree trunk along its X axis again so it is properly centered on the vertical midpoint of the safe area.

5 Restore the Slate Material Editor window.
6 On the Noise Parameters rollout, change Color \#1 and Color \#2 for the Leaves sub-material to red and orange respectively.


7 Render the Perspective viewport.


Tree object with fall-like parameters

By reducing the number of leaves and adjusting the leaf colors, you have created a tree that is suited to a fall scene.

8 On the Rendered Frame Window, click Save Image, then on the Save Image dialog File Name field, type my_elm_fall.tif and click Save. Be sure to specify the 8 -bit and alpha channel options.
At this point, you could create as many different sizes, leaf density, pruning level, colors, and species of trees as you like to be referenced by the particle system. In this tutorial, however, you already have a dozen tree types made for you, sufficient to create a convincing-looking forest.

\section*{Save the scene:}

■ For future reference and adjustments, save the scene as my_elmtree.max.

\section*{Creating a Particle System}

Now that you have set up the images you want to manage using a particle system, it is time to create the particle system itself.

\section*{Set up the lesson:}
- On the Quick Access toolbar, click
(Open File), navigate to the \scenes\rendering\particle_trees folder, then open ptrees_basics.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.


The scene consists of a simple plane on which you will place the particle-based trees. It also includes a Daylight system for outdoor illumination, and a camera.

\section*{Create a particle system:}

1 On the
 drop-down list, and choose Particle Systems.


2 On the Object Type rollout, click PF Source to turn it on. In the Top viewport, drag anywhere outside the plane to place the Particle Flow source icon.


The size and location of the source icon is not important, since the particles will be generated from the plane object.

3 Right-click to end object creation.

4 Go to the Modify panel. In the Emission rollout \(>\) Quantity Multiplier group set the Viewport \% spinner to 100.0.


When the Viewport Quantity is 100 percent, the viewports display every particle in the system. For an effect such as smoke or fluid, this could slow down 3ds Max performance, but for the particle-tree forest, there are not that many particles, and you want to be able to see all of them.

5 On the Setup rollout, click Particle View.
TIP You can also display Particle View by pressing 6 on your keyboard.


Particle View manages a particle system and helps you visualize the particle source and parameters, as well as events that influence a particle's appearance and behavior during its life span.

Initially, the system contains two events: the source that you just created, and a default Event 001.

6 In Event 001, click the Birth 001 operator to highlight it.


On the right of Particle View, the Birth 001 rollout displays parameters that relate to particle creation. The Emit Start and Emit Stop spinners indicate that particle generation will start at frame 0 and end at frame 30. The Amount spinner indicates that 200 particles will be generated by the system.
\begin{tabular}{|c|c|}
\hline Birth 001 & ヘ \\
\hline Emit Start: 0 & \\
\hline Emit Stop: 30 & \\
\hline (0) Amount: 200 & \\
\hline (-) Rate: 60.0 & 寺 \\
\hline Total: 200 & \\
\hline \(\checkmark\) Subframe Sampling & \\
\hline
\end{tabular}

7 Drag the time slider to see how the default particles are generated.


Particles emanating from the emitter object

By default, there are a large number of particles that fall downward from the Particle Source icon. You need to modify the Birth 001 parameters so that the system generates only six particles that remain stationary at all times.

\section*{Change the particle settings so particles are stationary, with visible geometry:}

1 On the Birth 001 rollout, set Emit Stop to 0 (this ensures that the particles do not pop up over time) and set the Amount spinner to 6, so that only six particle trees are created.
\begin{tabular}{|c|c|}
\hline Birth 001 & 入 \\
\hline Emit Start: 0 & \(\stackrel{\rightharpoonup}{*}\) \\
\hline Emit Stop: 0 & * \\
\hline (0) Amount: 5 & - \\
\hline (-) Rate: 60.0 & - \\
\hline Total: 6 & \\
\hline ( Subframe Sampling & \\
\hline
\end{tabular}

2 In Particle View, click the Speed 001 operator to highlight it, then right-click and choose Delete, since you do not want the particle trees to move.


3 Delete the Rotation 001 operator as well, since the orientation of the particles will be driven by the camera position.

4 The "depot" is the list of operators and tests that appears at the bottom of the Particle View window. Drag a Position Object operator from the depot and in Event 001, drop it directly over the Position Icon 001 operator.


3ds Max displays a red line to indicate you are replacing the original operator with the new one.

5 Click the new Position Object 001 operator to highlight it. In the Position Object 001 rollout \(>\) Emitter Objects group, click Add. In any viewport, click the Plane01object.


Before, particles were emitted from the particle source icon. Now, particles are emitted from the Plane01 object: You can see them scattered about the plane's surface.

6 Click the Display 001 operator to highlight it. On the Display 001 rollout, open the Type drop-down list, and choose Geometry.


It is now easier to visualize the particles, although soon you will be replacing these shapes with tree images.


7 Click the Position Object 001 operator again and on the Parameters panel, scroll down to the Uniqueness group. Click New to change the positioning of the particles. Continue clicking the button until you get a grouping you like.

\section*{Uniqueness:}


\section*{Change the particles to shapes that face the camera:}

1 From the depot, drag a Shape Facing operator directly over the Shape 001 operator to replace it.

2 Click the Shape Facing 001 operator to highlight it. In the Size/Width group, make sure In World Space is chosen, then change the value of Units to 40.0, and press Enter.


This value increases the size of the particles.
3 In the Look At Camera/Object group, click the button labeled "None" and in any viewport, click the Camera01 object.
The particles, which previously lay flat on the plane emitter, now face the direction of the Camera01 object.


NOTE To refresh the scene properly, you might need to adjust your view in the Camera01 viewport, using any viewport navigation control.

4 On the Shape Facing rollout, open the Pivot At list, and choose Bottom.


5 At the bottom of the Size/Width group, change the value of Variation \% to \(\mathbf{2 5 . 0}\).


This creates a range of particle sizes. The tree images mapped onto each particle will also vary in size.


Next, you will map the tree images onto the particles. You will do so using the Material Static operator, the best choice for a material that is not animated.

\section*{Map tree images to the particles:}

1 From the depot, drag a Material Static operator to the PF Source 001 event. Drop it just below the Render 001 operator. A blue line indicates the point of insertion.


NOTE You are defining the material at the PF Source 001 level because you want all the trees to share the same material throughout the particle life span. If you wanted to assign the trees different materials based on a specific particle event, you would have dragged the Material Static operator to the appropriate event box.

2 Open the
Slate Material Editor.
3 Drag an Arch \& Design entry from the Material/Map Browser into the active View.

4 Double-click the Arch \& Design material node to display its parameters.
5 Name the new material Trees.
6 On the Templates rollout, open the drop-down list and choose Matte Finish.
With Matte Finish, the trees will not pick up any reflection from neighboring objects.

7 Drag a Bitmap entry from the Browser into the active View.
3ds Max opens a file dialog. Navigate to \sceneassets \images and choose elm_summer.tif.

8 Wire the new Bitmap node to the Diffuse Color socket of the Trees material.


9 Double-click the Bitmap node so you can see its parameters.
10 On the Coordinates rollout, turn off Use Real-World Scale if it is on, and make sure Tiling is set to 1.0 for U and V .


This step ensures that the image area matches the size of the particle.
11 Click the Trees material node to make it active, then on the Slate Material

Editor toolbar, click
(Show Map In Viewport) to turn it on.
12 Move Particle View and the Slate Material Editor so you can see both windows. In Particle View, highlight the Material Static 001 operator, then drag from the output socket of the Trees material node, and in Particle View, drop the material on the Assign Material button (initially labeled "None"). When 3ds Max asks whether to use a copy or an instance, make sure Instance is chosen, then click OK.


TIP If the tree maps don't appear in the shaded viewport right away, turn off Assign Material and then turn it back on.

Now the tree map is now applied to all particles in the scene. Their background remains visible: You still need to make them cutouts by using the alpha-channel information.


Tree map applied to all particles in the scene

Use cutout mapping for the tree particles:
1 In the Slate Material Editor, Shift+drag the Bitmap node to make a copy of it.


2 Wire the new Bitmap copy to the Cutout Map socket of the Trees material node.


3 Double-click the new Bitmap node so you can see its parameters.
4 On the Bitmap Parameters rollout, in the Mono Channel Output group, choose Alpha, and then in the RGB Channel Output group, choose Alpha As Gray.
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|r|}{Bitmap Parameters} \\
\hline \multicolumn{2}{|l|}{Bitmap: forialslscenes\renderinglparticle_trees\my_elm_tree.tif} \\
\hline Reload & Cropping/Placement \\
\hline Filtering & \(\square\) Apply View Image \\
\hline ( Pyramidal & ( Crop Place \\
\hline Summed Area
None &  \\
\hline \begin{tabular}{l}
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RGB Intensity
\end{tabular} & \(\square\) Jitter Placement: 1.0 | \(\mid\) | \\
\hline (0) Alpha & Alpha Source \\
\hline \multirow[t]{2}{*}{RGB Channel Output:
RGB} & ( Image Alpha \\
\hline & RGB Intensity \\
\hline 9 Alpha as Gray & \\
\hline & \(\checkmark\) Premultiplied Alpha \\
\hline
\end{tabular}

Now the background of the tree bitmap no longer appears.


Next, you will boost the amount of self-illumination so that all parts of the tree can still be visible even when the leaves and branches are not in direct sunlight.

\section*{Set particle tree self-illumination:}

1 In the Slate Material Editor, wire the original Bitmap node (the one you are using for colors, not for the alpha channel) to the Self-Illumination Map socket of the Trees material node.

2 Double-click the Trees material node so you can see its parameters.
3 On the Self Illumination (Glow) rollout, turn on Self Illumination.

> Self Illumination (Glow)
\(\checkmark\) Self Illumination (Glow)
dapor
D65 Illuminant (Refeı
Filter
(O) Kelvin:
6500.0

Luminance
Physical Units: (cd/m²)
1.0
- Unitless

Glow options
V Visible in Reflections
Illuminates the Scene (when using FG)

At this point, the self-illumination has no real effect, because the default Luminance values are overpowered by the Daylight system exposure value set for your exterior scene.

4 In the Luminance group, leave Unitless chosen, and enter a value of 5000.0.

 Close the Slate Material Editor.

\footnotetext{
6 Render the Camera01 viewport.
}


Particle trees with self illumination added

Now the self-illumination of the trees is apparent.

Save your work:
- Save the scene as mytrees.max.

\section*{Defining Tree Shadows}

In this lesson, you will instruct the particle system to generate a second set of trees, with only its shadows visible. You will then orient the shadows so they continually face the light source in the scene. As a result, the shadows will appear to belong to the first set of visible trees.

\section*{Set up the lesson:}

■ Continue working on the scene file you saved in the previous lesson, or

open ptrees.max.

\section*{Generate a second set of tree particles:}

1 Press 6 to display Particle View, drag a Spawn operator from the depot to Event 001, and drop it at the bottom of the event, below the Display 001 operator.


The Spawn operator will generate a new set of particles from the ones you defined in Event 001.

2 Highlight the Spawn 001 operator to display its parameters.
In the Spawn 001 rollout > Spawn Rate And Amount group, the Once option should be chosen, indicating that only one set of particles will be created.

\section*{Set the particles to follow the sun:}

1 In Event 001, click to highlight the Shape Facing 001 operator, then right-click it and from the pop-up menu, choose Copy.

2 Right-click an empty area of the event-display area below Event 001, and from the pop-up menu, choose Paste.


3ds Max creates a new event, called Event 002, with an operator that also instructs the particles to face the camera. Now you will modify this operator so that the particles will face the scene light source instead of the camera.

3 Click the new Shape Facing 002 operator so you can see its parameters. In the Shape Facing 002 rollout \(>\) Look At Camera/Object group, click the Pick button (which at first is labeled Camera01), then in any viewport, click the [Daylight01] Sun01 object.


4 In Event 002, click the Display 002 operator. On the Display 002 rollout, click the color swatch and use the Color Selector controls to choose a red color.


This color is used to display the shapes of the second set of particles in wireframe views. It will not be visible in renderings. The red color will help you better identify the second set of particles.

5 Open the Type drop-down list and choose Geometry.
6 In Event 001, click the Display 01 operator and choose a dark blue color, to better see the first set of particles in wireframe view.

7 Click the blue handle to the left of the Spawn operator and drag it to the Event 002 input (the empty circle that protrudes from the top of Event 002).


With this connection, Event 001 spawns a set of particles once and sends them to Event 002, where they are instructed to face the sun.

8 In the Front viewport, select the camera. On the main toolbar, click

(Select And Move). In the Top viewport, move the camera about the scene.



Top: Camera position 1

\section*{Bottom: Camera position 2}

Billboard trees (shown in blue) follow the camera position, while the shadow particles (shown in red) do not

9 Press Ctrl+Z to undo the camera movement.

Do a test rendering:



Rendered scene showing two sets of particle tree shadows

There are now two sets of particle trees, each of which cast shadows. You need to hide the shadows of the particle trees that face the camera, then hide the particle trees that face the sun but keep their shadows visible.

\section*{Fix the visibility of shadows:}

1 Highlight the header of Event 001, then right-click it and from the pop-up menu, choose Properties.
Remember that in Particle View, Event 001 represents the particle trees that face the camera, while Event 002 represents the particle trees that face the sun.

2 In the Object Properties dialog \(>\) General panel \(>\) Rendering Control group, click By Layer (if By Object is not already active) and turn off Receive Shadows, Cast Shadows and Apply Atmospherics. Click OK.
```

Rendering Control
Visibility: \1.0 By Object
\ Renderable
|}\mathrm{ Inherit Visibility
V}\mathrm{ Visible to Camera
V}\mathrm{ Visible to Reflection/Refraction
Receive Shadows
Cast Shadows
Apply Atmospherics
hRender Occluded Objects
G-Buffer
Object ID: 0 - |

```

3 Highlight the header of Event 002, then right-click it and from the pop-up menu, choose Properties.

4 In the Object Properties dialog \(>\) General panel \(>\) Rendering Control group, click By Layer (if By Object is not already active) and turn off Inherit Visibility, Visible to Camera, Visible to Reflection/Refraction, Receive Shadows and Apply Atmospherics. Click OK.

\section*{Rendering Control}

Visibility: \(\sqrt{1.0}\) |sy
\(\checkmark\) Renderable
\(\square\) Inherit Visibility
\(\square\) Visible to Camera
\(\square\) Visible to Reflection/Refraction
\(\square\) Receive Shadows
\(\checkmark\) Cast Shadows
Apply Atmospherics:
Render Occluded Objects
G-Buffer
Object ID: 0 -


Particle trees with only one set of shadows visible

The rendering shows one visible set of particle trees, and shadows cast by the second set of trees, which are otherwise hidden.

\section*{Save your work:}

■ Save the scene as my_ptrees_shadows.max.

\section*{Introducing Variety}

The trees in your scene are casting shadows properly, but while they vary in size, they are all identical in shape and color. To make a convincing forest, you need to add a few more tree varieties into the mix.

\section*{Set up the lesson:}
- Continue working on the scene file you saved in the previous lesson, or ت open ptrees_shadows.max.

Adjust the camera view:

1 On the main toolbar, click

(Select And Move). In the Front viewport, move the Camera01 object until it is closer to the ground.


2 Activate the Camera01 viewport, and
 - dolly forward until the trees are in full view.


Increase the number of tree particles：
1 In Particle View，in Event 01，click the Birth 01 operator to highlight it．
2 On the Birth 01 rollout，change the Amount value to 25 ．
\begin{tabular}{|c|c|}
\hline Birth 01 & 人 \\
\hline Emit Start： 0 & 考 \\
\hline Emit Stop： 0 & \\
\hline （0）Amount： 25 I & － \\
\hline （－）Rate： 60.0 & 者 \\
\hline Total： 25 & \\
\hline \(\checkmark\) Subframe Sampling & \\
\hline
\end{tabular}

3



Now the particle system generates 25 trees. Each particle uses the same image of the elm tree you selected earlier. Next, you will change the particles to reference three different types of trees.

\section*{Create a Multi/Sub-Object material to contain multiple tree maps:}

1 Open the
 Slate Material Editor.

2
 Zoom out in the active View, then drag a Multi/Sub-Object from the Browser into the active View, and drop it to the right of the Trees material.

By default, the Multi/Sub-Object material contains 10 entries, each of which allows you to specify a sub-material. Fortunately, you don't need all of these.

3 Drag box to select all of the submaterial nodes, then press Delete.
4 In the Slate Material Editor, click (Zoom Extents), then move the Multi/Sub-Object material node closer to the main Trees material node.

5 Double-click the Multi/Sub-Object material node so you can see its parameters.

6 Name this material Elm Trees.
7 On the Multi/Sub-Object Basic Parametrers rollout, click Set Number. On the Set Number Of Materials dialog, change the value to 3.
You will specify three different tree types to use on the particles.
8 Wire the Trees material node to the (1) sub-material socket of the Elm Trees node.


Now you need to create the other two sub-materials.

\section*{Create a fall sub-material, and then another for winter:}

1 Click the minus-sign (-) icon on the title bar of the Trees material node to collapse this node display, then hold down the Shift key and drag the Trees node to make a copy of it.


2 Click the plus-sign (+) icon on the title bar of the new material node to open the node display again, then drag away from the input sockets to disconnect the wired bitmaps.


3 Click the minus-sign (-) icon to collapse the new material node again, then Shift+drag to make another copy.


4 Double-click the Trees material node so you can see its parameters. Change the name of this sub-material to Elm - Summer.

5 Double-click the second material node, and change its name to Elm - Fall.

On the Slate Material Editor toolbar, turn on

(Show Standard Map In Viewport).

6 Double-click the third material node, and change its name to Elm - Winter.

On the Slate Material Editor toolbar, turn on

(Show Standard Map In Viewport).

7 Wire the second and third material nodes to the (2) and (3) sockets of the Elm Trees material node to make them sub-materials as well.


Add the bitmaps for the new sub-materials:
1 Click the plus-sign (+) icon of the Elm - Fall sub-material node to open the node, then press \(L\) so you can see all of the material tree.


2 Drag a wire from the Diffuse Color Map socket of the Elm - Fall sub-material node, then release the mouse. From the pop-up menu, choose Standard > Bitmap.


3ds Max opens a file dialog. Choose the elm tree with autumn foliage you rendered in the previous lesson, or navigate to \sceneassets \images and choose elm_fall.tif.

3 Wire the new Bitmap node to the Self Illumination Map socket as well.


4 Shift+drag the new Bitmap node to make a copy of it, then wire the copy to the Cutout Map socket of the Elm - Fall sub-material.


5 Double-click the Bitmap node that is wired to the Cutout Map socket. On the Bitmap Parameters rollout, change Mono Channel Output to Alpha, and RGB Channel Output to Alpha As Gray.

6 Repeat steps 1 through 5 for the third sub-material node, this time using \sceneassets \(\backslash i m a g e s ~ \ e l m \_w i n t e r ~ a s ~ t h e ~ b i t m a p . ~\)

\section*{Change the particle system to use randomly chosen trees:}

1 Press 6 to display the Particle View window. Arrange the windows so you can see both the Material Static 001 rollout on Particle View, and the output socket of the Elm Trees material in the Slate Material Editor.

2 In Particle View > PF Source 001, click Material Static 001 to highlight it. Drag a wire from the output socket of the new Elm Trees Multi/Sub-Object
material node, and drop it on the Material Static 001 rollout Material button.

3 On the Material Static 001 rollout, turn on Assign Material ID and Show In Viewport.
\begin{tabular}{|c|c|}
\hline Material Static 01 & tic 01 \\
\hline \multicolumn{2}{|l|}{( Assign Material} \\
\hline \multicolumn{2}{|l|}{Elm Trees} \\
\hline \multicolumn{2}{|l|}{\(\checkmark\) Assign Material ID} \\
\hline \multicolumn{2}{|l|}{\(\checkmark\) Show In Viewport} \\
\hline \multicolumn{2}{|l|}{\(\bigcirc\) Cycle Random} \\
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\hline \multicolumn{2}{|l|}{Rate:} \\
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\hline \multicolumn{2}{|l|}{Uniqueness:} \\
\hline \multicolumn{2}{|l|}{Seed: \begin{tabular}{|c|c|c|}
12345 \\
\hline
\end{tabular}} \\
\hline
\end{tabular}

4 Change the Material ID value from 1 to 2 and 3 to display one of the three different tree sub-materials you set up earlier.


Elm trees with fall colors: Material ID=2


Elm trees in winter: Material ID=3

5 To get a mix of all three tree types, choose Random.


The Camera01 viewport updates to show a random selection of all three tree types.


\section*{Random assortment of particle trees}

6 In the Material Static 001 rollout > Uniqueness group, click New repeatedly until you obtain a mix of tree types that you like.

\section*{Uniqueness:}

- Render the Camera01 viewport to see the result.


Save your work:
■ Save the scene as my_ptrees_various.max.

\section*{Placing the Particle Trees}

In this lesson you use polygon selection to define the area in which tree particles appear.

\section*{Set up the lesson:}
Open ptrees_placement.max.
The scene consists of an undulating terrain bisected by a riverbed and populated by a number of particle-based trees.

Use polygon selection to define where trees will appear:


Maximize the Top viewport and set viewport shading mode to Smooth + Highlights (you can press F3).

2


Zoom in to the river.


Notice how a few particle trees stand in or on the very edge of the river bed.

3
\(Q^{ \pm}\)
The light blue guidelines show the camera's field of view. Assume for the moment that you want only a static shot, or plan to have the camera move toward the upper-left corner of the terrain. This means there are many particle trees elsewhere on the plane that will never be seen and consequently do not need to be generated.


Camera field of view

Now you will use polygon selection to indicate where to place the particle trees (within the field of view and not in or near the river).

5 On the Selection rollout, click
\(\square\) (Polygon).



Click just outside the top left corner of the Plane01 object and drag toward its center.


7 On the main toolbar, choose

(Paint Selection Region) from the Selection Region flyout (initially it shows \({ }^{(\cdots \cdots \cdots)}\) (Rectangular Selection Region)).

8 In the Camera01 viewport, hold down Ctrl and start painting over the polygons adjacent to the riverbank.


Selected polygons near riverbank


Top view, showing selection of polygons near the riverbank.

9 In the Top view, hold down the Alt key and deselect polygons at the periphery of the camera's field of view, as shown in the next illustration.


Top view, with polygons beyond periphery of camera view deselected

10 On the Selection rollout, click \(\square\) (Polygon) again to exit the polygon sub-object level.

Set the particle system to use the sub-object selection:

1


Click an empty area of the Top viewport to deselect the Plane01 terrain object, then press 6 to open the Particle View window.

2 In Event 01, click the Position Object 01 operator to highlight it (if it is not highlighted already).

3 In the Position Object rollout > Location group, open the Location drop-down list and choose Selected Faces.


Previously, particles were generated across the entire plane. Now, the same number of particles are generated only on the polygon faces you just selected.


Particle generation restricted to top left region of plane object

Because the generation area is reduced, you can reduce the total number of particles generated.

4 Click the Birth 01 operator to highlight it. On the Birth 01 rollout, set the Amount spinner to \(\mathbf{5 0}\) and press Enter.

5 If you like, adjust tree placement in the Position Object 01 rollout \(>\) Uniqueness group by clicking New until you see a grouping you prefer.

6 In PF Source 01, click the Material Static 01 operator to highlight it. In the Material Static rollout > Uniqueness group click New until the Camera01 viewport displays a mix of trees that looks good to you.
- Render your scene.


Rendered 50-tree view of the particle forest

The 50 particle trees should take just a minute or two to render. If, on the other hand, the scene were made up of 3D trees at 30,000 polygons each, 3ds Max would need to process over a million polygons: This would require a great deal more time to render.

There is one aspect to watch out for when using particle systems to create trees with shadows. As the next illustration demonstrates, the base of the tree on the left does not quite match the base of its shadow.


Tree trunk not aligned with particle tree shadow

Recall that you created two sets of particle trees: One set oriented to face the camera and another, hidden set that faces the sun. Depending on the respective positions of the light source and the camera, a hidden tree might cast a shadow that is out of alignment with the visible tree.

To solve this problem, you can rearrange tree placement by changing the particle trees' Seed value, or you can add objects such as rocks to obscure unwanted detail.

\section*{Save your work:}
- Save the scene as my_ptrees_forest.max.

You can find a completed version of this scene in the \scenes\dynamics_and_effects\particle_trees folder, called ptrees_completed.max.

\section*{Summary}

Particle systems offer a fast, effective way to populate scenes with multiple objects.

In this tutorial you used images of trees and mapped them onto billboard-sized particles. But you could just as easily have mapped other types of images; for example, you could use photographs of people to create a crowd scene.

When using this particle-creation technique, make sure your particles are set to face the camera. If you need to cast shadows, generate a second set of particles and make sure their shadows continually face the light source.

\section*{mr Proxies}

In this tutorial, you will learn how to use mr Proxy objects to create a scene of a forest that, despite its large size, can render quickly.

You will convert trees to mr Proxy format, then give each proxy a material you saved in a material library. Finally, you will use the Object Paint feature to instance the proxies multiple times and distribute them across the scene.


In this tutorial, you will learn how to:
- Save materials to a material library
- Save objects in mr Proxy file format
- Create mr Proxies and associate them with imported proxy files
- Add materials to mr Proxies

■ Use Object Paint to instance and distribute mr Proxies in a scene

Skill level: Intermediate
Time to complete: 1 hour

\section*{Creating mr Proxy Objects}
mr Proxies are useful when you want to fill a scene with instances of objects that have a high polygon count, such as 3D trees. Proxy objects save you time and free up memory because they do not need to be converted to mental ray format and their source objects do not need to be present during render time.

In this lesson, you convert trees to .mib format so they can be used as mr Proxy objects.

\section*{Set up the lesson:}
- Click
(Open File), navigate to the \scenes \rendering \(\backslash m r\) _proxies folder, and open trees.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

\section*{Render the scene:}

1

pan so the tree objects fill the viewport.

2
- Render the scene.


The eight trees in the scene show foliage from four different seasons: winter, spring, summer, and fall. The trees in the front row are oaks, and the trees in the back row are elms.

These trees were created and textured using the methods described in the lesson Creating Billboard Tree Maps on page 1376. The only difference is that there was no need to center each trees in a viewport and render it: The mr Proxy method works with referenced geometry instead of with rendered bitmaps.

\section*{3 \\ \(\square\) \\ Close the Rendered Frame Window.}

\section*{Save the materials to a library:}

The tree materials that you saw in the rendering will need to be reused for the mr Proxy objects. The best way to do this is to save the materials in a library, so you can access them for use in various scenes and situations.

1


Open the Slate Material Editor.

2 On the Material/Map Browser panel at the left, scroll down so you can see the Scene Materials group. (It helps to drag the edge of the Browser panel to make the Browser wider, too.)
- Scene Materials

DefaultContourContrastShader (Contour Contrast...
DefaultContourOutputShader (Contour Composite..
DefaultContourStoreShader (Contour Store Functi...
DefaultOutputShader (Glare) [Environment]
Tree-Fall (Multi/Sub-Object) [Elm-Fall, Oak-Fall]
Tree-Spring (Multi/Sub-Object) [Elm-Spring, Oak..
Tree-Summer (Multi/Sub-Object) [Elm-Summer,...
Tree-Winter (Multi/Sub-Object) [Elm-Winter, Oa...

The four Tree materials are the ones you want to save.
3 Right-click the Tree-Fall entry and from the pop-up menu, choose Copy To \(>\) Temporary Library.


3ds Max creates a Temporary Library group that appears at the bottom of the Browser panel. The Temporary Library has a copy of the Tree-Fall material in it.
```

- Temporary Library
LIB
Material \#0 (Multi/Sub-Object)

```

IMPORTANT A Temporary Library such as this one lasts only as long as the current 3ds Max session.

4 Right-click the Temporary Library label, and from the pop-up menu, choose Save As.


3ds Max opens a file dialog. On the file dialog, navigate if you need to to the \materiallibraries subfolder of your Project Folder, then enter mytrees as the library name (the file name extension for a material library is MAT), and then click Save.

5 At the top of the Browser panel, click (Material/Map Browser Options). This opens a pop-up menu. On the pop-up menu, choose Open Material Library.


3ds Max opens another file dialog. In the \materiallibraries subfolder, choose the library you just created, mytrees.mat, and then click Open. 3ds Max opens a group for mytrees.mat at the very top of the Browser panel. (The Temporary Library remains visible at the bottom of the panel.)
\begin{tabular}{|l|}
\hline Matarial/ilap Erov/jer \\
\hline \(\boldsymbol{\nabla}\) Search by Name ... \\
\hline - mytrees.mat \\
\hline Material \#0 (Multi/Sub-Object) \\
\hline
\end{tabular}

6 In the mytrees.mat group, right-click the Material \#0 entry and from the pop-up menu, choose Rename.


3ds Max opens a Rename dialog. Change the material name back to Tree-Fall, then click OK.


7 In the Scene Materials group, right-click the Tree-Spring material entry. On the pop-up menu, choose Copy To \(>\) mytrees.mat.


8 In the mytrees.mat group, use Rename to name this material Tree-Spring once again.

9 Copy Tree-Summer and Tree-Winter to mytrees.mat as well. Each time, change the name of the material back to its original name.

10 Right-click the mytrees.mat label, and on the pop-up menu, choose the first entry, C:\Users \(\backslash . . . \backslash\) mytrees.mat \(>\) Save.


11


Close the Slate Material Editor.
Now you have a library of materials to use for the proxy objects. The next task is to create those proxies.

\section*{Save source objects in mr Proxy file format:}

1 On the
Create panel, click

(Geometry), then open the Objects drop-down list and choose "mental ray."


2 On the Object Type rollout, click "mr Proxy" to turn it on.


3 Drag in the viewport to create an mr Proxy object.


4 Go to the

\(\%\)Modify panel. On the Parameters rollout, in the Source Object group, click the Source Object button (initially labeled "None").


In the viewport, click the Elm-Winter tree object.
Parameters 친
Source Object:
Elm-Winter
Write Object to File...

5 In the Parameters rollout > Source Object group, click Write Object To File.


3ds Max opens a file dialog. If you need to, navigate to the \sceneassets \(\backslash\) renderassets folder. Name the file My_Elm_Winter (it has a file name extension of MIB), and then click Save.
3ds Max opens an "mr Proxy Creation" dialog. On this dialog, click OK to accept the default values.
```

(9) mr Proxy Creation

```

Geometry to Write
(O) Current Frame

Active Time Segment (one file per frame)
Custom Range (one file per frame):
Start: \(\sqrt{0}\left|\frac{\Delta}{\nabla}\right|\) End: \(\sqrt{49} \mid\) |분
Writing a sequence of frames allows capturing animated geometric deformations (including topology changes) of objects in the proxy files.

Preview Generation
Include only Source Object in Preview
V Automatic Zoom Extents

OK
Cancel

NOTE If your tree object were animated, you would use the "mr Proxy Creation" dialog to save the object as a sequence of frames, with one .mib file created per frame. You specify the time segment to save in the Geometry To Write group.

3ds Max briefly displays a small Rendered Frame Window while it renders the proxy geometry.


In the viewport, 3ds Max displays the mr Proxy object as a point cloud.


6 In the Parameters rollout > Display group, change the Viewport Verts value from 128 to 512, and press Enter.


The object outline becomes more apparent as more points are displayed, but a denser point cloud can affect viewport performance.


7 Change the Viewport Verts value back to 128, then turn on Show Bounding Box to display the extents of the tree proxy.


3ds Max displays the proxy surrounded by a complete bounding box.


8 With the proxy object selected, repeat steps 4 through 7 for the Elm-Spring tree object.
When you're done, you should have an .mib file for Elm-Spring.
If you were working from scratch, you would repeat the steps for every tree in the scene, but to speed things up a little, we have created .mib files for all the tree types. These are saved in the \sceneassets \renderassets folder. You will use these proxies in the next lesson.

9 Do not save the current scene file.
The work you needed to save is contained in the MIB files and their associated bitmaps.

\section*{Loading Proxy Files Into a Scene}

In this lesson, you create a group of mr Proxy objects, and associate each proxy with an .mib file such as the ones you saved in the previous lesson. Then you assign each proxy a material from your mytrees material library.

\section*{Set up the lesson:}

1 If you have a scene open from the previous lesson, do not save it.

2
Open proxy_trees_start.max.
The new scene features a rolling terrain intersected by a riverbed.

Create an mr Proxy object and associate it with an .mib file:

1 Go to the
Create panel and click
(Geometry). Open the Objects drop-down list, and choose "mental ray." On the Object Type rollout, click "mr Proxy."

2 In the Top viewport, click and drag anywhere to the right of the plane object.
The proxy object you create can be of any size.


3 Go to the


Modify panel and rename the object Elm-Winter.
4 Inthe Display group, turn on Show Bounding Box.


5 In the Parameters rollout \(>\) Proxy File group, click the
button.


3ds Max opens a file dialog. Go to the \sceneassets \(\backslash\) renderassets folder, choose elm1_winter.mib, then click Open.


The scale of the imported proxy file is too large.
6 In the Parameters rollout > Proxy File group, set the Scale spinner to 0.1 to reduce the proxy to one-tenth its default size.


Copy the original proxy and change the tree types:



2 In the Clone Options dialog \(>\) Object group, make sure Copy is chosen, then set Number of Copies to 3 . Click OK.


Select a copied proxy and on the

4 In the Parameters rollout > Proxy File group, click the \(1 \begin{aligned} & \square \\ & \text { browse }\end{aligned}\) button and use the file dialog to choose elm2_spring.mib.

5 Repeat steps 3 and 4 for each of the two remaining proxies, rename them Elm-Summer and Elm-Fall, and associate them with their corresponding .mib files.

6


Select all four proxy objects and Shift+move them once, downward. In the Clone Options dialog, make sure Copy is chosen, then click OK.


7 Repeat steps 3 and 4 for each of the new proxies. Rename them Oak-Winter, Oak-Spring, Oak-Summer, and Oak-Fall, and associate them with their corresponding .mib files.

\section*{Render the result:}

1 Activate the Camera01 viewport. Press P to make it a Perspective view.
 Zoom, pan, and - orbit so you have a good view of all eight tree proxies, then
 . render the Perspective viewport.


Tree proxies with the same material

The tree proxies have different shapes and leaf densities, but their leaves and trunks are all the same color. In the next procedure, you will associate each proxy with a material you saved earlier in the material library.

2 Minimize the Rendered Frame Window.

\section*{Assign materials to the tree proxies:}

1 From the main menu, choose Rendering > Material/Map Browser.
2 In the Top viewport, Click and Ctrl+click to select Elm-Winter and Oak-Winter, then drag the Tree-Winter material from the Material/Map Browser \(>\) mytrees.mat group, and drop this material on your selection.


3ds Max opens an Assign material dialog. On the dialog, make sure Assign To Selection is chosen, then click OK.


3 Repeat the previous step for each of the spring, summer, and fall pairs of tree proxies, using the appropriate library material.

4


Close the Material/Map Browser.

- Render the Perspective viewport once again.


Tree proxies after receiving materials from the material library

Now you have eight different types of trees that are ready to be multiplied and distributed across your scene.

6
 Close the Rendered Frame Window.

7 Change the Perspective viewport back to the Camera01 view.

\section*{Save your work:}

■ Save your file as my8_trees.max.

\section*{Next}

Using Object Paint to Distribute the Trees on page 1491

\section*{Using Object Paint to Distribute the Trees}

Now that you have your tree proxies properly defined, you need a way to instance them multiple times and distribute them across your terrain. You can do this by using the Object Paint feature, which is new to Autodesk 3ds Max 2011. Object Paint lets you paint objects onto other objects: In this lesson, you will paint proxy trees onto the terrain object, Plane01.

\section*{Set up the lesson:}
- Continue from the previous lesson or
 open 8_trees.max.

Choose the trees with which you will paint:

1 If the ribbon isn't already open, then on the main toolbar click

(Graphite Modeling Tools). Click the
 expand/collapse icon until you can see the full height of the ribbon.

2 On the ribbon, click the Object Paint tab.


3 On the Paint Objects panel, click

(Edit Object List).


3ds Max opens a Paint Objects dialog.


4 On the dialog, click Add.
3ds Max opens a Select Objects dialog.
5 Click and Shift+click to select all eight tree objects, and then click Add.

Select Objects
Select Display Customize
 Find： \(\mid\) Selection Set：\(\quad\) 屋 屋 珢

\section*{Name}

Plane01
Camera01
Camera01．Target
Plane02
Compass01
Daylight01
Elm－Winter
Elm－Spring
Elm－Summer
Elm－Fall
Oak－Spring
Oak－Summer
Oak－Fall
Oak－Winter

The grove you paint in this lesson will be an eclectic one．Another time， you might want to choose only spring trees，for example，or fall ones．

6


Close the Paint Objects dialog．
Now you are able to paint the trees onto the terrain．By default，the Paint Objects tool uses the first object in the set you selected．

\section*{Set up the Object Paint tool:}

1 On the Paint Objects panel, choose All, Randomly from the drop-down list.


When you paint, the trees will appear in random order.
2 Also on the Paint Objects panel, open the Paint On drop-down list and choose Selected Objects.


3 On the Brush Settings panel, set Spacing to 40.00 units.


4 Also on the Brush Settings panel, open the Align drop-down list, and turn off Align To Normal.
\begin{tabular}{|l|}
\hline Align: \({ }^{-}\) \\
\hline\(\square\) Align to Normal \\
\hline\(\square\) Follow Stroke \\
\hline
\end{tabular}

We want the trees to grow vertically, not to lean wherever the terrain is not flat.

5 The right-hand side of the Brush Settings panel has three groups of controls: Scatter, Rotate, and Scale. In this tutorial, we don't use the Scatter tools, but do make adjustments to the other two groups.
In the Brush Settings panel > Rotate group, click the drop-down arrow next to the Z coordinate field, and in the drop-down list, turn on Random Z.


When you paint, the trees will have a random amount of rotation about their vertical ( \(Z\) ) axis.

6 In the Brush Settings panel > Scale group, make sure
 axis Lock (Uniform Scale)) is turned on, then open the 際 * Scale Type drop-down list, and choose Random.



After you choose Random, the Scale group shows a range of values for the axes; because Axis Lock is on, you can change only the X axis values.

7 Also in the Scale group, set the minimum \(X\) value (on the left) to 60 and the maximum \(X\) value (on the right) to 160.


The trees will vary in height and girth from 60 units to 160 .
Now you are ready to begin painting trees.

\section*{Paint the proxy trees:}

1


Select the terrain object, Plane01.
Remember that Object Paint is set to paint onto the currently selected object.

2


Maximize the Top viewport, and click -4 (Zoom Extents Selected).

3 On the Paint Objects panel, click to turn on

(Paint).


4 Hold down the mouse button as you drag over the terrain object. 3ds Max adds copies of trees to the scene. The trees are at least 40 units apart.


You can paint the trees densely together, but on the near bank of the stream, avoid painting directly in front of the camera's line of sight.


Minimize the Top viewport, then activate the Camera01 viewport,


TIP If any of the trees appear to be floating above ground level, then on the Paint Objects panel, set the Offset value to a negative value; for example, -3.0.

6 One good feature of Object Paint, is that you can preview the scene with renderings before you commit.

■ If you are not happy with the results, click

(Cancel). 3ds Max removes the trees you painted, allowing you to start over.

■ When you are happy with the results, click

(Commit). 3ds Max adds the trees to the scene, as copies of the original tree proxy objects.
If you like, experiment with other options, such as painting with only trees from a certain season, as we suggested earlier, or changing the range of Scale X to paint a greater (or lesser) range of variation in size.

\section*{Save your work:}

Save the scene as my_forest_painted.max.

You can compare your work with a finished version of this scene, proxy_trees_final.max.

\section*{Summary}

When you render with the mental ray renderer, mr Proxies are a useful way to create a large scene with many instances of a similar object. While mr Proxy objects cannot be edited directly, they offer the advantage of freeing up memory and speeding up render time.

\section*{Effects Tutorials}

3ds Max provides a variety of tools for improving the visual richness and realism of a scene. This section introduces a few special-purpose techniques:
- Using the Garment Maker and Cloth modifiers to create a costume

■ Using the Hair And Fur modifier to give a character hair
■ Using a Particle Flow system to model smoke


\section*{(\$5) Creating a Costume out of Cloth}

The Garment Maker and Cloth modifiers work together to create clothing for your characters, human or not human.


In this tutorial, you will remain in the human realm, and create the clothing for a fashion model. Aside from her shoes, which are already supplied, the model wears two outer garments:
- A pullover made of a clinging stretch fabric

■ A skirt made of a loose and flowing fabric, with pleats

With Garment Maker, you specify the construction of clothing, based on pattern shapes. The Cloth modifier then fits those clothes to the character who wears them; later, Cloth also generates realistic animation for the clothing.

Skill level: Intermediate
Time to complete: \(21 / 2\) hours

\section*{Preparation for This Tutorial}
- On the Quick Access toolbar, click

(Project Folder) and set your current project to Autodesk 3ds Max 2011 Tutorials.


\section*{Draw the Patterns for the Clothes}

For the most part, clothes are made of flat pieces of fabric that are then sewn together. A pattern is often printed on paper, so cloth can be cut to match
the pattern. The Garment Maker modifier is based on this work model: It constructs a garment out of outlines drawn with 3ds Max splines.

Set up the scene:
> Click
(Open File), navigate to the \scenes \(\backslash e f f e c t s ~ \ c l o t h ~ f o l d e r, ~ a n d ~\) open fashion_model_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene contains a model who is wearing shoes but no clothes.
The scene is also animated: In frames 0 through 12, the model stands in a reference pose, but starting from frame 13 , she walks forward as if on a runway in a fashion show.

\section*{Draw the Outline of the Pullover}

The model's upper garment is a pullover with a collar. Its pattern has simple straight line segments.


Pattern for the front of the pullover

NOTE If you plan to use the Garment Maker modifier's Panel Position controls, then you must create the pattern in the Top viewport. This tutorial does not use those controls, so you will create the pattern in the Front viewport, which is a more intuitive way to work.

\section*{Draw the outline of the pullover:}

1 On the


Create panel, click
 (Shapes) to turn it on, then in the Object Type rollout, turn on Line.


2 In the Creation Method rollout, make sure that Initial Type is set to Corner, and set Drag Type to Corner as well.
\(\left[\begin{array}{c}\text { Creation Method } \\ \hline \text { Initial Type } \\ \bigcirc \text { Corner } \\ \text { Smooth } \\ \text { Drag Type } \\ \text { O. Gprner } \\ \text { Sntboth } \\ \text { Bezier } \\ \end{array}\right]\)

When you create a pattern for Garment Maker, it is best to use Corner vertices. Later, the modifier provides any smoothing that the garment requires.

3 Begin by drawing the top of the shoulder seam, and the neckline.


4 Continue down along the side of the model, roughly following the contour of the figure, and adding a bit of flare for the bust. Extend the outline to the level of the model's hips.


5 Hold down the Shift key while you drag across the model's hips. This ensures that the spline segment will be level.


6 Continue up the model's right side, keeping the vertices as symmetrical as you can.


7 End the last segment of the outline by clicking over the first vertex, and when 3ds Max prompts you to close the spline, click Yes.


8 At this point, if you want to adjust the vertices, go to the


Modify panel, turn on (Vertex) to go to the Vertex sub-object level, and

move vertices until you have a symmetrical pattern with which you are comfortable.

TIP If the spline you drew is hard to see in the viewport, click the color swatch for the spline, and choose a color that is easier to read. When you do this, you might want to turn off Assign Random Colors: This gives you greater control over object color.


Draw the outline of the collar:

1 On the
 on, and then turn on Rectangle.


2 In the viewport, draw a rectangle that will be the pattern for the collar. The rectangle should be above the neckline, in front of the model's mouth.


3 Right-click the collar, and from the Transform (lower-right) quadrant of the quad menu, choose Convert To \(>\) Convert to Editable Spline.

4 Go to the Modify panel, and turn on
 the Vertex sub-object level.

5 Drag a box to select all the vertices in the collar outline. By default, 3ds Max creates a Rectangle shape with Bezier Corner vertices.


6 Right-click to display the quad menu, then in the Tools 1 (upper-left) quadrant of the quad menu, choose Corner.
This converts the vertices to Corner vertices like those in the main part of the pullover pattern.


7 In the modifier stack, click Editable Spline to exit the Vertex sub-object level.


\section*{Attach the collar to the main pattern:}

1 Click to
1 Click to select the main spline of the pullover pattern, Line01.

2 On the


Modify panel
Geometry rollout, click to turn on Attach, and then click the collar outline, Rectangle01.


3 Click Attach again to turn it off.
4 Change the name of the pattern shape to Pullover Pattern
```

Pullover Pattern

```

\section*{Break the vertices for seams:}

The Garment Make modifier recognizes seams by breaks in the outline of the pattern: A broken pair of coincident vertices indicates the end of a seam, while an unbroken vertex is part of a continuous seam. Because of this, you have to break vertices selectively before you apply Garment Maker.

1 On the


Modify panel, turn on
 (Vertex).

2


Drag a box to select all the vertices in the collar outline.


3 On the Geometry rollout, click Break.


4


Drag a box again to select the vertices at the top of the shoulder straps, but not the midpoint of the neckline, or the midpoint of the armholes.


5 Click Break once more.
6 Drag a box to select the vertices at the bottom of the armholes, but not the vertices at the waistline.


\section*{7 Click Break.}

8 Finally, drag a box to select the hip vertices at the bottom of the pattern.


9 Click Break a final time for the pullover pattern.

\section*{Copy the pullover outline to create the back panel:}

1 Turn on (Spline) to go to the Spline sub-object level, and drag to select the entire pattern.

2 Turn on (Select And Move), then Shift+move the pullover pattern to the right to make a clone of the original splines.


Adjust the neckline of the back panel:

1 On the


Modify panel, turn on
(Vertex) to go to the Vertex
sub-object level, then

move the center vertex of the back panel's neckline vertically, so the neckline at the back of the pullover doesn't plunge as the front neckline does.


2 In the modifier stack, click the Line entry to exit the Vertex sub-object level.

The pattern is now ready for you to apply Garment Maker to it. Before doing that, you will create a comparable pattern for the skirt.

\section*{Save your work:}

Save the scene as fashion_pullover_pattern.max.

\section*{Draw the Outline of the Skirt}

The skirt is also a simple pattern, but it includes lines to control where the pleats will be.


\section*{Pattern for the skirt}

Draw the outline of the skirt:

1


Zoom out in the viewport a bit, to see more of the model's figure.

2 On the
Create panel, turn on
 on, and click to turn on Rectangle.


3 Begin the skirt outline by drawing a rectangle. The skirt should begin at the model's waist, above the navel, and end at the model's knees.


4 Change the name of the rectangle to Skirt Pattern. Skirt Pattern

5 Right-click, and from the Transform (lower right) quadrant of the quad menu, choose Convert To \(>\) Convert To Editable Spline.

6 Go to the


Modify panel, and turn on
 (Segments).

7


Select the two vertical sides of the rectangle.


8 On the Geometry rollout, scroll down to find the Divide button, then click Divide to add a vertex to the side segments.


9 Turn on (Vertex). Drag a box to

select all the vertices in the skirt, then right-click, and from the Tools 1 (upper left) quadrant of the quad menu, choose Corner.


Drag a box to select the new, middle vertices along the side of the skirt pattern.


11
Move the vertices vertically so they are just below the top vertices of the rectangle. They should form a waistband for the skirt.


Change the hem line to a rounded hem:
1 On the main toolbar, choose


3 Drag the vertices outward along the X axis to create a flare for the skirt.


4 Right-click, and choose from the Tools 1 (upper left) quadrant of the quad menu, choose Bezier Corner.

This is a temporary measure so you can shape the hem.

5


Move the lower tangent handles, along the hemline, downward to create a rounded hem for the skirt.


\footnotetext{
6 Turn on
(Segment), then click to

select the hemline.
}


7 On the Geometry rollout, change the Divide value to 10, and then click Divide.

Hide
Bind
Delete
Divide
Detach

\section*{Unhide All}

\section*{Unbind}


Same Shp Reorient Copy

The new vertices will become the basis of the pleats of the skirt.


8 Turn on
 the hemline, including the outer ones. Then right-click, and from the Tools 1 (upper left) quadrant of the quad menu, choose Corner.
Now you are ready to create the pleats of the skirt.

\section*{Add the segments that will become pleats:}

The Garment Maker and Cloth modifiers provide a number of different ways to create pleats, darts, and so on. The method we use in this tutorial is one of the easier and more efficient ways. For more details about modeling clothes, see the 3ds Max help.

3
®
- (Snaps Toggle) to display the Grid And Snap Settings dialog. In the dialog, click Clear All, and then click to turn on Vertex.


2 On the main toolbar, click to turn on
- (3D Snaps Toggle).


4 Start creating a line by snapping to the vertex that is just before the right edge of the hem. Then press \(S\) to toggle snaps off temporarily, and click to place the end of the line just below the waistline, in front of the model's torso. Right-click to end line creation.


5 Press S to turn on snaps once again, and draw a similar line beginning at the next hem vertex to the left.

6 Continue to add a line to each of the vertices along the hem, snapping to the hem vertex, but leaving the top vertex free (don't worry too much about the placement of the top vertices). When you finish, the skirt should have 10 seam lines in all.


7 Turn on (Select And Uniform Scale), then drag a box to select
all the top vertices of the seam lines. all the top vertices of the seam lines.


8
 Scale downward along the Y axis until the vertices are level with each other.


Move individual vertices horizontally along the X axis so the tops of the pleats are more or less equidistant.
You don't have to be too accurate in this step: As the skirt drapes and moves, the pleats will be more noticeable at the hemline than at the waist.

10 Drag to
select all the vertices in the skirt pattern, then on the Geometry rollout, click Break.
\(\left[\right.\)\begin{tabular}{ll}
\multicolumn{1}{c}{ Geometry } \\
\hline New Vertex Type \\
O Linear \(\bigcirc\) Bezier \\
Smooth \(\bigcirc\) Bezier Corner \\
Create Line & Break \\
Attach & \(\square\) Reorient \\
Attach Mult. & Cross Section
\end{tabular}

Now the pattern for the skirt is nearly complete.
Copy the pattern to create the back of the skirt:

1 Turn on
(Spline), and drag a box to

select all the splines in the pattern.


2


Shift+move the skirt to the right, to create a duplicate panel that will become the back of the skirt.


3 In the modifier stack, click the Editable Spline entry to exit sub-object mode.


Save your work:
■ Save the scene as fashion_both_patterns.max.

Now you are ready to use Garment Maker to build the costume.

\section*{Next}

Use the Garment Maker and Cloth Modifiers to Prepare the Pullover on page 1537

\section*{Use the Garment Maker and Cloth Modifiers to Prepare the Pullover}

The Garment Maker modifier works on spline patterns. It does two main things:
- Subdivides the panels into a mesh that the Cloth modifier can use
- Specifies how the panels are stitched together

\section*{Use the Garment Maker Modifier to Prepare the Pullover}

Set up the scene:
- Continue working from the previous lesson, or

open the file fashion_model01.max.

\section*{Apply Garment Maker to make the pullover pattern into a cloth-style mesh:}

1 Click 5 viewports.

2 Click to select the pullover pattern.

3 On the


Modify panel, open the Modifier List, and choose Garment Maker.
In shaded viewports, you can see that the pullover pattern now has a mesh.


4 Activate the Perspective viewport if it isn't active already, and then press F4 to display edged faces.


Garment Maker creates an irregular mesh. The mesh looks a bit odd, but it is good at deforming the way cloth deforms.

\section*{Move the pullover panels into position:}

1 In the modifier stack, click
(the plus-sign icon) to expand the Garment Maker modifier hierarchy, and then click the Panels level to make it active.


2 Turn on
 (Select And Rotate), and then turn on (Angle Snap Toggle).

3 Change the transform coordinate system to Local.


4 Click and Ctrl+click to

select the right-hand portion of the pullover.


These panels will become the back of the pullover.

\section*{5}

Rotate the panels 180 degrees about their Y axis.


Garment Maker creates single-sided meshes, so you have to make sure that panels are oriented correctly.

6


Move the back panels along the X axis until the front and back are in the same X location, and them move them back along the Y axis so the back panels are behind the model.


For this step, having all four viewports visible is a help.

\section*{Improve the initial position of the collar:}

The main panels of the pullover are parallel to each other, but we want the front of the collar to be lower than the back. Because of this, it helps to adjust the initial shape and position of the collar.

1 Still at the Panels sub-object level,

select just the front panel of the collar.

2 In the Deformation group, click to choose Curved, and then set the Curvature value to \(\mathbf{- 4 . 0}\).

Deformation

\section*{Reset Reset All}

Use Preserved
NoneCurved
Curvature \(\longdiv { - 4 . 0 } \mid \stackrel{\rightharpoonup}{-}\)
(O) X-axis \(\bigcirc\)-axis

To see this effect, it might help to
 - orbit the active viewport.


3


Select the back panel of the collar, and set its deformation to Curved, with a value of \(\mathbf{- 4 . 0}\) as well.

(The same value works for both panels, because of the one-sided orientation that panels have.)

4
Rotate the front panel of the collar up about 30 degrees in its Local X axis, and then rotate the back panel of the collar down about -30 degrees, also in the X axis.
 move the two collar panels so they are
5 In the Left viewport, closer to the model, and so their edges line up.


With this setup, it will be easier for the Cloth modifier to join the two halves of the collar.


\section*{Create the seams:}

1 In the modifier stack, click to highlight the Garment Maker sub-object level Seams.


To the Garment Maker modifier, a seam is a set of edges connected by unbroken vertices.

2 In the Perspective viewport, click to select the main seam at the left side of the back panel.


TIP It is hard to see selected seams unless the viewport is displaying Edged Faces. Press F4 to turn on face edges, if they are not already on.

3 Ctrl+click to select the matching seam at the front of the pullover.


4 On the seams rollout, click Create Seam.


Garment Maker displays the seam as a set of lines connecting the two edges. The Garment Maker modifier does not change the position of the panels: You will use Cloth to accomplish that soon.

5 Using the technique of the previous three steps, create additional seams between the tops of the shoulder straps and the two right ends of the collar.


NOTE While you create seams, you might see this warning:


If this happens, increase the Seam Tolerance value (this field is near the bottom of the Seams rollout); for example, to \(\mathbf{0 . 2}\) or \(\mathbf{0 . 3}\), and then try to create the seam again.


Orbit the Perspective view, and create the corresponding three seams for the left side of the pullover.


TIP You can use Shift+Z to undo viewport changes after you have finished creating the seams.

7 Finally, create seams between the two collar panels and their corresponding neckline.


Now the pullover is ready for the Cloth modifier.

\section*{Use the Cloth Modifier to Fit the Pullover}

\section*{Apply the Cloth modifier to the pullover:}

1 In the modifier stack, click the Garment Maker entry to exit the Seams sub-object level.


2 From the Modifier List, choose Cloth.
3 On the Object rollout, click Object Properties to display the Object Properties dialog.


For the Cloth simulation to run correctly, you have to set some conditions in the Object Properties dialog.

4 In the Object Properties dialog, click Pullover Pattern to highlight it, and then click Cloth.


This tells Cloth to treat the (Garment-modified) Pullover Pattern as cloth.
When you choose Cloth, 3ds Max enables a variety of options. These settings are described in the 3ds Max help. Using them can be a matter of trial and error, but Cloth includes some useful presets: For the pullover, we will use a preset and adjust only one Cloth Properties setting.

5 From the Presets drop-down list, choose Spandex.


6 Change the Damping value to \(\mathbf{0 . 0 2}\).
7 Under Objects In Simulation, click Add Objects.


3ds Max opens a Scene Explorer dialog. In the Scene Explorer, click to highlight the body object, and then click Add.

8 Make sure that body is highlighted in the Objects In Simulation list, and then choose Collision Object.


This tells Cloth to treat the body of the model as a solid object.
9 In the Collision Properties group, change the value of Offset to \(\mathbf{0 . 1 5}\).


The lower the Offset value, the closer the simulated cloth will come to the collision object (in this case, the model herself). The new value ensures that the pullover will be form fitting.

10 Click OK to exit the Object Properties dialog.

Fit the pullover to the model's torso:
1 Go to the Simulation Parameters rollout.
TIP Drag the left edge of the Command Panel area to the left, to expand it to two columns so you can see both the Object and Simulation Parameters rollouts at once.

2 On the Simulation Parameters rollout, turn off Gravity.


3 On the Object rollout, click Simulate Local (Damped).


The Cloth modifier runs a simulation that animates over time. When the cloth is tightly fitted to the body, click Simulate Local (Damped) again to turn it off.

NOTE If you click Simulate Local instead of Simulate Local (Damped), the pullover will have an ill-fitting seam and some protrusions that shouldn't be
there. If this happens,
 (Damped).


4 If you look closely, you will notice that the seams did not close all the way.


To fix this problem, go to the Simulation Parameters rollout. Turn off Use Sewing Springs.

5 On the Object rollout, click Simulate Local (Damped) once again.
The Cloth modifier runs further simulation, and closes the gap between panels.


6 When the panels have come together, click Simulate Local (Damped) to turn it off once again.

NOTE There are a few different Simulate buttons on the Object rollout. Simulate Local and Simulate Local (Damped) are for fitting garments to characters: They don't create animation, and if you were to play the anmimation now, the model would simply walk out of the pullover.

Simulate Local (Damped) runs more slowly than Simulate Local: This can be an advantage when you are fitting garments. Sometimes the speed of Simulate Local can cause crumpled areas that don't look good.

The Simulate button does generate animation: You will use this in a later section.

\section*{Change the color of the pullover:}

1 In the Name And Color area, click the color swatch for the pullover.


2 In the Object Color dialog, click the black color swatch, and then click OK.


Save your work:
■ Save the scene as fashion_pullover_completed.max.

\section*{Next}

Use the Garment Maker and Cloth Modifiers to Prepare the Skirt on page 1561

\section*{Use the Garment Maker and Cloth Modifiers to Prepare the Skirt}

Turning the skirt pattern into a skirt is even simpler than doing so for the pullover, except for the additional steps to prepare the pleats.

\section*{Set up the scene:}
- Continue working from the previous lesson, or = open the file fashion_model02.max.

\section*{Isolate the pleat lines from the main outline of the pattern:}

At this point, if you were to apply the Garment Maker modifier to the skirt pattern, 3ds Max would display the following warning:


The reason is the segments for the pleats, which Garment Maker does not know how to handle. The workaround is to assign a different Material ID to the pleat lines,

1


Select the skirt and on the


Modify panel, turn on (Segments).

2 Drag and Ctrl+drag selection boxes to
 select all the pleat segments, but none of the segments in the skirt outline.


3 Scroll down to the Surface Properties rollout, and change the Set ID field to 2 .


Now you are ready to apply Garment Maker.

\section*{Apply Garment Maker to the skirt pattern:}

1 In the modifier stack, click the Editable Spline entry to exit the Segments sub-object level.


2 From the Modifier List, choose the Garment Maker modifier.
Garment Maker turns the skirt panels into subdivided surfaces. (If the viewport is not displaying Edged Faces, press F4.)


\section*{Set up the pleats or creases:}

The pleats of the skirt should have an alternating pattern, like that in the following illustration.


To accomplish this, you'll set the values for alternating pairs of pleats.
+
1 In the modifier stack, click
(the plus-sign (+) icon) to open the Garment Maker hierarchy, if it isn't visible already. Then click the Seams sub-object level to make it active.


2 Click and Ctrl+click to
select the first pair of seam segments, at the left side of the viewport.


TIP The pleat segments are hard to see, because of all the face edges (but you can't select the edges). Look for the straight lines that end at the hem
of the skirt. It helps to
 in the Front viewport.

3 On the Seams rollout, change the Crease Angle value to 150.0. Change the Crease Strength value to \(\mathbf{5 . 0}\).


4


Select the next pair of seams, moving to the right.


5 On the Seams rollout, change the Crease Angle value to - \(\mathbf{1 5 0 . 0}\) this time. Change the Crease Strength value to 5.0 again.


6 Repeat the previous four steps for the remainder of the pleat segments, always assigning a Crease Strength of 5.0, but alternating the Crease Angle between \(\mathbf{1 5 0 . 0}\) and its opposite, \(\mathbf{- 1 5 0 . 0}\). Continue the alternation as you continue onto the back panel of the skirt.


These pleats have a positive crease angle.


These pleats have a negative crease angle.

\section*{Increase the density of the skirt mesh:}

1 In the modifier stack, click the Garment Maker entry to exit the Seams sub-object level.


2 On the Main Parameters rollout for Garment Maker, change the value of Density to \(\mathbf{1 . 5}\).
\(\left[\begin{array}{l}\text { Main Parameters } \\ \text { Density } \sqrt{1.5} \\ \square \text { Auto mesh } \square \text { Rebserve } \\ \square \text { Relax }\end{array}\right]\)

The result is a much denser mesh. This will help give the skirt its flowing quality.

(You can see why we chose to set up the pleats before increasing the Density.)

Move the skirt panels into position, and create the seams:
1 In the modifier stack, click the Panels sub-object level to make it active.


2 Turn on
(Select And Rotate). Make sure
(Angle Snap Toggle) is turned on, then as you did for the back of the pullover, rotate the back panel of the skirt 180 degrees about its Y axis (using Local coordinates).

3


Move the back panel along the X axis so it has the same X position as the front panel, and then move it back along the Y axis so it is behind the body of the model.

4 On the modifier stack, click the Seams sub-object level to make it active.


5 For each side of the skirt, there are just two seams to create: the one defined by the short segments at the sides of the waistband, and the one that defines the length of the skirt.
Click and Ctrl+click to select each pair, and then on the Seams panel, click Create Seam.


Waistband seam created


Side seam created

6


Orbit the view, and repeat the previous step to create the two seams on the opposite side of the skirt.
(You can use Shift+Z to undo the orbit, later.)

\section*{Use Cloth to Shape the Skirt}

You use cloth for the skirt essentially in the same way you did for the pullover. The difference is that you also need to attach the waistband to the torso of the model. Because of this, local simulation proceeds in two steps.

\section*{Apply the Cloth modifier to the skirt:}

1 In the

modifier stack, click the Garment Maker entry to exit the Seams sub-object level.


2 From the Modifier List, choose Cloth.
3 On the Object rollout, click Object Properties to open the Object Properties dialog.


4 In the Object Properties dialog > Objects In Simulation list, click Skirt Pattern to highlight it, and then choose Cloth.

\section*{Object Properties}

Objects in Simulation
Add Objects... Remove
Skirt Pattern
- Inactive
© Cloth \(\square\) Use Panel Properties
Cloth Properties Presets

5 With Skirt Pattern still highlighted, choose Cotton from the Presets drop-down list.

6 In the Cloth Properties group, change the value of U Stretch to 50.0 (this changes the V Stretch value as well). Change the value of Shear to \(\mathbf{1 8 0 . 0}\). Leave the other cloth settings unchanged.


7 Click the Add Objects button. 3ds Max displays a Scene Explorer. In the Scene Explorer, click to highlight the body object, and then click Add.

8 In the Object Properties dialog, make sure body is still highlighted, and then choose Collision Object.

9 In the Collision Properties group, change the Offset value to 0.5.


The Offset value is a bit larger than the Offset used for the pullover (0.15), because the skirt does not need to be form fitting, and because the waist of the skirt should be outside the pullover.

10 Click OK to close the Object Properties dialog.

\section*{Fit the skirt to the model's waist:}

1 On the Simulation Parameters rollout, click to turn off Gravity, and turn off Use Sewing Springs as well.


Eventually, we do want gravity to affect the skirt, but at this point, the skirt would simply slide right off the model!

2 On the Object rollout, click Simulate Local (Damped).


3 Watch in the viewport, and when the seams of the skirt have closed, click Simulate Local (Damped) againt to turn it off.


\section*{Attach the waistband to the body:}

1 Activate the Front viewport.

2 In the modifier stack, click
(the plus-sign (+) icon) to expand the Cloth hierarchy, then click the Group sub-object level to make it active.


3 In the Front viewport, drag a selection box to select the vertices in the waistband. You don't have to be accurate about this, but make sure the top row of vertices is selected.


4 On the Group rollout, click Make Group.


3ds Max opens a Make Group dialog. Name the vertex selection Waistband, and then click OK.


5 On the Group rollout, click Surface.
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|r|}{Group \(\hat{\text { 人 }}\)} \\
\hline Make Group De & Delete Group \\
\hline Detach & Initialize \\
\hline Shange Group & Rename \\
\hline Node & Surface \\
\hline Cloth & Preserve \\
\hline Drag & Sim Node \\
\hline Group & NoCollide \\
\hline Forcefield S & Sticky Surf \\
\hline Sticky Cloth & Weld \\
\hline Make Tear C & Clear Tears \\
\hline \multicolumn{2}{|l|}{Waistband (unassigned)} \\
\hline 1 III & + \\
\hline \multicolumn{2}{|l|}{151 Vertices Selected} \\
\hline
\end{tabular}

6 In the viewport, click the body object.
The waistband is now attached to the body.


NOTE You can pick the body because it is part of the Cloth simulation. You could not pick the Pullover Pattern, for example, because it has not been added to the skirt simulation.

7 In the modifier stack, click the Cloth entry to exit the Group sub-object level.


Now you are ready to use gravity.

\section*{Use gravity to finish shaping the skirt:}

1 On the Simulation Parameters rollout, click Gravity to turn it back on.


2 On the Object rollout, click Simulate Local to begin simulating the effect of gravity.


Because you have already joined the seams of the skirt, you can afford to run the simulation a bit faster, this time.

3 Watch the viewport while the simulation runs. When the skirt looks good, and does not appear to be changing any longer, click Simulate Local again to turn it off.


\section*{Save your work:}
- Save the scene as fashion_costume_completed.max.

\section*{Next}

Finish the Clothing and Animate It on page 1586

\section*{Finish the Clothing and Animate It}

Before you animate the clothing, there are a couple of steps to improve the general appearance of the clothes.

\section*{Set up the scene:}
- Continue from the previous lesson.

\section*{Use the Relax modifier to improve the appearance of the skirt:}

If you render the skirt at this point, you will see that the skirt drapes well and the pleats look fairly good, but there is bunching along the pleats that it would be nice to remove.


Rather than twiddling Cloth parameters, you simply can apply a Relax modifier.

1


Select the skirt.

2 From the


Modifier List, choose Relax.
3 On the Parameters rollout, change the Relax Value to \(\mathbf{0 . 7 5}\).
\(\left[\begin{array}{c}\text { Parameters } \\ \text { Relax Value: } \sqrt{0.75} \\ \text { Iterations: } \sqrt{1} \text { Keep Boundary Pts Fixed } \\ \square \text { Save Outer Corners }\end{array}\right]\)

Now the pleats look smoother when you render the model.


\section*{Change the color of the skirt:}

1 In the Name And Color area, click the color swatch for the skirt.


2 In the Object Color dialog, click the dark red color swatch, and then click OK.


\section*{Use the Shell modifier to give the clothes some thickness:}

At present, the pullover and the skirt are extremely thin: In fact, technically they have no thickness. This can become a problem when you animate the cloth, especially the pullover: Patches of skin might appear through the fabric. To avoid this "wardrobe malfunction," use the Shell modifier to give the garments some thickness.

1


Select the pullover.
2 From the Modifier List, choose Shell.
3 On the Parameters rollout, change the value of Outer Amount to 0.002m.


Two millimeters is a realistic thickness for a piece of cloth.
4 Right-click the modifier stack, and choose Copy from the pop-up menu.


5


Select the skirt.
6 Right-click the modifier stack, and choose Paste Instanced from the pop-up menu.


Now the pullover and skirt both have an equal thickness.

Animate the clothing:

1
Select the pullover.
2 On the modifier stack, click the Cloth modifier to make it active.
3 On the Object rollout, click Simulate. Let the simulation run for all 200 frames. This will take a few minutes.
\(\left[\begin{array}{c}\begin{array}{c}\text { Object } \\ \hline \text { Object Properties } \\ \text { Cloth Forces } \\ \text { Simulation } \\ \hline \text { Simulate Local } \\ \text { Simulate Local (damped) } \\ \text { Simulate } \nabla \text { Progress } \\ \text { Simulated }\end{array} \\ \hline 1\end{array}\right.\) select the skirt.

5 On the Object rollout, click Simulate. Let the simulation run for all 200 frames. This will take several minutes, because the skirt is a dense mesh.


6

\section*{\(10 \times 1\)}

The pullover clings to the model's body, while the skirt sways according to gravity and the movement of the model; it also moves from colliding with the model's knees.


\section*{Save your work:}

Save the scene as fashion_costume_animated.max.

To see a completed version of the model with cloth, you can
 open fashion_model_completed.max. You can also see a completed movie of the model's walk by choosing Rendering \(>\) View Image File, and then opening fashion_model.avi.

\section*{Summary}

The Garment Maker and Cloth modifiers work together to create clothing that animates in a realistic manner. Garment Maker operates on patterns constructed from splines, similar in form to the paper patterns used by clothing makers. It adds a mesh to the pattern, and lets you specify other details such as seams and pleats. Cloth takes panels set up using Garment Maker, joins seams, and deforms the modeled fabric. Cloth can fit fabric to a character mesh, provide the effect of gravity, and animate garments.

\section*{(5) Adding Hair to a Human Head}

The Hair And Fur modifier adds hair to a model.
In this tutorial, you add both facial hair and head hair to the head of a Viking character. The work proceeds in three steps of increasing complexity:

1 Beard The beard has very little styling,
2 Mustache The mustache requires some styling and brushing.
3 Head hair The hair on top of the Viking's head is shaped by a spline cage.


Skill level: Intermediate to Advanced
Time to complete: 1 hour and 40 minutes

\section*{Preparation for This Tutorial}
- On the Quick Access toolbar, click
(Project Folder) and set your current project to Autodesk 3ds Max 2011 Tutorials.


\section*{Create the Beard}

Creating the beard demonstrates the basic controls for Hair And Fur.

Set up the scene:
- Click

(Open File), navigate to the \scenes \(\backslash e f f e c t s \backslash h a i r\) folder, and open viking_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene contains the head of a warrior character.


NOTE You might notice that the texture on the crown of the skull doesn't quite match the skin on the face. This is because the model was created from an earlier model wearing a cap. The discrepancy doesn't matter for this tutorial, because you are going to cover the crown area with hair, anyway.

\section*{Create the faces for the beard:}

You can grow hair directly from the Head object, or from a subset of its faces, but creating a separate set of nonrendering faces gives you more flexibility, as the following steps will show.

1 Make the Left viewport active.

2
Select the Head object.
3 In the Graphite Modeling Tools Ribbon > Polygon Modeling group, click to turn on Modify Mode.


3ds Max opens the Modify panel.

TIP If you can't see the ribbon in the 3ds Max window, then on the main
 (Graphite Modeling Tools (Open)).

4 Also in the Polygon Modeling group, click \(\square\) (Polygon) to go to the Polygon sub-object level.


5 Use selection tools to
select the polygons in the area where the beard will grow. Use the following illustration as a reference.
If the viewport doesn't show face edges, press F4 to turn on Edged Faces display.


\footnotetext{
TIP (Lasso Selection Region) can be a convenient way to select faces in such an irregular shape.
}

6 Switch to the Right and then to the Front viewport to make sure the selection is symmetrical. Use Ctrl+click to add faces or Alt+click to remove faces, as necessary.


7 In the Graphite Modeling Tools ribbon \(>\) Geometry (All) group, click
 (Detach).


3ds Max opens a Detach dialog.
8 On the Detach dialog, turn on Detach As Clone. Name the detached faces Beard, and then click OK.


9 Click \(\square\) (Polygon) again to exit the Polygon sub-object level.

\section*{Make the beard faces nonrendering:}

1


Select the Beard object. Right-click, and from the Tools (lower right) quadrant of the quad menu, choose Object Properties.


3ds Max opens the Object Properties dialog.
2 In the Object Properties dialog > Rendering Properties group, click to turn off Visible To Camera, and then click OK.
```

Rendering Control
Visibility: \1.0 侤 By Object
\nabla Renderable
|}\mathrm{ Inherit Visibility
Visible to Camera
/visible to Reflection/Refraction
Receive Shadows
| Cast Shadows
Apply Atmospherics
Render Occluded Objects
G-Buffer
Object ID: 0 合

```

The Beard faces are for growing the hair of the beard, but they don't need to appear in renderings.

\section*{Adjust the shape of the beard:}

1 With the Beard object still selected, in the Ribbon > Polygon Modeling group, turn on \begin{tabular}{ll|l}
\hline\(\square_{\square}^{\square}\) & (Vertex).
\end{tabular}

2 Click the Shading viewport label menu (the one on the right, which now reads "Smooth + Highlights + Edged Faces"), and change the Left viewport to Wireframe display.

3 Use region selection (drag a small selection box) to select pairs of vertices,
on both the left and right sides of the face, then
 vertices along the cheek so the beard has a smoother outline. Also move the vertex for the area of the sideburn that extends behind the ear. Use the following illustration for reference.


4 Also in the Left viewport,

region-select the vertices along the lip. \begin{tabular}{c}
4 \\
4 \\
4 \\
\hline
\end{tabular}

Move them slightly downward and a little to the left.


NOTE After moving vertices, some of the Beard faces might be behind some of the Head faces. This is why you worked in wireframe mode, but it is not a problem: When you apply hair, it will just grow through the Head faces.

5 Double-check your work in the Right and Front viewports.


6 Click
 (Vertex) again to exit the Vertex sub-object level.

\section*{Apply the Hair And Fur modifier:}

1 Activate the Perspective viewport.
IMPORTANT Hair appears in orthographic viewports (Front, Left, Top, and so on), but it does not render in orthographic viewports. You can render hair only in Perspective and Camera viewports.

2 From the


Modifier List, choose WORLD-SPACE MODIFIERS Hair And Fur (WSM).

Hair now grows from the faces of the beard.


3 On the Modify panel, scroll down to the Display rollout.
TIP Drag the left edge of the Command Panel area to the left, to expand it to two columns. Like the Cloth modifier, Hair And Fur has a multitude of rollouts and settings.

4 On the Display rollout, turn on Display Guides.


In the viewport, hair guides display as yellow lines.


The Hair And Fur modifier generates guide hairs at the corners of polygons. When you style hair, you are styling only the guides: The hairs between the guides are interpolated from the guide hairs.

5 Also on the Display rollout, change the Display Hairs \(>\) Percentage value to \(\mathbf{1 0 . 0}\).


3ds Max increases the number of hairs shown in the viewport.


Increasing the percentage of displayed hairs helps you visualize how the beard will look.

\section*{Set the hair color:}

The Viking should have reddish-brown hair. He is middle aged, so the hair should also be starting to turn gray.

1 Open the Material Parameters rollout. Click the Root Color color swatch.


3ds Max opens a Color Selector.
2 Change the Root color of the hair to \(\mathrm{R}=\mathbf{3 0}, \mathrm{G}=\mathbf{2 0}\), and \(\mathrm{B}=\mathbf{1 5}\), and then click OK.


This is a very dark brown with a hint of red.
3 On the Material Parameters rollout, click the Tip Color color swatch.


4 In the Color Selector, change the Tip color of the hair to \(\mathrm{R}=1 \mathbf{3 0}, \mathrm{G}=1 \mathbf{1 2 0}\), and \(\mathrm{B}=\mathbf{1 2 0}\), and then click OK.
The color at the tip of the hairs is a brownish gray.
The Hair And Fur modifier shades hairs from the Root color, where they begin, to the Tip color, where they end. But actual hairs usually vary, and you can use the Mutant Color controls to model this variation.

5 Drag the Root Color color swatch, and drop it on the Mutant Color color swatch.
3ds Max opens a Copy Or Swap Colors dialog. Click Copy.


6 Change the Mutant \% value to 15.
Now Hair will randomly choose 15 percent of the hairs to maintain the Root color: That is, they will be dark instead of graying.

\section*{Trim the beard a little:}

1 Open the Styling rollout, and click Style Hair to turn it on.


2 Make the Front viewport active.

3 In the Styling rollout > Styling group, click

(Hair Cut) to turn it on.

In the active viewport, the Hair Cut cursor appears as a green circle. If you look at other viewports, you can see that the cursor is actually a cylinder: Its effect goes deep into the scene.


The cursor has falloff: Its effect is greatest at the center, and less at the edges.

TIP You can use the slider in the Styling group to change the diameter of the brush.


4 With single clicks, use the Hair Cut cursor to trim the left side of the beard (on the right of the viewport), making the sideburns and cheek hairs less lengthy than the chin hairs.


NOTE Dragging the Hair Cut cursor has no effect.

5 Do the same for the right side of the beard (on the left of the viewport).


Don't worry about being perfectly symmetrical. We can imagine that the Viking didn't care.

6 On the Styling rollout, click Finish Styling to turn off hair styling.



7 Close the Styling rollout.
8 Make the Perspective viewport active again.

\section*{Adjust some more Hair And Fur settings:}

1 Scroll down to the Display rollout, and turn off Display Guides.


2 Scroll up so you can see the General Parameters rollout. Change the Hair Count value from the default of 15,000 to 6000 .


You can improve Hair And Fur render time by reducing the Hair Count value, and setting hairs to have multiple strands.

3 Scroll down and open the Multi Strand Parameters rollout. Change these values:
- Count = 2
- Root Splay \(=0.6\)

■ Tip Splay \(=1.3\)


The beard is now bushier and a little more wild.


4 Open the Frizz Parameters rollout. Change Frizz Root to 50.0.


NOTE When Frizz Root and Frizz Tip both equal 0.0, the hair is perfectly straight, and follows the normal of the face that it grows from.

5 Close the Frizz Parameters rollout and open the Kink Parameters rollout. Change these settings:
- Kink Root = \(\mathbf{3 . 0}\)

■ Kink Tip = 5.0


The Frizz and Kink setting changes make the beard even more bushy.


\section*{Render the beard:}
\(>\) On the main toolbar, click \(\quad\) (Render Production).
3ds Max renders the head of the Viking quickly. It takes a more little time to render the beard.


TIP If you want to reduce the length of the beard, there are two ways to do so, both of them on the General Parameters rollout. Scale keeps the shape of all the hairs, and scales them as a percentage. Cut Length also retains hair shape, but trims hairs from the tip toward the root.

\section*{Save your work:}

Save the file as viking_beard.max.

\section*{Next}

Create the Mustache on page 1617

\section*{Create the Mustache}

You use a similar method to create the mustache, and the mustache has similar settings, but it requires a bit more styling than the beard does.

Set up the scene:
- Continue from the previous lesson or open viking_01.max.

\section*{Create the faces for the mustache:}

1


Select the Beard object. Right-click, and from the Display (upper right) quadrant of the quad menu, choose Hide Selection.

2

- Orbit the view so you can see the front of the Viking's face. If Edged Faces aren't visible, press F4.


3 In the Ribbon > Polygon Modeling group, click to turn on Modify Mode.
\begin{tabular}{|l|} 
Graphite Modeling Tool \\
Polygon Modeling \\
\hline
\end{tabular}


3ds Max opens the


Modify panel.

4 Also in the Polygon Modeling group, click to turn on \(\square\) (Polygon).


5 Click and Ctrl+click to

select the faces where the mustache will grow.


6 In the Ribbon > Geometry (All) group, click


3ds Max opens a Detach dialog.
7 On the Detach dialog, turn on Detach As Clone. Name the detached faces Mustache, and then click OK.


8 Click (Polygon) again to exit the Polygon sub-object level.

9
Select the Mustache object. Right-click, and from the Tools (lower right) quadrant of the quad menu, choose Object Properties.
\begin{tabular}{|l|}
\hline \multicolumn{2}{|c|}{ transform } \\
\hline Move \\
Rotate \\
Scale \\
Select \\
Select Similar \\
\hline Clone \\
\hline Object Properties... \\
\hline Curve Editor... \\
Dope Sheet... \\
Wire Parameters... \\
\hline Convert To: \\
\hline
\end{tabular}

3ds Max opens the Object Properties dialog.
10 In the Object Properties dialog \(>\) Rendering Properties group, click to turn off Visible To Camera, and then click OK.
```

Rendering Control
Visibility: 1.0 By b Object
Renderable
Inherit Visibility
Visible to Camera
~Visible to Reflection/Refraction
Receive Shadows
Cast Shadows
Apply Atmospherics
Render Occluded Objects
G-Buffer
Object ID: 0 |⿻人人

```

Like the Beard faces，the Mustache faces are for growing hair，but don＇t need to appear in renderings．

\section*{Adjust the size of the mustache faces：}

1 With the Mustache object still selected，open the Graphite Modeling Tools



Move vertices along the upper edge of the Mustache object to give the mustache a larger area．


NOTE If the mustache were to be a short one, you might want to raise the vertices along the line of the upper lip as well. But since the Viking's mustache will droop over the lip, for this lesson you can leave these vertices as they are.

Check your work in side views to make sure the mustache polygons don't stray far from the original face of the model.


3 Make the Perspective view active again.
 (Vertex) again to exit the Vertex sub-object level.

\section*{Apply Hair And Fur:}

1 From the


Modifier List, choose WORLD-SPACE MODIFIERS > Hair And Fur (WSM).

2 On the Frizz Parameters rollout, set Frizz Tip to 0.0.
\begin{tabular}{|c|c|}
\hline Frizz Parameters & へ \\
\hline Frizz Root 15.5 & \\
\hline Frizz Tip 0.0 & \\
\hline Frizz X Freq. 14.0 & \\
\hline Frizz Y Freq. 14.0 & \\
\hline Frizz Z Freq. 14.0 & \\
\hline Frizz Anim. 0.0 & \\
\hline Anim. Speed 0.0 & \\
\hline
\end{tabular}

3 On the Kink Parameters rollout, make sure Kink Root equals the default value of 0.0.


Setting Frizz Root and Kink Root to zero is a temporary measure that makes it easier for you to see the effect of styling the mustache.

4 On the Material Parameters rollout, give the mustache the same colors as the beard:
- Tip Color: \(\mathrm{RGB}=\mathbf{1 3 0} \mathbf{1 2 0} 120\)

■ Root Color: \(\mathrm{RGB}=\mathbf{3 0}, \mathbf{2 0}, 15\)
■ Mutant Color \(=\) Root Color: \(\mathrm{RGB}=\mathbf{3 0}, \mathbf{2 0}, 15\)
■ Mutant \(\%=15.0\)


5 On the General Parameters rollout, change the Hair Count to 3000.
\begin{tabular}{|c|c|}
\hline General Parameters & 入 \\
\hline Hair Count 3000 & \\
\hline Hair Segments 5 & \\
\hline Hair Passes 1 & \\
\hline Density 100.0 & \\
\hline Scale 100.0 & \\
\hline
\end{tabular}

6 On the Display Parameters rollout, change Display Hairs > Percentage to \(\mathbf{1 5 . 0}\).


7 On the Multi Strand Parameters rollout, change the values as follows:
- Count \(=2\)
- Root Splay \(=\mathbf{0 . 1 5}\)

■ Tip Splay \(=\mathbf{0 . 1}\)


Now the mustache is ready to style.


\section*{Style the mustache:}

1 Open the Styling rollout, and click Style Hair to turn it on.


NOTE When you turn on Style Hair, 3ds Max displays the hair guides in viewports.

2 Activate the Front viewport.

3 In the Styling rollout > Styling group, click


Select to turn it on.

4 In the viewport, drag to select the portion of the mustache to the left of the Viking's nose (at the right of the viewport).


While you are styling hair, active guides appear orange, while inactive guides are yellow.

5 In the Styling rollout > Styling group, click
 turn it on.

The Hair Brush cursor is like the Hair Cut cursor: It appears circular in the active viewport, cylindrical in others, and it has a falloff such that its action is strongest at the center axis of the cylinder.

6 Make sure

(Translate) is active, then

brush the mustache downward to make it droop.


Notice that while you use the Hair Brush, only the guides are affected: After you release the mouse, other hairs deform to follow the guides.

7 Activate the Top viewport.

8
Brush the left side of the mustache (right side of the viewport) so it stands away from the skull.


TIP You might want to orbit the viewport a bit, as in this illustration, to see the mustache better.

9 Click

(Scale) to make it active, then
brush the mustache outward to make it longer.


10 Activate the Front viewport again.

11 Turn on

brush the mustach to make it less chaotic.


12 Repeat steps 3 through 11 for the right side of the mustache (to the left of the viewport).
As when you trimmed the beard, don't worry too much about making the mustache symmetrical: Faces and facial hair rarely are.

13
 brush the hairs below the nose so they also hang downward.


14 On the Styling rollout, click Finish Styling to turn off hair styling.


15 Close the Styling rollout.
16 Activate the Perspective viewport again.

Adjust some more Hair And Fur settings:
1 On the Frizz Parameters rollout, set Frizz Root to 15.0.
2 On the Kink Parameters rollout, set Kink Root to 0.5, and Kink Tip to 3.0.

\section*{Render the mustache:}

1 Right-click the viewport, and from the Display (upper right) quadrant of the quad menu, choose Unhide All. Now the beard is visible again.

2 On the main toolbar, click \(\quad\) (Render Production).


Once you create the hair for the Viking, the model will be complete.

\section*{Save your work:}

■ Save the file as viking_beard_and_mustache.max.

\section*{Next}

Create the Head Hair on page 1634

\section*{Create the Head Hair}

To create the hair for the top of the head, you will use a spline cage; this method helps to style a large amount of hair, especially long hair, all at once.


Spline cage for growing a head of hair
The spline cage method is somewhat different from the polygon method you used for the beard and mustache:
- Hair grows from the splines, instead of from the Head surface.

■ There are no guide hairs: The splines themselves are the guides.
■ When you grow hair from splines, the default values are different from when you grow hair from polygons.

\section*{Set up the scene:}
- Continue from the previous lesson or
 open viking_02.max.

Hide the beard and mustache:
- Click and Ctrl+click to

select the Beard and Mustache objects (or use Select By Name). Then right-click, and from the Display (upper right) quadrant of the quad menu, choose Hide Selection.

Draw the spline cage:
NOTE The tutorial files include a spline cage that has already been drawn. If you have trouble completing this procedure and the two that follow, or if you don't want to spend the time it takes to construct the splines, you can skip ahead to the procedure Apply Hair And Fur on page 1645.

1 On the
Create panel, click

(Shapes) to make it active, then on the Object Type rollout, click to turn on Line.


2 On the Creation Method rollout, change both the Initial Type and the Drag Type to Smooth.
\(\left[\begin{array}{c}\text { Creation Method } \\ \hline \text { Initial Type } \\ \text { O Corner } \\ \text { O Smooth } \\ \text { Drag Type } \\ \text { Corner } \\ \text { Smooth } \\ \text { Sezier } \\ \hline\end{array}\right]\)

3 On the main toolbar, right-click
- (Snaps Toggle) to open the Grid And Snap Settings dialog. In the dialog, click Clear All, and then click to turn on Face.


4 Click
3

5 Open the Rendering rollout, and turn on Enable In Viewport.
\(\left[\right.\)\begin{tabular}{c}
\multicolumn{1}{c}{ Rendering } \\
\(\square\) Enable In Renderer \\
\(\nabla\) Enable In Viewport \\
Use Viewport Settings \\
\(\square\) Generate Mapping Coords. \\
\(\square\) Real-World Map Size
\end{tabular}\(]\)

This simply helps you see the splines better while you create them.
6 Draw the first spline, on the left side of the head, from the crown down to the right shoulder. Right-click to end spline creation.


Because you are snapping to faces, some portions of the spline might sink below the skin. Don't worry about this: You will move the splines away from the head before you generate the hair.

7 Using the illustrations as a guide, draw the remaining splines.
On each side of the head, there are three splines in front of the ear, and three behind the ear.


There are also two additional splines at the very back of the head.

- Orbit the viewport while you draw the splines (you can use Shift+Z later to undo the view changes).

\section*{Assemble the splines into the cage:}

1 When you have drawn the splines to your satisfaction,
 the first (temple). Right-click it, and from the Transform (lower right) quadrant of the quad menu, choose Convert To: \(\boldsymbol{>}\) Convert To Editable Spline.

2 Make the Top viewport active.


3 Go to the
 Modify panel. With the first spline
 selected, turn on the Geometry rollout > Attach button and proceeding in a counterclockwise direction, click to attach each of the additional splines in the cage.
The order is important: If splines are out of order, the hair will be tangled or scrambled. Because of this, you can't use the Attach Multiple button, either.


TIP If it is hard to see the splines, you can select the head, right-click and choose Hide Selection, and then do the attaching as described earlier in this step.

4 When you have added all the splines to the cage, turn off Attach.

Move the cage away from the scalp:
1 Turn off Rendering \(>\) Enable In Viewport.
 (Vertex) to go to the Vertex sub-object level.

4 Click and Ctrl+click to select all the first vertices of the hair splines (the ones that display in yellow, when they aren't selected).


TIP At this point, if the root vertices seem to be a bit far apart, you might
want to use so the viking doesn't have a bald spot.

5 Press Ctrl+l to invert the selection.
 Center), and then scale the vertices up a bit, so that all but the first, scalp vertices are at a distance from the skin of the head.


\section*{Apply Hair And Fur:}

1 Do one of the following:
■ If you followed the preceding procedures to create the spline cage, and are happy with how it looks, then skip ahead to step 2.

■ If you prefer to use the prepared spline cage, or you didn't create your

? \(\quad \times\)

```

Find Case Sensitive Sort
(O) Alphabetical
By Type
By Color

```

List types

Geometry
All
Shapes
Lights
None
InvertCameras
Helpers
Space Warps
Groups/Assemblies
Bone Objects

All None Invert Influences
Display Subtree
Select SubtreeSelect Influences

2 Select the spline cage.

3 On the


Modify panel, from the Modifier list, choose WORLD-SPACE MODIFIERS \(>\) Hair And Fur (WSM).


4 On the Material Parameters rollout, give the head hair the same colors as the beard and mustache:

■ Tip Color: \(\mathrm{RGB}=\mathbf{1 3 0} \mathbf{1 2 0} 120\)

■ Root Color: \(\mathrm{RGB}=\mathbf{3 0} \mathbf{2 0} \mathbf{1 5}\)
■ Mutant Color \(=\) Root Color: \(\mathrm{RGB}=\mathbf{3 0} \mathbf{2 0} \mathbf{2 0} 15\)
■ Mutant \(\%=\mathbf{1 5 . 0}\)


5 On the General Parameters rollout, change the Hair Count to \(\mathbf{3 0 0 0}\).
\begin{tabular}{|c|c|}
\hline General Parameters & ล \\
\hline \multicolumn{2}{|l|}{\multirow[t]{2}{*}{Hair Count \(\qquad\) Hair Segments \(\square\)}} \\
\hline & \\
\hline Hair Passes 1 & \\
\hline Density 100.0 & \\
\hline Scale \(\longdiv { 1 0 0 . 0 }\) & \\
\hline
\end{tabular}

Notice that the default Hair Count is 450: This is far lower than the default for hair grown from polygons, and it is too low a value.

6 Also on the General Parameters rollout, change Hair Segments to 100 and Hair Passes to 2.
\begin{tabular}{|c|c|}
\hline General Parameters & 入 \\
\hline Hair Count 3000 & \\
\hline Hair Segments 100 & \\
\hline Hair Passes \({ }^{\text {® }}\) & \\
\hline Density 100.0 & \\
\hline
\end{tabular}

Hair Segments specifies how many segment subdivisions Hair And Fur uses for each hair. We increased this value because the Viking's hair is long.

Hair Passes is a quality control: Increasing its value increases rendering time, but also improves the appearance of the hair.

7 Also on the General Parameters rollout, change Random Scale to 20.0.
\begin{tabular}{rl} 
Cut Length \(\sqrt{100.0}\) & \(\square\) \\
Rand. Scale & 20.0 \\
Root Thick & 10.0 \\
Tin Thirk & \(\square 0\)
\end{tabular}

This specifies that 20 percent of the hairs will have a random variation in their length.

8 On the Frizz parameters rollout, change Frizz Root to 3.0 and Frizz Tip to 2.0.


9 On the Kink Parameters rollout, change Kink Root to 0.1 and Kink Tip to 2.0.


10 On the Multi Strand Parameters rollout, change the settings as follows:
- Count \(=3\)

■ Root Splay \(=\mathbf{1 . 2}\)
■ Tip Splay \(=\mathbf{1 . 1 5}\)


Now you are ready to try rendering the hair.


\section*{Render the hair:}

1 On the main toolbar, click \(\quad\) (Render Production).
Because the hair is longer, the head takes longer to render than the beard or mustache.


The result is not good: The hair looks matted and oily. In part, this is because the defaults for hair grown from splines differ from those for hair grown from polygons.

2 On the General Parameters rollout, change the value of Root Thick to 2.5 and the value of Tip Thick to \(\mathbf{0 . 2 5}\).


The default Root Thick(ness) for polygon hair is 5.0, while for spline hair it is 10.0 !

3 On the Material Parameters rollout, change the values of Specular and Glossy to both equal 15.0.


In this case, the defaults are the same as for the beard and mustache, but the greater area of the head hair makes highlights more apparent.

4 Right-click a viewport, and from the Display (upper right) quadrant of the quad menu, choose Unhide All.

5

- Render the head once more.


This time, the appearance of the head hair is more in keeping with the beard and mustache.

\section*{Save your work:}

■ Save the scene as viking_hairy.max.

\section*{Summary}

In this tutorial, you grew hair from polygons, and also from a spline cage. You used several of the numerous Hair And Fur settings to change the hair color and appearance and obtain a realistic result.

\section*{Using Particle Flow to Generate Smoke}

Particle systems can model snow and rain, flowing water, smoke, explosions, and so on. Typically they give you animated effects.

In this tutorial, you use the Particle Flow particle system to model smoke on a bombing range or battlefield.


NOTE 3ds Max provides a number of particle system types. Particle Flow is the most versatile and general purpose of these.

Skill level: Intermediate
Time to complete: \(21 / 2\) hours

\section*{Preparation for This Tutorial}

■ On the Quick Access toolbar, click
(Project Folder) and set your current project to Autodesk 3ds Max 2011 Tutorials.


\section*{Create a Particle Flow that Behaves like Smoke}

The first step is to set up a particle system that behaves like smoke. Once the behavior is established, then you can adjust the appearance of the particles.

Set up the scene:
\(>\) Click (Open File), navigate to the \scenes \(\backslash e f f e c t s \backslash s m o k e\) folder, and open pflow_start.max.

NOTE If a dialog asks whether you want to use the scene's Gamma And LUT settings, accept the scene Gamma settings, and click OK. If a dialog asks whether to use the scene's units, accept the scene units, and click OK.

The scene is of a desert landscape. There are scorched areas on the ground, and the wreckage of a jeep \({ }^{\circledR}\).


\section*{Create the particle system:}

1 In the Top viewport, \(\square\) jeep.


The jeep is in the road, toward the right-hand side of the landscape.

2 Go to the Create panel. Turn on already on.

3 From the drop-down list, choose Particle Systems.
\begin{tabular}{|l|l|}
\hline Standard Primitives \\
\hline \begin{tabular}{l} 
Standard Primitives \\
Extended Primitives \\
Compound Objects \\
Particle Systems \\
Patch Grids \\
NURBS Surfaces \\
Doors \\
Windows \\
mental ray \\
AEC Extended \\
Dynamics Objects \\
Stairs
\end{tabular} \\
\hline
\end{tabular}

4 On the Object Type rollout, click PF Source to turn it on.
\(\left[\begin{array}{cc}\text { Object Type } \\ \square \text { AutoGrid } \\ \text { PF Source } & \text { Spray } \\ \hline \text { Snow } & \text { Blizzard } \\ \hline \text { PArray } & \text { PCloud } \\ \text { Super Spray } & \end{array}\right.\)

5 In the Top viewport, drag across the jeep to create a Particle Flow source icon.


6 Go to the


Modify panel. On the Emission rollout, change the Icon Type from Rectangle to Circle.
\(\left[\right.\)\begin{tabular}{rl}
\multicolumn{1}{c}{ Emission } \\
\(\begin{array}{rl}\text { Emitter Icon: } \\
\text { Logo Size: } & 5.047\end{array}\) \\
Icon Type: & Rectangle \\
Length: \\
Width: \\
Rectangle \\
Box
\end{tabular}\(| \begin{array}{l}\text { Circle } \\
\text { Heighere }\end{array}\)

7 Also on the Emission rollout, set the circle Diameter to 3.0.


Particles will be emitted from the area of the circle, which is a bit smaller than the size of the jeep itself.

NOTE The Logo Size value has no effect on particle generation: It just adjusts the size of the Particle Flow icon, which gives you an object to select in viewports. But the emitter icon and its dimensions (in this case, the circle and its diameter) do affect where particles will appear.

8 In the Emission rollout > Quantity Multiplier group, change Viewport \(\%\) to \(\mathbf{1 0 0 . 0}\).

Quantity Multiplier:


For large particle systems, using a Viewport \% value less than 100.0 can improve 3ds Max performance, but displaying 100 percent of the particles gives you a better idea of what the result of your adjustments will be.

9 If you drag the time slider, you can see in the Orthographic viewport, and only in the Orthographic viewport, that particles are being emitted downward. This is the default orientation when you create the icon in the Top view.

(Angle Snap Toggle), then rotate the Particle Flow icon 180 degrees about its \(Y\) axis, so the arrow points straight up.


11 Drag the time slider again.
Now the particles move upward instead of downward, and you can see them in all four viewports.


At present, the particles appear in a single burst, between frame 0 and frame 30, then no more particles appear. You will correct this, and also set up some other particle behavior, in the procedure that follows.

Adjust the Particle Flow settings:

1 Go to the
 Modify panel. On the Setup rollout, click Particle View.


3ds Max opens a Particle View window.


Particle View is the main interface to Particle Flow systems. This is where you add and adjust the particle behavior. In the window, the main areas are the event display at upper left, which shows events you've already created, and the "depot" at lower left, which contains operators that you can add to the event display.

At present, the event display shows the PF Source 01 operator you added to the scene, and Event 01, which so far contains default settings.


2 In Event 01, click the Birth 01 operator to highlight it.


On the right side of Particle View, 3ds Max displays a parameters rollout for the Birth operator. As the fields show, the Birth operator generates 200 particles in all. It starts emitting particles at frame 0, and stops emitting them at frame 30 .
\begin{tabular}{|c|c|}
\hline Birth 01 & 入 \\
\hline Emit Start: & - \\
\hline Emit Stop: 30 & \(\stackrel{\rightharpoonup}{*}\) \\
\hline ( Amount: 200 & \(\stackrel{\square}{\square}\) \\
\hline (-)Rate: 60.0 & \(\checkmark\) \\
\hline Total: 200 & \\
\hline V Subframe Sampling & \\
\hline
\end{tabular}

3 Change the value of Emit Start to - \(\mathbf{1 0 0}\) and the value of Emit Stop to 300.
\begin{tabular}{|c|c|}
\hline Birth 01 & ^ \\
\hline Emit Start: -100 & \\
\hline  & \\
\hline (-)Rate: 60.0 & * \\
\hline Total: 200 & \\
\hline \(\checkmark\) Subframe Sampling & \\
\hline
\end{tabular}

Starting emission at an imaginary frame - 100 means tells 3ds Max to generate particles before the animation begins, so there will already be some smoke in the scene at frame 0 . Stopping particle emission at frame 300, the last frame of the animation, means that smoke will continue to appear throughout the animation.

4 Drag the time slider to see the animation.


Particles are present at frame 0 , and they continue throughout the animation, but so far, they aren't exactly billowing.

5 On the Birth rollout, change the value of Amount to 2000.


6 Drag the time slider again.


Now the particles are more numerous and beginning to look a little more like smoke, but they are still moving too quickly.

7 In the event display, click the Speed 01 operator to highlight it.


In the parameters panel on the right side of Particle View, 3ds Max replaces the Birth rollout with a Speed operator rollout.
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|l|}{Speed 01} \\
\hline Speed: 300.0 & \(\stackrel{\rightharpoonup}{*}\) \\
\hline Variation: 0.0 & \(\stackrel{\text { - }}{ }\) \\
\hline Direction: & \\
\hline Along Icon Arrow & \\
\hline \(\square\) Reverse & \\
\hline Divergence: 0.0 & \(\stackrel{\text { - }}{ }\) \\
\hline Uniqueness: & \\
\hline Seed: \(\sqrt{12345}\) & \\
\hline
\end{tabular}

8 On the Speed rollout, change the value of Speed to 6.0, and the value of Variation to \(\mathbf{1 . 0}\).


9 Drag the time slider.


Now the smoke rises more slowly, in a dense column. This is a better effect, but its path is unnaturally straight and vertical.
Before you add effects to make the smoke behave naturally, you will adjust its viewport display to see the effect a little better.

10 In the event display, click the Display 01 operator to highlight it.


Now the parameters panel shows a Display operator rollout.


11 On the Display rollout, change the Type from Ticks to Geometry.
\(\left[\right.\)\begin{tabular}{ll}
\multicolumn{1}{c}{ Display 01 } \\
Type: & Ticks \\
Visible & \(\begin{array}{l}\text { None } \\
\text { Dots }\end{array}\) \\
\(\square\) Show & \(\begin{array}{l}\text { Ticks } \\
\text { Cirdes }\end{array}\) \\
Selected: \\
\hline
\end{tabular}

TIP If you don't care for the color of the particles, click either the color swatch on the Display rollout, or the color dot on the Display operator entry in Event 01.


Clicking either the swatch or the dot displays a Color Selector that lets you change the display color.

12 In the event display, click the Shape 01 operator to highlight it.


13 In the Shape rollout that 3ds Max now displays, change the value of Size to \(\mathbf{0 . 2}\).


Now the particles appear as a mass of tiny cubes, as you can see in the Perspective viewport.


This is not meant to be the final form of the particles: It is just a temporary setting to help you visualize the effects you are about to add.

\section*{Add a space warp for the updraft:}

To give the column of smoke more realistic motion, you will add a couple of Wind space warps to the scene.

1 Minimize Particle View.
TIP While a Particle Flow system is in the scene, the keyboard shortcut 6

hides or displays Particle View. On the main toolbar, turn on (Keyboard Shortcut Override Toggle) for this shortcut to work. You don't have to select the Particle Flow icon before you press 6.

2 On the


Create panel, turn on (Space Warps).

3 On the Object Type rollout, turn on Wind.


4 In the Top viewport, click the Shading viewport label menu (at present, it says "Smooth + Highlights"), and change the Top viewport to a wireframe view.

5 In the Top viewport, drag to create a Wind space warp just to the left and below ("southwest" of) the Particle Flow source icon.


The Wind space warp icon is a square with an arrow coming out of it. In shaded viewports, the square is hidden by terrain, but in the Perspective viewport, it is easier to see the arrow.


6 Change the name of the Wind space warp to Updraft.


This space warp will model the updraft caused by the heat of the fire, itself.

Add a space warp for wind:
1 With the Top viewport still active, click \(\square^{\Gamma}\)


2 Turn on Wind again, if the button is not still on.


3 In the Top viewport, drag just to the right ("east" of) the terrain to create a second Wind space warp.


4 Turn on (Select And Rotate), makes sure
 Toggle) is on, then activate the Camera01 viewport, and rotate the Wind icon - 90 degrees on its Y axis, so the arrow is pointing to the left.


5 Change the name of this second Wind space warp to East Wind.


This space warp will model an actual wind coming from the east.

\section*{Include the space warps in the particle animation:}

1 Restore Particle View (6).
2 In the "depot" at the lower left of Particle View, click to highlight the Force operator, then drag it to the event display, and drop it on Event 01, just above the Shape operator.


Force operator in the depot


Dropping the Force operator on the event

3 Click the new Force operator entry to highlight it.


3ds Max displays the Force operator parameters in a rollout on the parameters panel to the right.


4 On the Force 01 rollout, click By List.
3ds Max opens a Select Force Space Warps dialog.


5 Click and Ctrl+click to highlight both the East Wind and Updraft space warps, and then click Select.

6 Hide Particle View (6).
7 Drag the time slider.


The particles move upward and toward the west, as we want them to, but now they are so widely dispersed that the smoke is hardly visible. This is because the default Wind settings are too strong. You will correct that in the next procedure.

\section*{Adjust the space warp settings:}

1
 Select the East Wind object, and go to the
 Modify panel.

2 In the Parameters > Force group, set Strength to 0.01 and Decay to 0.025 .


3 In the Parameters > Wind group, change the settings as follows:
■ Turbulence \(\mathbf{=} \mathbf{0 . 0 1}\)
- Frequency \(=3.0\)
- Scale \(=0.1\)

Wind
Turbulence: \(\sqrt{0.01}\) |
Frequency: 3.0
Scale: 0.1 |는

These settings were arrived at by trial and error.

4


Select the Updraft object.
NOTE You might notice that, now that the Wind space warps are part of the Particle Flow system, selecting the space warp also selects the Particle Flow.

5 Change the Updraft settings as follows:
- Strength \(=0.0\)

■ Turbulence \(=\mathbf{0 . 0 5}\)
■ Frequency \(=6.8\)
- Scale \(=0.2\)


6 Drag the time slider again.


The particles seem to be a little denser and to move more slowly, but it is still hard to see the system in the Camera01 viewport.

7 Restore Particle View (6). Click the Birth 01 operator to highlight it, then change the Amount value to \(\mathbf{1 0 0 0 0}\) (ten thousand).

8 Click (Time Configuration), and in the Time Configuration dialog > Playback group, turn off Active Viewport only, then click OK.


Now the smoke is a thick stream that is visible in the Camera01 viewport. Its motion is controlled by the two Wind space warps, and it shows some turbulence as it rises and drifts to the west.


To render smoke effectively using small particles like this, you would need even more than 10,000 of them. Using this many particles is not a good idea: The large number of particles will slow down 3ds Max, and rendering the animation will take a long time. The next lesson shows a way to display smoke using the Wind settings you just created, but with fewer particles in the system.

\section*{Save your work:}

■ Save the scene as smoke_particles.max.

\section*{Next}

Set up Particle Geometry that Changes over Time on page 1684

\section*{Set up Particle Geometry that Changes over Time}

In this lesson, you set up the particle geometry to change over time as the smoke disperses. You also set up the Particle Flow system so it uses fewer particles.

\section*{Set up the scene:}
- Continue from the previous lesson or open pflow_01.max.

\section*{Change the particle geomery:}

1 Restore Particle View (6).
2 Click the Birth 01 operator to highlight it, then change the Amount of particles emitted to \(\mathbf{2 5 0}\).


3 From the depot, drag a Shape Facing operator, and drop it on top of the Shape operator, to replace the Shape operator with Shape Facing.


Unlike the blue line that appears when you add an operator by dropping the operator between two others, the line for replacing an operator appears red.


In viewports, the particles change to square shapes that are larger than the small cubes you generated before. However, their orientation is random: This is because the particles aren't yet oriented to anything.

4 Move Particle View so you can see a viewport with the camera visible in it. (The lower-left Orthographic view is good for this.)
5 Click the Shape Facing operator to highlight it.


6 On the Shape Facing operator rollout, click to turn on the Look At Camera/Object button (at present it is labeled "None"), then in the viewport, click Camera01.

\section*{Shape Facing 01 ㅊ}

Look At Camera/Object:


Click the Look At button to turn it on.


Look At button after you pick the camera

7 Hide Particle View (6).
8 Drag the time slider.

Now particles face in a uniform direction, and always face the camera, as you can see most easily in the Perspective viewport.


Shape facing particles always face another object. Usually this is a camera: The idea is to assign the particles a material that makes the scene geometry appear to be more complicated than it actually is. (The tutorial Particle Trees on page 1372 is another example of this technique.)

9 Restore Particle View (6).
10 In the Shape Facing parameters rollout > Size/Width group, make sure In World Space is chosen, and then change the value of Units to 5.0.


Now when you drag the time slider, smoke particles are easily visible even in the Camera01 viewport.


\section*{Set the particles to grow over time:}

The smoke particles should grow over time: As the smoke rises, it also disperses. To model this, you use a Scale operator.

1 Drag a Scale operator from the depot to Event 01, and drop it between the Shape Facing and Force operators.


2 Click the Scale operator to highlight it.


3 In the Scale parameters, choose Relative Successive from the Type drop-down list.


4 Make sure Constrain Proportions is turned on, then change the value of Scale Factor > X \% to \(\mathbf{1 0 0 . 2}\).


Because Constrain Proportions is on, the Y \% and Z \% factors update to 100.2 as well.

The factor by which the particles grow doesn't need to be great. Even two-tenths of a percent increase at each frame adds up quickly.

5 Hide Particle View (6) and drag the time slider.
The particles increase in size as they rise.


\section*{Create a dynamic material for the particles:}

The next step is to create a material that changes over time while the particles change in size.

1 On the main toolbar, click

(Material Editor) to display the Slate Material Editor.

TIP If this is the first time you have used the Slate Material Editor, you might have to resize it to make it larger so you can easily see all the panels.

2 In the Material/Map Browser panel on the left, locate Materials Standard \(>\) Standard, and drag the Standard material entry into the active View.


3 In the active View, double-click the Standard node so you can see its parameters on the Parameter Editor panel to the right.


4 Name the new material Smoke.


5 On the Material/Map Browser panel, locate Maps Standard > Particle Age, and drag the Particle Age entry into the active View.


6 In the active View, wire the Particle Age map output to the Standard map's Diffuse Color input.


NOTE When you wire the Particle Age map, 3ds Max also adds a Bezier Float controller node. You won't be using that in this tutorial.

7 Double-click the Particle Age map node to display its parameters.


The Particle Age map specifies three colors: By default, Color \#1 is the color at a particle's birth ( 0 percent), Color \#2 is the color when the particle is halfway through its life (50 percent), and Color \#3 is the color at the particle's death (100 percent). You can change the ages, but we won't do so in this tutorial.

8 Change Color \#1 to yellow, Color \#2 to green, and Color \#3 to blue.


Don't worry about the precise values: These are just arbitrary colors to test the Particle Age effect. Once Particle Age is working as we want it to, you will replace the colors with more realistic patterns.

9 In the Material/Map Browser panel, scroll so you can see the Sample Slots group. Drag from the output socket of the Smoke material node (at the right), and drop it on an unused sample slot. In the Instance/Copy dialog, choose Instance, then click OK.


Add the new material to the particle system:
1 Minimize the Slate Material Editor and restore Particle View (6).

2 Drag a Material Dynamic operator from the depot, and drop it on Event 01 between the Force and Display operators.


3 Click the Material Dynamic operator to highlight it.


4 In the Material Dynamic parameters, click the Assign Material button.


3ds Max opens a modal version of the Material/Map Browser.
5 Scroll to the Sample Slots group, and double-click the Smoke material.


6 Hide Particle View (6).

7 Activate the Camera01 viewport, click
(Go To End), and then

NOTE The Particle Age effect doesn't appear in viewports, so when you use this map, you have to render to see the result.


The particles still have a uniform yellow (birth) color.
The reason for this is that the particles don't yet have a defined life span. The Birth operator controls particle creation, but not particle death.

\section*{Define the life span of particles:}

1 Restore Particle View (6).
2 In Particle View, drag a Delete operator from the depot, and drop it on Event 01 between the Birth and Position Icon operators.

```

Birth 01 (-100-300 T:250)
Position Icon 01 (Surface)
Speed 01 (Along Icon Arrow) ${ }^{+}$
Rotation 01 (Random 3D)
Shape Facing 01 (Camera01)
Scale 01 (Relative Successi..
Force 01 (updraft +1)
Material Dynamic 01 (Smoke)
Display 01 (Geometry)

```

3 Click the Delete operator to highlight it.


4 In the Delete parameters, choose Remove \(>\) By Particle Age.


Choosing By Particle Age enables the Life Span and Variation parameters.
\(\left[\right.\)\begin{tabular}{l}
\multicolumn{1}{c}{ Delete 01 } \\
\hline Remove: \\
All Particles \\
Selected Particles Only \\
By Particle Age \\
Life Span: \(\sqrt{60}\) \\
Variation: \(\sqrt{10}\) \\
Uniqueness: \\
Seed: \(\sqrt{12345}\) 考 \\
\end{tabular}

5 Change the value of Life Span to \(\mathbf{3 5 0}\) and the value of Variation to \(\mathbf{5 0}\).


The Variation setting introduces a random variation in the life span of particles, so the system doesn't appear too uniform.

6 Hide Particle View (6).

7


The particles begin with a yellow color, which shades to green at their half-life, and then to blue as they near the end of their existence.

Now you are ready to change the particle colors from the test colors to a pattern that simulates smoke. This is the subject of the next lesson.

\section*{Save your work:}

■ Save the scene as smoke_dispersing.max.

Next
Create a Material to Model Smoke on page 1704

\section*{Create a Material to Model Smoke}

The material that models smoke uses maps with computer-generated patterns that have a naturalistic appearance.

Set up the scene:
- Continue from the previous lesson or
 open pflow_02.max.

\section*{Use a Noise map to create a smoke-like pattern:}

1 On the main toolbar, click
(Material Editor) to open the Slate Material Editor.
(If you're continuing from the previous scene, you can just restore the Material Editor window: Press M.)

2 If the Smoke material isn't already in the active View, drag it into the View from the Scene Materials group as an instance.

3 Double-click the Particle Age map node to display its parameters.
4 Drag a Noise map from the Browser into the Active View.
5 Wire the Noise map to the Color 1 component of the Particle Age map.


In the parameters for the Particle Age map, you can see that the Color \#1 map button now shows the Noise map.

6 Double-click the preview in the title bar of the Noise node, to get a better view of the map.


The Noise map is a mix of black and white, and this is a good first approximation to a smoke pattern.

7 Double-click the Noise node (in an area other than the preview) so you can see its parameters.

8 On the Noise Parameters rollout, choose Fractal as the Noise Type.


The Fractal pattern is more sharply defined than the Regular pattern.


9 Also on the Noise Parameters rollout, change the value of Levels to 10.0.


Increasing the number of levels increases the complexity of the Noise pattern.


10 Change the value of Noise Threshold \(>\) High to 0.65 and Noise Threshold \(\boldsymbol{>}\) Low to \(\mathbf{0 . 3 5}\).


This increases the contrast of the Noise pattern.


11 Click the Color \#1 color swatch. In the Color Selector, set V=29.0 (a very dark gray; the RGB values change to equal 29.0 as well), and then click OK.

12 Click the Color \#2 color swatch. In the Color Selector, set V=86.0 (a moderately dark gray), and then click OK.


The smoke in its initial stages will be very dark, nearly black.
13 Change the value of Size to 4.0.


The material preview now shows a very fine-grained Noise pattern, but this Size value matches the scale of the scene: Remember that when particles are born, they are 5.0 units square.

\section*{Vary the map as particles age:}

1 Hold down the Shift key, and in the active View drag the Noise map node to create a clone of the node.

2 Wire the second Noise map to the Color 2 component of the Particle Age map.


The second, mid-life color now has a map assigned to it.
3 Double-click the new Noise map node to see its parameters.

4 By the Noise color swatches, click the Swap button.


The idea is that, for each succeeding Noise map, the lighter Color \#2 becomes the darker Color \#1.

5 Click the Color \#2 color swatch. In the Color Selector, set V=161, and then click OK.


6 Also on the Noise Parameters rollout, change these settings:
■ Noise Threshold \(\boldsymbol{>}\) High \(=0.8\)
■ Noise Threshold \(\boldsymbol{>}\) Low \(=\mathbf{0 . 2}\)
■ Size \(=5.0\)


7 Double-click the previews of the two Noise map nodes, to make the previews small again.

8 Hold down the Shift key and drag the second Noise node to make a clone of it.

9 Wire the new, third noise node to the Color 3 component of the Particle Age map.


10 Double-click the third Noise map node to see its parameters.
11 By the Noise color swatches, click the Swap button.


12 Click the Color \#2 color swatch. In the Color Selector, set V=220, and then click OK.


13 Also on the Noise Parameters rollout, change the value of Size to 4.0.


TIP When you are done adjusting the Noise map nodes, you can click the minus-sign (-) icon in the title bar of each to minimize the size of these nodes.

14 Minimize the Slate Material Editor, activate the Camera01 viewport,
go to the last frame, and
 - render the scene.


The particles now have a good smoke pattern that begins very dark and grows lighter over time.

The next step is to make the particle edges transparent, so they blend together more naturally, and don't have sharp edges against the terrain or the sky.

\section*{Add an Opacity map to hide particle edges:}

1 Drag a new Particle Age map from the Browser to the active View.
2 Wire the new Particle Age map to the Opacity component of the Smoke material.


If the Controller node that 3ds Max creates for the new Particle Age map obscures the new Particle Age node, move it out of the way.

TIP You can update the layout of the active View by pressing L.
You will animate the opacity to decrease over time, as the smoke disperses.
3 Drag a Gradient map from the Browser to the active View, and wire it to the Color 1 component of the new Particle Age map.


4 Double-click the new Gradient map node to see its parameters.
5 On the Gradient Parameters rollout, change the Gradient Type to Radial.


6 Double-click the preview in the title bar of the Gradient map node to enlarge the preview.


The center of the map, where it is white, will be completely opaque, while the black areas at the edges will be completely transparent.
You will use the Gradient map's Noise controls to make this pattern more irregular, to obtain a more natural appearance.

7 In the Noise group, change the type to Fractal.
Noise:


8 Also in the Noise group, change these settings:
■ Amount \(=0.3\)
■ Levels \(=\mathbf{1 0 . 0}\)
■ Size \(=\mathbf{5 . 0}\)


Now the opacity pattern appears more natural, but retains the opaque center and transparent edges.


9 Drag a Noise map from the Browser to the active View, and wire the new Noise node to the Color 2 component of the Gradient map node.


By now, you will have to use some of the Slate Material Editor navigation tools to move around the tree of the Smoke map, which is becoming fairly elaborate.

10 Double-click the Noise map node so you can see its parameters.
11 Change the Noise map settings as follows:
- Noise Type = Fractal
- Levels = \(\mathbf{1 0 . 0}\)

■ Noise Threshold > High = 0.7
■ Noise Threshold \(>\) Low \(=\mathbf{0 . 3}\)
(Do not change the colors or the Size value.)


12 Look at the preview for the Gradient map.


Now the opacity map is even more irregular.
13 Drag a second wire from the same Noise map, and wire it to the Color 3 component of the Gradient map.


Now Color \#2 and Color \#3 of the Gradient map both use the same Noise map.


Decrease opacity as the particles age:
1 Click and Ctrl+click to select both the Noise map and the Gradient map, then Shift+drag to clone both nodes.

(You need to select both nodes; otherwise, the Gradient is copied but the Noise map remains an instance, or vice versa.)

2 Wire the new Gradient node to the Color 2 component of the Particle Age map.


3 Clone the Noise/Gradient node pair again, and wire this new combination to the Color 3 component of the Particle Age map.


4 Double-click the Particle Age map node (for Opacity) to see its parameters. Now all three particle ages have a Gradient map with Noise.


5 Double-click the Noise map node connected to the Gradient map that is connected to Color 2.

6 In the Noise Parameters rollout, click the Color \#2 color swatch. In the Color Selector, change V=161, and then click OK.


The darker color makes particles more transparent in midlife.
7 Double-click the Noise map node connected to the Gradient map that is connected to Color 3.

8 In the Noise Parameters rollout, click the Color \#2 color swatch. In the Color Selector, change V=64, and then click OK.


The new Color \#2 value makes the particles even more transparent as they near the end of their life.


You now have good, realistic smoke.

\section*{Add shadows to the scene:}

1 On the main toolbar, click
 (Select By Name).

2 In the Select From Scene dialog, click to highlight the light Direct01, and then click OK.



Modify panel, \(\boldsymbol{>}\) General Parameters rollout \(>\) Shadows shadows for the Directional light. group, turn on shadows for the Directional light.
\begin{tabular}{l} 
Shadows \\
On \(\square\) Use Global Settings \\
Ray Traced Shadows \\
\hline
\end{tabular}

Now the smoke particles cast shadows onto the landscape and also onto each other, making the smoke effect even more convincing.

Now you have used Particle Flow to create a realistic smoke simulation. In the next lesson, you will add the smoke to other areas of the terrain,.

\section*{Save your work:}

■ Save the scene as smoke_material.max.

\section*{Next}

Apply the Smoke to Other Parts of the Scene on page 1725

\section*{Apply the Smoke to Other Parts of the Scene}

It would be possible to copy the original Particle Flow icon to other locations in the scene; Instead of this, we will use a special operator, Placement Paint, to generate additional sources of smoke from the single Particle Flow system.

Set up the scene:


\section*{Use Particle Paint to emit smoke from other areas of the terrain:}

1 In the Top viewport,
 zoom in once again on the area near the wrecked jeep.


2 Change the Top viewport to a Wireframe view.


3 On the


Create panel, turn on
 Flow from the drop-down list, then on the Object Type rollout, click to turn on Particle Paint.


\section*{\(\bigcirc\) Q 日曷回 \(\approx\)}

\section*{Particle Flow}

\section*{Object Type}

人
AutoGrid
SpeedByIcon Find Target
Particle Paint Birth Texture
Initial State Group Select

4 In the Top viewport，drag near the jeep to create a Particle Paint helper．


5 On the Setup rollout，change the Brush Radius value to 2．0．


6 Change the shading of the Top viewport back to Smooth + Highlights.


Select the Plane01 object, choose
 and then click this navigation button.

7


Zoom in a little more closely so you have a good view of the scorch marks.


8 Click (Maximize Viewport Toggle) to maximize the Top viewport.


10 On the Setup rollout, click to turn on Freehand Paint.


Now you are ready to paint particle seeds in the viewport.
IMPORTANT Before you go to the next step, make sure you are at frame 0 .


Click
(Go To Start) if the time slider is still at frame 300 or some other frame.

11 While Freehand Paint is active, click and drag a single stroke to paint a rough circle around the wreck of the jeep.


After you release the mouse, 3ds Max displays a number of ticks along the path you painted.


Each tick is a particle seed that eventually will generate particles for the Particle Flow system.

12 Paint a similar circular stroke on the two other scorched areas, one at the lower right (southeast) area of the terrain, and the other at the upper right (northeast) area.


Apply the Smoke to Other Parts of the Scene | 1733

13 For the lengthwise scorched area in the road, at the left (west) area of the terrain, paint a single back-and-forth stroke (in other words, go over the lengthwise area twice, but in a single motion of the Freehand Paint cursor).


14 Right-click to turn off Freehand Paint.
Your scene should now have four areas with particle seeds: the three circular scorched areas on the right (east), and the long scorched area in the road on the left (west).


\section*{15 Click \\ \(\square\) (Maximize Viewport Toggle) once again to return to a four-viewport layout.}

Now that you have placed the particle seeds, you need to add a Particle Flow operator that allows the Smoke system to use these seeds.

\section*{Add a Placement Paint operator:}

1 Restore Particle View (6).
2 From the depot, drag a Placement Paint operator, and in Event 01, drop it on top of the Position Icon operator to replace Position Icon.


3 Click the Placement Paint operator to highlight it.


The Placement Paint entry is followed by "( ??? )". This indicates that you haven't yet assigned a Particle Paint helper.

4 Move the Particle View window so you can see the Particle Paint helper icon in a viewport.

5 On the Placement Paint rollout, click the Particle Paint Helper button (initially, it is labeled "None").

\section*{Placement Paint 01}

Particle Paint Helper:


6 In a viewport, click the Particle Paint helper icon.
Particle Flow now uses the Particle Paint helper as the geometric source for particle generation.
\(\left[\right.\)\begin{tabular}{l}
\multicolumn{1}{c}{ Placement Paint 01 } \\
\hline Particle Paint Helper: \\
\left.\begin{tabular}{|l}
\hline \multicolumn{1}{c}{ Particle Paint 01 } \\
Total Particles: 1183 \\
Total Strokes: 4
\end{tabular}\(\right]\)
\end{tabular}

However, at this stage, particles are generated from a point that is the average center of all the paint seeds taken together.


7 In the Particle Paint rollout > Acquire Paint Data group, choose Paint Position To > Position.


Now Particle Flow generates particles wherever there are seeds in the scene.


8 In the Index Order group, turn on Stop If Count Overflow.


This option tells Particle Flow to stop creating particles when the number of particles in the system exceeds the number of seeds you painted. It prevents the particle system from becoming "overcrowded."

9 Hide Particle View (6).


10 Click (Go To End) to go to frame 300, then click
 Production).


Now smoke issues from all four scorched areas. It looks good, but a bit sparse: The same number of particles is now shared among the four areas.

\section*{Add a Spawn operator to increase the number of particles:}

One way to increase the number of smoke particles is simply to increase the Amount value in the Birth operator. But in this lesson, we will adjust the number of particles by using a Spawn test. This is a useful alternate technique, and using Spawn will also be a help when you create embers in the lesson that follows.

The actions in the depot that have yellow, diamond-shaped icons, are known as tests.
\begin{tabular}{|c|c|c|}
\hline Mapping & Shape Instance & （s）Script Test \\
\hline （ Mapping Object & S Shape Mark & 48 Send Out \\
\hline Material Dynamic & Speed & ＊Spawn \\
\hline Material Frequency & Speed By Icon & \(\stackrel{4}{5}\) Speed Test \\
\hline Material Static & Speed By Surface & 4）Split Amount \\
\hline －0，Placement Paint & ， D Sin & 4.5 Split Group \\
\hline ［－0．0 Position Icon & Age Test & Split Selected \\
\hline F－if Position Object & Collision & \(\stackrel{4}{4}\) Split Source \\
\hline 2）Rotation & Collision Spawn & 睉 Cache \\
\hline 固 Scale & Find Target & 回Display \\
\hline S Script Operator & Go To Rotation & 固 Notes \\
\hline Shape & （ Lock／Bond & 0 Render \\
\hline －Shape Facing & 45 Scale Test & \\
\hline
\end{tabular}

\section*{Test entries in the Particle View depot}

1 Drag a Spawn test from the depot，and drop it on Event 01 between the Material Dynamic and Placement Paint operators．
\begin{tabular}{ll} 
Event 01 ． B \\
\hline
\end{tabular}

2 Click the Spawn test to highlight it．


3 On the Spawn rollout, change the Offspring \# to 2, and change the Spawnable \% to 60.0.


This tells Particle Flow to take 60 percent of the original particles, and spawn two child particles from each of the originals.

4 Hide Particle View (6).
- render the scene.


Now the smoke is much denser.

You have now completed the smoke itself. The remaining exercise is to generate embers from the burning jeep.

\section*{Save your work:}
- Save the scene as smoke_multiplied.max.

Next
Generate Embers from the Burning Jeep on page 1743

\section*{Generate Embers from the Burning Jeep}

You will use a subset of particles to simulate not smoke, but embers (burning debris) from the jeep.

Set up the scene:
> Continue from the previous lesson, or
 open pflow_04.max.

Set aside some particles to behave as embers:
1 Restore Particle View (6).

2 Drag a Split Amount test from the depot, and drop it on Event 01 just above the Spawn test (and below the Material Dynamic operator).


3 Click the Split Amount test to highlight it.


4 On the Split Amount rollout, make sure Test True For \(>\) Fraction Of Particles is chosen, then change the value of Test True For \(>\) Fraction Of Particles > Ratio \% to 15.0.


This "siphons off" 15 percent of the original 250 particles (because the Split Amount test precedes the Spawn test). These particles will become embers.

5 Drag the Material Dynamic operator and drop it below the Spawn test.


Moving the Material Dynamic operater enables you to assign the ember particles a different material from the smoke particles.

\section*{Add a new Particle Paint helper:}

1 In Event 01, click the icon of the Display operator to turn the Display operator off.


This disables particle display in viewpors (though not in renderings). This is a temporary measure to make it easier for you to paint new particle seeds.

2 Hide Particle View (6).
3 Activate the Top viewport, and \(\stackrel{\text { zoom in on the jeep. }}{ }\)


\section*{| 4}

Go to frame 0 .

5 On the


Create panel, turn on

(Helpers). Choose Particle Flow from the drop-down list, then on the Object Type rollout, click to turn on Particle Paint.

\section*{圂品 \\  \\ \(\square\)}
○日ロ區回き
Particle Flow
Standard
Atmospheric Apparatus
Camera Match
reactor
Assembly Heads
Manipulators
Particle Flow
VRML974
CAT Objects
Name and Color
\(\bigcirc Q 8 \approx\) 回
Particle FlowObject Type人
AutoGrid
\begin{tabular}{ll|}
\hline SpeedByIcon & Find Target \\
Particle Paint & Birth Texture \\
Initial State & Group Select \\
\hline
\end{tabular}

6 In the Top viewport，drag near the jeep to create a second Particle Paint helper．


7 On the Setup rollout, change the Brush Radius value to 0.4.


Now you are ready to paint the seeds for the ember particles.

\section*{Paint where and when the embers will appear}

For the smoke, you painted all seed particles at frame 0 . For the embers, you will add them at particular frames, to distribute them in time as well as in space.

1 Make sure Particle Paint 002 is still selected, then go to the


Modify panel.

2 In the Top viewport, zoom in even more closely, so you can see the geometry of the jeep.


3 On the
Modify panel \(\boldsymbol{>}\) Setup rollout, click to turn on Freehand Paint.


4 At frame 0, paint two short strokes on the body of the jeep.


5 Drag the time slide to frame 80, and paint two more strokes.


6 Add an additional two short strokes at the following frames:
- Frame 160
- Frame 240
- Frame 280

When you are done, the jeep will be fairly well covered with particle seeds.


7 Right-click to turn off Freehand Paint.

\section*{Add the embers to the particle system:}

1 Restore Particle View (6).
2 Drag a Placement Paint operator from the depot to the gray area of the event display.


When you drop an event (an operator, test, and so on) the empty part of the event display, Particle Flow creates a new event. Initially, the new event contains the operator you dropped, and a Display operator.

TIP To rearrange events and the root PF Source entry in the event display, simply drag the entry by its title bar.

3 In Event 02, click the Placement Paint operator to highlight it.


4 Move Particle View so you can see a viewport that shows the Particle Paint 002 helper icon.

5 On the Placement Paint rollout, click the Particle Paint Helper button (initially, it is labeled "None").

\section*{Placement Paint 01 시}

Particle Paint Helper:


Total Strokes: 0

6 In a viewport, click the Particle Paint 002 helper icon.
Event 002 will use Particle Paint 002 as the source for generating ember particles.
\(\left[\right.\)\begin{tabular}{l} 
Placement Paint 02 \\
\hline Particle Paint Helper: \\
\hline \multicolumn{1}{|c}{ Particle Paint 02 } \\
Total Particles: 1035 \\
Total Strokes: 10
\end{tabular}\(]\)

7 In the Particle Paint rollout > Acquire Paint Data group, choose Paint Position To > Position.

\section*{Acquire Paint Data:}

\section*{Paint Position To: \\ Q) Position Script Vector Snap If Close}

Snap Distance:

8 In the Index Order group, turn on Stop If Count Overflow.
Index Order:
Type: Random
Vtop If Count Overflow Wbey Quantity Multiplier
Separate Streams Indexing

9 In the event display, the round blue sockets that protrude from test actions are known as test outputs. When you move the cursor over a test output, it changes to indicate the test is available for wiring.


Connect the Split Amount test to Event 02 by dragging a wire from the Split Amount test output to the input socket of Event 002.


Particle Flow wires the test to the new event.


Now Event 002 can use the particles that Split Amount sends to it.
10 Hide Particle View (6).
11 Drag the time slider.


Some embers fly upward and outward, while others hover near the jeep.
TIP If the ember particles are hard to see in viewports, click either the color swatch on the Display rollout, or the color dot on the Display operator entry in Event 02.


Clicking either the swatch or the dot displays a Color Selector that lets you change the display color.

\section*{Adjust the ember particle behavior:}

1 Drag a Speed operator from the depot, and drop it on Event 02.


2 Click the new Speed operator to highlight it.


3 On the Speed rollout, change the value of Speed to 20.0, and the value of Variation to \(\mathbf{1 0 . 0}\).


Now the particles move more slowly, and they all move vertically upward as the smoke particles initially did.


You will add space warps so the particles come back down to earth. But first, you will adjust how the particles appear in viewports and renderings.

4 Drag a Shape operator from the depot, and drop it on Event 002.


5 Click the new Shape operator to highlight it.


6 On the Shape rollout, leave 3D chosen, and choose Sphere 20-Sides from the 3D drop-down list.


7 Change the Size value to \(\mathbf{1 . 5}\).
\begin{tabular}{|c|c|c|}
\hline \multicolumn{3}{|c|}{Shape 01} \\
\hline - 2 D & Triangle & - \\
\hline (0) 3D & Sphere 20-s & - \\
\hline \multicolumn{3}{|l|}{\begin{tabular}{l}
Vertices: 12 \\
Faces: 20 \\
Shapes: 1
\end{tabular}} \\
\hline \(\square\) Sca & \% 1.5 & \\
\hline \multicolumn{3}{|l|}{Variation \% 0.0} \\
\hline \multicolumn{3}{|l|}{Multi-Shape Random Order
Generate Mapping Coords.
Fit Mapping} \\
\hline \multicolumn{3}{|l|}{Uniqueness:} \\
\hline \multicolumn{3}{|l|}{Seed: \(\sqrt{23232}\) |ㅂV New} \\
\hline
\end{tabular}

8 Click to turn on Scale \%. Leave its value at the default of 100.0.


9 In Event 002, click the Display operator to highlight it.


10 On the Display rollout, choose Geometry from the Type drop-down list.
\(\left[\right.\)\begin{tabular}{ll}
\multicolumn{1}{|c}{\(\begin{array}{l}\text { Display 01 }\end{array}\)} \\
\hline Type: \(\begin{array}{ll}\text { Ticks } \\
\text { Visible } & \begin{array}{l}\text { None } \\
\text { Dots }\end{array} \\
\square \text { Show } & \begin{array}{l}\text { Ticks } \\
\text { Circles }\end{array} \\
\text { Selected: } \\
\text { Lines } \\
\text { Bounding Boxes } \\
\text { Geometry }\end{array}\) \\
\hline \(\begin{array}{ll}\text { Siamonds } \\
\text { Boxes } \\
\text { Asterisks } \\
\text { Triangles }\end{array}\) \\
\hline
\end{tabular}

Now the ember particle geometry is visible in viewports.


\section*{Add a Wind space warp to propel the embers:}

1 Hide Particle View (6).

2 On the


Create panel, click to turn on
 (Space Warps).

3 On the Object Type rollout, turn on Wind.


4 In the Top viewport, drag to create a Wind space warp centered on the jeep.


The new space warp is a little easier to see in the Perspective viewport.


5 Name the new Wind space warp Explosion.


6 In the Parameters rollout > Force group, change the wind direction to Spherical.


7 Also in the Force group, change the value of Strength to \(\mathbf{0 . 0 2}\).

Force

- Planar © Spherical

8 In the Parameters rollout > Display group, change the Icon Size value to 0.6.


The Explosion space warp will propel the embers in circular paths.

Add a Gravity space warp so the embers will fall back to earth:
1 On the Create panel > Object Type rollout, turn on Gravity.


2 In the Perspective viewport, drag near the jeep to create a Gravity space warp.


3 In the Parameters rollout
Display group, change the Icon Size value to 1.2.


4 In the Parameters rollout > Force group, change the Strength value to 0.04 .


The force of gravity is slightly greater than the force of the wind.

Now you can use the space warps to control the ember particles.
Include the space warps in the particle system:
1 Restore Particle View (6).

2 Drag from the depot to add a Force operator to Event 02.


3 Click the new Force operator to highlight it.


4 On the Force rollout, click By List.


5 In the Select Force Space Warps dialog, click and Ctrl+click to select the space warps Explosion and Gravity001, then click Select.


Now the combination of a (spherical) wind and gravity will control the ember particles.

6 Hide Particle View (6).

7 Drag the time slider or
- play the animation.

The embers fly out of the jeep, then fall back to the earth. They are easiest to see in the Perspective viewport. They look rather large: But as with the smoke particles, the material you apply will help fix their appearance. Creating that material is the subject of the next procedure.


NOTE If you were modeling more solid particles (for example, solid chunks of the jeep), you might want to add a Collision test that would detect when the particles fell to the ground (Plane01). For this tutorial, that isn't necessary.

\section*{Create a material for the glowing embers:}

1 On the main toolbar, click

(Material Editor). to display the Slate Material Editor.

2 Right-click the blank area above the active View, and from the pop-up menu, choose Create New View.

3 In the Create New View dialog, name the new view Embers.


4 Drag a Standard material entry from the Materials \(>\) Standard group into the Embers view, and double-click the new Standard node to display its parameters.

5 Name the material Embers.
6 Click the Diffuse color swatch, and in the Color Selector, change the Diffuse color to \(\mathrm{RGB}=\mathbf{2 5 5} \mathbf{1 5 6}, \mathbf{0}\). Click OK to close the Color Selector.

7 Click to turn off the button that locks the Ambient component to the Diffuse component.
8 Click the Ambient color swatch, and in the Color Selector, change the Ambient color to \(\mathrm{RGB}=\mathbf{1 8 6}, \mathbf{0}, \mathbf{0}\). Click OK to close the Color Selector.

9 In the Self Illumination group, change the self-illumination value to 50 (percent).
Increasing the self-illumination value makes a material appear to glow.


10 In the Specular Highlights group, change the Specular Level value to 171, and the Glossiness value to 34 .

\section*{Specular Highlights}

\section*{Specular Level: \(\sqrt{171}|\stackrel{\mid}{\nabla}|\) \\ Glossiness: \(\sqrt{34} \left\lvert\, \frac{\Delta}{\square}\right.\) \\ Soften: \(0.1^{2}\)}


The highlights make the material appear brighter.


11 Drag a Falloff map from the Browser to the Embers view, and wire it to the Opacity component of the Embers material.


By default, the falloff map makes the edges opaque and the center transparent: This is the opposite of the effect we want.


12 Double-click the Falloff node so you can see its parameters.

13 On the Falloff Parameters rollout, click
 (Swap Colors/Maps). Now the center is opaque, and the edges are transparent.


TIP The Falloff map is good alternative for making the edges of particles transparent, when the particles are three-dimensional.

14 Drag the Standard material node's output socket to an unused sample slot in the Material/Map Browser \(>\) Sample Slots group. Choose Instance, and then click OK.

15 \(\boxed{X}\) Close the Slate Material Editor.

Add the embers material to the particle system:
1 Restore Particle View (6).

2 Drag from the depot to add a Material Static operator to Event 02.


You can use a Material Static operator for the embers event, because the material doesn't change over time.

3 Click the new Material Static operator to highlight it.


4 On the Material Static rollout, click the Assign Material button (initially it is labeled, "None").


5 In the Material/Map Browser > Sample Slots group, double-click the Embers material.


You can see the embers effect most clearly by renering the Perspective viewport. (For this illustration, we turned off rendering for the smoke particles.)


Up close, the embers still don't look too realistic. But they will look all right when you render the Camera01 viewport, and you will enhance the effect by adding motion blur to the embers. That is the subject of the next procedure.

\section*{Add motion blur to the embers:}

1 In Particle View, click the title bar of Event 02 to select the entire event.


2 Right-click, and from the pop-up menu, choose Properties.


3ds Max opens an Object Properties dialog for Event 02.
3 In the General panel > Motion Blur group, make sure Enabled is turned on, then click to choose Image.
```

Motion Blur
Multiplier: 1.0 |⿻| | By Object
V Enabled
ONone OObject QImage

```

4 Also in the Motion Blur group, change the Multiplier value to \(\mathbf{1 0 . 0}\).


5 Click OK to close the Object Properties dialog.
6 Activate the Perspective viewport, drag the time slider until you have a
frame with embers in it, then
 render the scene.


3ds Max renders the frame, and then in a second pass, adds motion blur to the ember particles. (For this illustration, we turned off rendering for the smoke particles, once again.)

In the Camera01 viewport, the effect is subtle because the embers are at a distance. The motion blur effect is most apparent when you play the animation.


\section*{(Optional) Render the animation:}

1 On the main toolbar, click

(Render Setup). 3ds Max opens the Render Setup dialog.

2 In the Time Output group, choose Active Time Segment.


TIP Rendering at the full resolution of \(1024 \times 554\) can take a lot of time. Before you render, you might want to reduce the size of frames in the movie; for example, to \(500 \times 271\). Smaller frames render more quickly.


Image Aspect: 1.84838

3 Scroll down to the Render Output group, and click Files.


3ds Max opens a file dialog. Enter a name for the file, choose a movie file type (AVI or MOV), and then click Save. 3ds Max opens a compression setup dialog for the movie format you chose. Adjust the settings or accept the defaults, and then click OK.

4 In Render Output group, make sure Save File is turned on. (By default, it turns on when you specify an output file.)

5 At the bottom of the Render Setup dialog, make sure Camera01 is chosen in the View drop-down list, and then click Render.

\section*{Save your work:}

■ Save the scene as smoke_completed.max.

To see a completed version of the smoking desert, you can
 pflow_completed.max. You can also see a completed movie of the smoke animation by choosing Rendering > View Image File. Navigate to \(\backslash\) sceneassets \(\backslash\) renderassets \(\backslash\), and then open either smoke.avi or smoke.mov.

\section*{Summary}

This tutorial demonstrated some aspects of particle systems; in particular:
- Particle Flow is a powerful, general-purpose particle system that you can use to model smoke and explosions, among other dynamic phenomena (rain, snow, and flowing water are other possibilities).

■ Particle Flow can work with space warps such as Wind and Gravity, to model real-world behavior.
- The Particle Flow Shape Facing operator is good for creating particles whose appearance is controlled by their material. You can design materials (for example, with a Noise map) to simulate more complex geometry.
- The Particle Age map lets you create materials that change over time as particles can.
- For flat particles, using a radial Gradient map for opacity can disguise the edges of the particles. For three-dimensional particles, using a Falloff map for opacity can accomplish the same thing.
- The Particle Paint helper in combination with the Placement Paint operator lets you set particle location by freehand strokes, and apply the same Particle Flow system to multiple locations in a scene.
- Particle Paint also lets you set particle generation at different frames in an animation.
- The Split Amount test is one way to treat a set of particles differently from the original set.

■ Applying Image Motion Blur to fast-moving particles can improve their appearance in animations.

\section*{Interoperability Tutorials}

One of the strengths of 3ds Max is its ability to share data with other Autodesk products. The FBX data format is one of these solutions. In this chapter, you learn how to rig and animate a character with the MotionBuilder character-animation tool, and then use the animation you created in 3ds Max.


MotionBuilder animation mapped onto a 3ds Max charater

\section*{MotionBuilder Interoperability}

Part of your development pipeline might take you to MotionBuilder, a powerful 3D character-animation suite.

With MotionBuilder, you can quickly and easily rig characters, then set up their animation using a full-body FK/IK manipulation rig. You can also retarget animation data between characters, as well as blend, edit, and sequence tracks in a timeline editor, combining animation with cameras, digital video, and audio.

As you build your animation, MotionBuilder provides real-time playback of character performance. There is no need to preview or render your work.

This tutorial shows you how to import a character to MotionBuilder, add animation using both the FK/IK manipulation rig as well as data from a motion-capture file, then export your work back to 3ds Max as a fully editable animated character.


In this tutorial, you will learn how to:
■ Label 3ds Max biped skeletons for easy conversion to MotionBuilder
■ Export a 3ds Max biped as an FBX file, then import to MotionBuilder
- Characterize a skeleton in MotionBuilder for animation as a full FK/IK rig
- Animate a character in MotionBuilder based on motion-capture data
- Use keyframes to fine-tune character movement

■ Export character animation as an FBX file from MotionBuilder, then import to 3ds Max
- Fine-tune character animation in 3ds Max.

Skill level: Intermediate
Time to complete: \(11 / 2\) hours

\section*{Preparation for This Tutorial}
- On the Quick Access toolbar, click
current project to Autodesk 3ds Max 2011 Tutorials.


\section*{Preparing 3ds Max Scenes for Export}

This lesson shows you how to take characters created in 3ds Max and prepare them for import to MotionBuilder.

\section*{Set up the lesson:}
- On the Quick Access toolbar, click

(Open File), navigate to Iscenes\interoperability\motionbuilder and open basics.max.

NOTE If your system units are set to anything other than Centimeters, a File Load: Units Mismatch dialog opens, prompting you to choose which unit scale to use. Turn on Adopt the File's Unit Scale and click OK.

The scene contains, from left to right, a mesh character and three skeletons that can be used to drive the mesh.


Mesh and three skeletons

Left: Mesh

\section*{Second from left: Skeleton A}

Third from left: Skeleton B

Fourth from left: Skeleton C

Skeleton A is made up of a conventional Bones system. Skeletons B and C are 3ds Max Biped systems.
Before MotionBuilder can recognize a model as a character that can be animated, its skeleton bones must be characterized. A model can be characterized only if its bones are labeled in a specific way. You can rename character bones in MotionBuilder, but it is a good idea to rename them properly in 3ds Max whenever you can.

View skeleton bone hierarchy and naming conventions:

1


Region-select Skeleton A, then right-click and from the quad menu, choose Isolate Selection.


Skeleton created from a conventional bone system

2 On the main toolbar, click (Select By Name).
3 On the Select From Scene dialog, choose Display \(>\) Display Children and then Display \(>\) Expand All. Scroll the list to view the skeleton hierarchy and see how each bone is named.


This is the naming convention recognized by MotionBuilder. If you name the skeleton bones this way, you can later characterize them in MotionBuilder with a simple click of the mouse.

4 Click Cancel to close the Select From Scene dialog, and then click Exit Isolation Mode to display the whole scene again.


Region-select Skeleton B, then right-click and from the quad menu, choose Isolate Selection.

6 On the main toolbar, click

(Select By Name).


The Select From Scene dialog opens, showing the bone hierarchy of the Skeleton B and its identifying names. This naming convention is the default for Biped. While it is different from the convention used by Skeleton A, MotionBuilder also recognizes it, and it can be used to quickly convert skeletons for animation.

7 Repeat steps 4 through 6 to isolate Skeleton C and view its skeleton hierarchy.


Even though the suffix of each bone name in Skeleton C is identical to the name suffixes in Skeleton B, the prefix to each bone name, "MIA," is different. MotionBuilder recognizes prefix changes for biped skeletons.

8 Click Cancel to close the Select From Scene dialog, and then click Exit Isolation Mode to display the whole scene again.

\section*{Exporting Scenes to MotionBuilder}

This lesson shows you how to export 3ds Max scene data in .fbx format to MotionBuilder. You can export an entire scene, or only a portion of the scene containing selected elements.

Set up the lesson:
- If you are continuing from the previous lesson, from the


Application menu choose Reset, do not save any changes, then reopen basics.max.

\section*{Export skeleton A in FBX format:}

1
Region-select all of skeleton A.


Notice that the skeleton has been positioned in a "T" pose, the stance commonly used by animators for skinning. You should always place your characters in this position before you export them to MotionBuilder.
Also, skeletons must be oriented in the minus Y axis direction. (All 3ds Max Biped systems are oriented this way when you create them.)


Skeleton A oriented in a minus Y direction

2 From the


Application menu, choose Export \(\boldsymbol{>}\) Export Selected.
3 In the Select File To Export dialog > File Name field, type mybone-skeleton and click Save.

NOTE The default location for the exported FBX file is the lexport folder in the current project.

3ds Max opens the FBX Export dialog. Here, you specify how to convert the 3ds Max scene information.

NOTE For conversion to take place properly, you must have the latest FBX driver installed. If this is the first time you have used FBX export, the dialog will prompt you to check for updates. You can also check if you are not sure whether you have the latest version: Click the Web Updates button in the Information group.
FBX Plug-in version: 2011.1.Beta1

4 On the FBX Export dialog, expand the Include > Animation group, and turn off the Animation check box.


This option should be turned on only when the scene you want to export has animation.

5 Close the Animation group, expand the Embed Media group, and Make sure Embed Media is also turned off (it should be off by default).


If you were exporting a mesh with a character, the Embed Media option would embed in the FBX file any texture maps associated with the character. But since you are exporting a skeleton only, this option is not needed.

6 Expand the Advanced Options \(>\) Axis Conversion group, and make sure Up Axis displays the Y-Up option (once again, this should be the default).
\begin{tabular}{|c|c|c|c|}
\hline - & \multicolumn{2}{|l|}{Advanced Options} & \\
\hline \(\pm\) & \multicolumn{2}{|r|}{Units} & \\
\hline \multirow[t]{2}{*}{=} & \multicolumn{2}{|l|}{Axis Conversion} & \\
\hline & Up Axis: & Y-up & * \\
\hline
\end{tabular}

This setting assigns the exported character a Y-up axis, the orientation used by objects in MotionBuilder. This setting is required because objects created in 3ds Max use a Z-up orientation.

7 Expand the Advanced Options > FBX File Format group, and choose the FBX version that is compatible with the version of MotionBuilder installed on your system.


In this case, we have MotionBuilder 2010 installed, so we chose FBX 2010 as the version to export.

8 Click OK to export Skeleton A as an FBX file.
Typically, you would also export a mesh, properly skinned onto a skeleton. This is what you do in the next procedure.

\section*{Export the Pepe character:}

1 On the Quick Access toolbar, click
 (Open File).

2 Do not save your scene file when prompted, and from the Open File dialog, choose pepe_biped.max.


Scene consists of a biped skeleton inside a mesh

3 On the main toolbar, click

Select From Scene
Select Display Customize


Name
- PEPE_Mesh
\(\pm{ }^{2} \mathrm{Bip} 01\)

The Select From Scene dialog opens, showing both the mesh and the biped. The biped hierarchy uses a naming convention recognized by MotionBuilder.

4 Click Cancel to close the dialog. On the main menu, turn on (Select And Move).

5 Move Pepe's right foot bone in any direction to see how the skinning controls the character behavior.


6 Right-click or click

(Undo) to undo the foot motion.


Application menu, choose Export, and in the File Name field, type my_pepe_biped01.

8 In the FBX Export dialog \(>\) Embed Media group, turn on Embed Media. Make sure the other export settings are the same as you used for the Bones skeleton, then click OK.
\begin{tabular}{|ll|}
\hline\(\square\) & Cameras \\
\(\square\) & Lights \\
\(\square\) & Embed Media \\
& Embed Media \\
\hline
\end{tabular}

The FBX Exporter displays a warning message. This is because Pepe has a Multi/Sub-Object material that FBX and MotionBuilder don't recognize. We don't plan to render Pepe in MotionBuilder (after animating in

MotionBuilder, you import the Pepe model back into 3ds Max), so the warning is not important: Click OK to dismiss it.

You might see an additional warning that says "Unsupported controller (1) / Turned edges (1)": This is because the Pepe mesh is an Editable Poly object, rather than an Editable Mesh. This doesn't affect the workflow, so dismiss this warning, too.

The Pepe character is exported as an FBX file to the same folder as the biped skeleton you saved earlier.

\section*{Rename the biped:}

1 In the viewport,

select any bone in the biped skeleton.

2 Go to the
Motion panel \(>\) Biped rollout, expand the Modes And Display group, and in the Name field, type PEPE.


3 On the main toolbar, click


The Select From Scene dialog displays the modified names of the character parts. Each bone is now identified by the PEPE prefix.


4 Click Cancel to close the Select From Scene dialog.
5 Export this modified scene as you did in steps 6 and 7 of the previous procedure, but name the exported file my_pepe_named.
In the next lesson, you will use this FBX file to learn how to import custom-named characters into MotionBuilder.

\section*{Save your work:}

1 Save your 3ds Max scene as my_pepe.max.
2 Exit 3ds Max.
In the next few lessons, you will be working in MotionBuilder.

\section*{Importing Scenes to MotionBuilder}

This lesson shows you how to import an FBX file to MotionBuilder and characterize the bones of the skeleton you need to animate. You will then assign the skeleton a control rig.

\section*{Import a skeleton:}

1 Start


MotionBuilder.
2 Choose Layout > Editing so the MotionBuilder layout will correspond to that shown in these lessons.

3 In MotionBuilder, on the Asset Browser explorer panel, right-click a blank area of the folder list and choose Add Favorite Path.


4 On the Open Directory dialog, navigate to the \3ds Max 2010 tutorials \export folder. Highlight the folder and click OK.
The folder displays as a shortcut in the Asset Browser
NOTE An lexport folder is also provided with MotionBuilder: By default, this one contains only a couple of files.

5 Click the folder name so you can view its contents.
The folder contents display in the right-hand pane of the Asset Browser.


Now you have fast access to the FBX files you want to import into MotionBuilder.

If you had saved your FBX files from MotionBuilder instead of from 3ds Max, you could open them simply by dragging their file icon from the Asset Browser into the Viewer. However, dragging the icons of FBX files created in external applications launches a series of dialogs that prompt you for more information. Because of this, it is easier to import files created in 3ds Max through an FBX Plug-in Import dialog.

6 From the main menu, choose File \(>\) FBX Plug-In Import.
7 On the Open File dialog, navigate to the \3ds Max 2010 tutorials \export folder, highlight mybone-skeleton.fbx, and click Open.
If you like, you can import the presaved file _bone_skeleton.fbx, instead.
8 On the FBX Plug-In Import Options dialog, leave the default settings unchanged, and click Open.
The MotionBuilder Viewer window displays the MotionBuilder equivalent of the Bones skeleton you exported from 3ds Max.


Familiarize yourself with Viewer navigation in MotionBuilder:
Pause now and take a moment to try a few MotionBuilder navigation techniques.

1 Press Ctrl+Shift+drag to orbit around the scene.
2 Ctrl+drag to zoom in and out of the scene.
3 Shift+drag to pan the scene.
TIP You can also use the ViewCube to navigate the scene. The ViewCube in the MotionBuilder Viewer behaves the same as it does in 3ds Max viewports.

\section*{Characterize the skeleton:}

Now you need to characterize the skeleton bones before you can animate them. Characterization is the way you rig a skeleton in MotionBuilder.

\section*{1 On the Asset Browser, click Templates \(>\) Characters.}

2 Drag the Character tool from the Asset Browser, and drop it on the skeleton's center of mass.


When you release the mouse, a pop-up menu shows the Characterize option.


3 Click Characterize.
4 On the Character dialog, click Biped to indicate the type of rigging to apply to the character (the other choice is Quadruped).


NOTE As the dialog mentions, the character must be in a "stance" (" T ") pose and be facing in the positive \(Z\) axis (the equivalent of the negative \(Y\) axis that you converted when exporting the .max file into .fbx format).

5 On the Character Controls window, choose Edit \(>\) Control Rig Input.


You must choose this setting if you intend to keyframe your character.
6 On the Create Control Rig dialog, click FK/IK.

\section*{Create Control Rig}

What type of control rig do you want to create?

\section*{FK/IK} IK Only Cancel

FK/IK is the method commonly used to animate characters.
7 In the Character Controls window \(>\) Active group, turn on Ctrl Rig In.


This setting activates the Character Controls \(>\) Character Representation to the left. The Character Representation is an image of a biped, with all the effectors you need to animate the control rig.
Your character is now rigged and ready to receive animation.
Because your character bones were properly labeled, it took just seven steps to successfully rig your character. In 3ds Max, rigging a character using regular FK/IK constraints would have taken a great deal more effort.

\section*{Animate the skeleton:}

1 On the Character Controls pane \(>\) Character Representation, click to select the right hand effector.


2 With your mouse over the Viewer, press T (for Translate), and move the hand down. As you continue to move the hand, the arm extends, and the rest of the body reacts in a natural movement.


\section*{Characterize a Biped skeleton:}

1 From the main menu, choose File \(>\) New. Do not save the skeleton animation.

2 Choose File > FBX Plug-In Import.
3 On the Open File dialog, navigate to the \3ds max tutorials \(\backslash\) export \(\backslash\) folder, highlight турере_biped01.fbx and click Open.

If you like, you can import the presaved file_pepe_biped_bip01.fbx, instead. On the FBX Plug-in Import dialog, leave the default settings unchanged and click Open.

The Pepe character mesh displays in the Viewer.


4 Place the cursor anywhere inside the Viewer and press A.
Pressing A is the equivalent of using Zoom Extents in 3ds Max. It zooms in to all visible objects in the Viewer.

5 With your cursor still in the Viewer, press Ctrl+A to obtain a skin-only view. Press \(\mathrm{Ctrl}+\mathrm{A}\) again to switch to X -ray mode.


Pepe character in X-ray mode

In this mode, you can view and select both the character mesh as well as the bones, either individually or by region selection.

6 Drag the Character icon from the Asset Browser into the Viewer, then release the icon over the skeleton's center of mass, as shown in the next illustration.


Pepe character center of mass

7 On the pop-up menu, click Characterize.
An error message displays, indicating that the characterization of the bones could not be completed. This is because MotionBuilder could not recognize the names that identify the Pepe character bone system.

\section*{Character Definition Error}

The characterization process could not be completed because some required nodes are missing or do not follow naming conventions. Click Ok to view a list of the missing nodes.

Ok
Close

8 Click OK.
A list displays all the bones MotionBuilder could not find.

\section*{Character Definition Error: Missing Nodes}

The following required nodes are missing and need to be mapped using the Character Definition pane.
- Hips
- LeftUpLeg
- LeftLeg
- LeftFoot
- RightUpLeg
- RightLeg
- RightFoot
- LeftArm
- LeftForeArm
- LeftHand
- RightArm
- RightForeArm
- RightHand

Close

9 Click Close, then go to the Navigator window, expand the Characters list, then double-click the Character entry.


10 If the Character Definition pane is not already active, click the Character Definition tab.

11 In the left-hand column, expand the Base (Required) list.
\begin{tabular}{|c|c|c|c|}
\hline Character Definition & \multicolumn{3}{|l|}{Character Settings} \\
\hline \multirow[t]{3}{*}{Character:
\(\square\) Characterize} & & & \\
\hline & & & Clear Mapping \\
\hline & Mapping List & Naming Template & \\
\hline Reference & <Drop Object Here> & <Not Set> & \\
\hline Left Foot Floor & <Drop Object Here> & <Not Set> & \\
\hline Right Foot Floor & <Drop Object Here> & <Not Set> & \\
\hline Left Hand Floor & <Drop Object Here> & <Not Set> & \\
\hline Right Hand Floor & <Drop Object Here> & <Not Set> & \\
\hline Base (required) & & & \\
\hline + Auxiliary & & & \\
\hline + Spine & & & \\
\hline
\end{tabular}

The Mapping List in the Character Definition pane shows all the skeleton components whose mapping conversion was not recognized by MotionBuilder. The Base (Required) list shows the most crucial of these.
\begin{tabular}{|c|c|c|}
\hline & Mapping List & Naming Template \\
\hline \multicolumn{3}{|l|}{- Base (required)} \\
\hline - Hips & <Drop Object Here> & <Not Set> \\
\hline - LeftUpLeg & <Drop Object Here> & <Not Set> \\
\hline - LeftLeg & <Drop Object Here> & <Not Set> \\
\hline - LeftFoot & <Drop Object Here> & <Not Set> \\
\hline - RightUpLeg & <Drop Object Here> & <Not Set> \\
\hline - RightLeg & <Drop Object Here> & <Not Set> \\
\hline - RightFoot & <Drop Object Here> & <Not Set> \\
\hline - Spine & Bip01 Spine & <Not Set> \\
\hline - LeftArm & <Drop Object Here> & <Not Set> \\
\hline - LeftForeArm & <Drop Object Here> & <Not Set> \\
\hline - LeftHand & <Drop Object Here> & <Not Set> \\
\hline - RightArm & <Drop Object Here> & <Not Set> \\
\hline - RightForeArm & <Drop Object Here> & <Not Set> \\
\hline - RightHand & <Drop Object Here> & <Not Set> \\
\hline - Head & Bip01 Head & <Not Set> \\
\hline
\end{tabular}

The standard MotionBuilder character template works well for 3ds Max Bones systems, but it is not set up for Biped skeletons. You will try again with the Biped template.

\section*{Change the template to a Biped template:}

1 In the Navigator list, click the Character entry to highlight it, then right-click and choose Delete.

2 Drag the 3ds Max Biped Template from the Asset Browser to the Viewer, and drop it on the Pepe character's center of mass.
This tool is similar to the Character tool you used earlier, but it is designed to recognize the bones of a biped object created in 3ds Max (bones that use the Biped link-naming convention for their suffixes).

3 On the pop-up menu, choose Characterize.
4 On the Character Controls window, choose Edit \(>\) Control Rig Input.
5 On the Create Control Rig dialog, click FK/IK.


6 In the Character Controls window \(>\) Active group, turn on Ctrl Rig In.
7 On the Character Control pane > Character Representation, click to select the right hand effector, then with your mouse over the Viewer, press T for Translate, and move the hand.


The Pepe skeleton is fully rigged.
8 Go to the Navigator window, double-click the Bip01 entry, and on the Character Definition pane, expand the Base (Required) list.

Character Definition Character Settings


The Mapping List column shows how the 3ds Max Biped Template tool has characterized the bones by mapping their conventional Biped names onto the default MotionBuilder naming convention, shown in the Base (Required) list. No Naming Template was used.

You can characterize any Biped skeleton this way, regardless of the prefix given to the bones of the biped. If you want to, try it with the file you saved earlier called my_pepe_named.fbx (or use the presaved file _pepe_biped_pepe.fbx).

\section*{Save your work:}

■ Choose File > Save As, and save the file as mypepe_rigged.fbx. In the Save Options dialog, accept the defaults, then click Save.

\section*{Animating Characters In MotionBuilder}

In MotionBuilder, you can animate characters by setting keyframes manually or by using motion-capture data. This lesson shows you how to do both.

NOTE If you already know how to animate characters in MotionBuilder, you can skip this lesson and go to the next lesson on page 1835.

Load Pepe with characterization:

1 In
MotionBuilder, from the main menu, choose File
New.
2 In the Asset Browser > Export folder, click to highlight pepe_biped_characterized.fbx.


This file contains the Pepe character you worked on in the last few lessons. To speed things up, he has already been characterized and saved in MotionBuilder, so he is ready to receive animation.

3 Drag pepe_biped_characterized.fbx to the Viewer.
4 On the pop-up menu that appears, choose FBX Open \(>\) <All Takes>.


MotionBuilder has the ability to store multiple animation "takes" or sequences within the same project, and this option would open all of them if they existed. Alternatively, you could choose <No Animation> or Take 001.

5 With the cursor in the Viewer, press A to zoom in to the Pepe character.
6 Press Ctrl+Shift and drag to orbit until the Pepe's right side is in view.


Pepe is ready to accept keyframe animation using control-rig input from the Character Controls window. But in this case, you will retarget animation to Pepe from one of the motion-capture files that ship with MotionBuilder.

\section*{Animate the Pepe character using motion-capture data}

1 From the Asset Browser > Export folder, choose iceslip and drag it to the Viewer.


2 A pop-up menu appears. Choose FBX Merge \(>\) IceSlip.


3 Zoom out until the yellow skeleton that represents the motion-capture animation is visible.


Pepe with skeleton containing motion-capture information

NOTE If you do not see the yellow skeleton, place your cursor in the Viewer and press Ctrl+A to exit Models Only mode.

4 On the Transport Controls, click
 (Play) to view the animation.


You will now assign this movement to the Pepe character. In MotionBuilder, this task is easy to accomplish.

Apply the animation to the Pepe character:
1 On the Character Controls window \(>\) Character Controls pane, make sure PEPE is displayed in the character list.

\section*{Character Controls}
\begin{tabular}{|l|l|l|l|}
\hline \multicolumn{2}{|c|}{ Character Controls } & Groups & S \\
\hline \hline \multicolumn{2}{|c|}{} \\
\hline PEPE & & & \(\nabla\) \\
\hline Body & Hands & Feet & \\
\hline
\end{tabular}

2 Choose Edit > Input > Skeleton2, which is the yellow skeleton containing the motion-capture animation.


3 Scrub the animation either by dragging the animation slider bar, or by holding down the J key and dragging left or right in the viewport.
The skeleton's animation now drives the Pepe character.

\section*{Identify a problem area:}

The skeleton is a good deal larger than Pepe, and when scales are mismatched in this way, you can expect that some motion doesn't translate correctly.

1 Press Ctrl+A until only Pepe is visible.
2 Drag the timeline indicator (equivalent to the 3ds Max time slider) to frame 92. You can also use the Play Controls to find the right frame.

3 Zoom in on the Pepe character.
If you look carefully, you will see how one of Pepe's hands passes into his face. You might need to orbit the Viewer and scrub the animation a few times to see the problem.


Unwanted hand movement inherited from motion capture

This behavior occurred because the animation driving Pepe's bone movement is based on the skeleton, which has a very different physiology. (Pepe's head, hands, and feet, for example, are much larger than the skeleton's, while his shoulders are much narrower.)
In the next procedure, you will correct Pepe's hand movement.

\section*{Correct the hand-in-the-face problem:}

1 On the Character Representation, click the right hand effector, then press T and try to move Pepe's hand in the viewport.

Nothing happens because Pepe's animation is controlled by the skeleton, not the control rig. Before you can go any farther, you need to bake the skeleton animation onto the Pepe character's control rig.

2 On the Character Control window \(>\) Character Controls pane \(>\) Edit menu, choose Plot Character.
\begin{tabular}{|c|c|c|c|}
\hline \multicolumn{2}{|l|}{Character Controls} & & \(x\) \\
\hline \multicolumn{2}{|l|}{Character Controls} & Groups & Sets \\
\hline \multicolumn{2}{|l|}{PEPE} & \(\nabla\) & - File \\
\hline Body Hands & Feet & - Edit & - Show \\
\hline \multirow[t]{6}{*}{} & & \multicolumn{2}{|l|}{Control Rig Input Input} \\
\hline & & \multicolumn{2}{|l|}{\multirow[t]{2}{*}{\begin{tabular}{l}
Plot Character... \\
Retarget...
\end{tabular}}} \\
\hline & & & \\
\hline & & \multicolumn{2}{|l|}{Stance Pose} \\
\hline & & \multicolumn{2}{|l|}{Edit Properties} \\
\hline & & \multicolumn{2}{|l|}{Reset Properties} \\
\hline \begin{tabular}{|l|l|}
\hline Reach T & K \\
\hline
\end{tabular} & & \multicolumn{2}{|l|}{\multirow[t]{2}{*}{Switch To Actor}} \\
\hline Reach R K & & & \\
\hline  & & \multicolumn{2}{|l|}{Expert Mode} \\
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Key Controls \\
Animation
\end{tabular}} & \(\checkmark\) & \multicolumn{2}{|l|}{\multirow[t]{2}{*}{\begin{tabular}{l}
Reach Override \\
Stiffness Override
\end{tabular}}} \\
\hline & \(\checkmark\) & & \\
\hline
\end{tabular}

3 On the Character dialog, click Control Rig.

\section*{Character}

Plot animation from input Character to...
```

Skeleton

```
 Cancel

On the second Character dialog, leave the default values unchanged, and click Plot.


Now you can edit the Pepe character using his control rig.

NOTE The Plot command creates a key at every frame at the base layer of the animation track, which makes edits difficult. Because of this, you will edit the keyframing on a different layer.

4 On the Key Controls window, click the Base Layer list and choose Layer 1.


The keyframes are hidden on the timeline, clearing your workspace.
5 Go to frame 80, which is the start of the problem hand movement. On the Character Representation, click the right wrist effector, then on the Key Controls panel, click Key.


TIP You can also create a key by placing your cursor anywhere in the Viewer and pressing K.

6 Go to frame 105, the end of the problem hand movement, and click Key again.
All character movement before the first key and after the second will remain unchanged. Only the character movement between frames 80 to 105 will be modified.

7 Go to frame 94, the midpoint between the two new keyframes you set.
8 Make sure the right hand effector is still active. In the Viewer, press T, move the hand away from Pepe's face on its X and Z axes, and create another key.


Left hand repositioned away from character's face

9 Hold down J, then drag back and forth to see how the hand reacts to the keys you just created.
Pepe's hand no longer intersects with his face while he is falling.

\section*{Correct the hand position after Pepe has fallen:}

1 Advance to the last frame of the animation and adjust the Viewer until you can see the right side of Pepe's body.


Right hand too close to the character's head

2 Move the hand away from the body and create a key.
3 Press R and use the rotate gizmo to modify the hand's position until it rests flat on the ground, then create another key.


Rotate gizmo used to reposition right hand

4 Go to frame 114 and position the right hand farther away from the head and create another key.

5
 Play back the animation to see the result. When you are satisfied with the animation, proceed to the next lesson. There, you will save your work and prepare it for import back to 3ds Max.

\section*{Preparing Animation for Export to 3ds Max}

3ds Max cannot read the control rig information that defines character animation in MotionBuilder. For 3ds Max to recognize this animation, you need to plot, or "bake," the keyframe data into the character's skeleton.

\section*{Set up the lesson:}

■ In


MotionBuilder, continue from the previous lesson, or from the main menu, choose File \(>\) New and then from the Asset Browser > Export folder, open the file pepe_biped_unplotted.fbx.

Bake animation onto the Pepe character skeleton:
1 On the Character Controls window \(>\) Character Controls pane \(>\) Edit menu, choose Plot Character.


2 On the Character dialog, click Skeleton.

\section*{Character}

Plot animation from Control Rig to...

On the second Character dialog, leave the default values unchanged and click Plot.


The character control rig is deactivated, but the Pepe character retains all animation information.

TIP If you need to edit the character's movement after its animation has been plotted, simply go back to the Character Control panel \(>\) Character Controls tab \(>\) Edit menu, and choose Plot Character \(>\) Control Rig again. When you are done, repeat steps 1 to 2 to bake the animation back onto the character skeleton.

When you save your file, you will have not only the animated character Pepe in your scene, but the reference skeleton as well. You could delete the skeleton from the scene or select the Pepe character and save it to another file for import to 3ds Max, but this is not mandatory. As you will see, you can just as easily strip out the skeleton during the import process to 3ds Max.

3 From the main menu, choose File > Save As, then in the Save File dialog, enter mypepe_biped_plotted and click Save. In the Save Options dialog, accept the defaults, then click Save.

4 Exit MotionBuilder.

\section*{Importing Animation to 3ds Max}

You can choose to import the entire contents of scenes saved in MotionBuilder, or only those elements whose names match elements in your 3ds Max scene.

The animation you import from MotionBuilder is fully editable in 3ds Max.

\section*{Set up the lesson:}

Start


3ds Max. On the Quick Access toolbar, click

(Open File). Open pepe_biped_pepe.max.
The skeleton bones in this scene file have the same PEPE prefix as the character you exported to MotionBuilder.

Import the animated character to 3ds Max:

2 On the Select File To Import dialog, navigate to the \3ds max 2011 tutorials \(\backslash\) export \(\backslash\) folder, and open mypepe_biped_plotted.fbx (or use the presaved file \import\_pepe_biped_plotted.fbx).

NOTE The presaved file is in the \(\backslash i m p o r t\) folder of the tutorial project, not the lexport folder.

3 On the FBX Import dialog, expand the Include group.
The File Content list displays Add And Update Scene Elements by default. If left as is, this setting would import not only the Pepe character, but the yellow reference skeleton as well.

4 From the File Content list, choose Update Scene Elements.


This option updates only the scene elements in 3ds Max that share the same name as those in the imported file. No new elements are imported. If you were importing animation from MotionBuilder to a new 3ds Max scene, you would instead choose the Add To Scene option.

5 Click OK.
3ds Max displays a warning about skeleton elements: The warning applies to the large MotionBuilder skeleton. You aren't using this in the 3ds Max scene, so click OK.

6 Scrub the time slider to see how the MotionBuilder animation has been baked into the bones of the Pepe character.

TIP It helps first to \& zoom out in the viewport, so you can see all of the animation.


Fine-tune the animation in 3ds Max:
1 Go to frame 0 and \(\stackrel{\text { zoom in and }}{ }\) orbit around Pepe's hands.


The character's fingers are too close to the thighs


3 Expand the Layers rollout and click
\(\square\) layer of animation.


4 On the main toolbar, click确 \(R\) Hand bone.

5 Right-click the viewport, and from the quad menu, choose Move.
6 Drag the hand away from Pepe's body on its X and Z axes.


7 Expand the Key Info rollout and click (Set Key).


8 Expand the Track Selection rollout and click
 Pepe's left hand.


9 Repeat steps 6 and 7 for the left hand, then
- replay the animation to see the result of your edits.

10 When you are satisfied with the new animation, on the Layers rollout,


\section*{Save your work:}

■ Save the scene as my_pepe_iceslip.max.

\section*{Summary}

In this series of lessons, you took a character called Pepe (consisting of a mesh and a Biped skeleton), and exported it to MotionBuilder as an FBX file. There, you characterized the biped bones, and animated the Pepe skeleton by plotting it to another skeleton whose movements were derived from motion capture. Then you baked the animation back to Pepe's control rig, made a few adjustments so that the motion better fit his cartoon-like dimensions, and baked the animation back into Pepe's skeleton for export to 3ds Max. Finally, you fine-tuned Pepe's body motion using the fully preserved Biped edit functionality.

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[^0]:    Cannon texture

[^1]:    $==$
    9 On the ribbon > Edit panel, turn on (SwiftLoop), then in the viewport, add two vertical edge loops. Each loop should be near the middle of the sky area, on either side of the peak of the roof.

[^2]:    4 On the ribbon $>$ Modify Selection panel, click $\rightleftharpoons$ (Ring).
    The Ring tool selects a ring of comparable edges, about the circumference of the cowl.

[^3]:    gr
    5
    Extrude the tail polygons a final time, stopping just shy of the top of the tail as shown in the blueprint images.

[^4]:    TIP You might want to
     zoom in more closely on the chessboard in di y pan a bit, to see it better. It is shown the Perspective viewport, and this way in the illustrations that follow.

[^5]:    Auto Key
    (Auto Key) and rotate the steering wheel until the

[^6]:    Shorten the duration of footstep 10.

[^7]:    Twist Poses

