



# Tutorials

## Lighting & Rendering

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9

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# 6 Lighting and Rendering

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## Lighting and Rendering Tutorials

The tutorials in this section relate to different lighting and rendering features that let you produce outstanding images and animations with 3ds Max. You will learn how to use a variety of lighting methods, how to render still images and animation, and how to use three powerful features in mental ray for achieving global illumination.

### Files for This Section

All the files necessary for this tutorial are provided on the program disc in the *tutorials* directory. Before starting the tutorials, copy the *tutorials* folder from the disc to your local program installation.

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## Introduction to Lighting

Lights are objects that simulate real lights such as household or office lamps, the light instruments used in stage and film work, and the sun itself. Adding lights to a scene can help give it a more realistic appearance. If a scene contains geometry but no light objects, 3ds Max provides default lighting. But as soon as you add a light object to

the scene, the default lighting is *turned off*. Setting up lighting is not difficult, but in order to do it well you need to plan ahead and experiment.

How you set up lights for a scene, depends on the purpose of your rendering or animation. Lighting situations fall into two broad categories:

- Lighting a space; for example, an architectural model.

Lighting an outdoor daylight scene is a special case of this, because 3ds Max has special features for daylight.



*Lighting an interior space*

- Lighting a specific subject; for example, a talking head.

Whether the subject is a character, a still life, or other detail, the principles of lighting are much the same.



*Lighting a subject*

Skill level: Beginner

Time to complete: 30 minutes

## Tutorial Files

Note: All the files necessary to do the tutorials can be found on the program disc. Before doing the tutorials, copy the *tutorials* directory from the disc to your local program installation.

## Lighting an Interior Space

To light an interior space, the guidelines are simple: use light objects with realistic values, and place them where you would in the actual building. Photometric lights are preferred for this, but to use photometric lights, it is *essential* that the model have realistic dimensions.

### Set up the scene:

- In the *tutorials\lights* directory, open the file *interior\_unfinished.max*.

The scene shows an interior living-room space, with a fireplace and entrance alcove. The walls, floor, and ceiling of the room have been frozen to make them difficult to select accidentally.

Tip: If the walls are hard to see, use **Customize > Customize User Interface > Colors** to make the viewport background a lighter gray.

If you were to render the scene now, you would see a plain, bare room. This is the default lighting from a single light source.



*Room rendered with default lights*

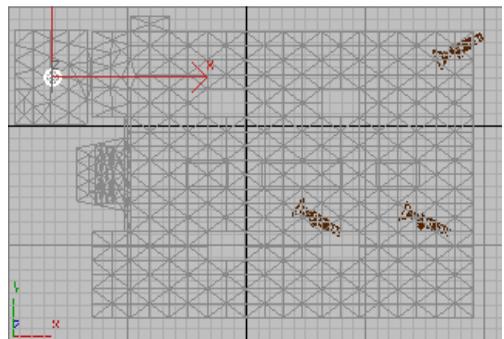
### Add a light with a preset value to the entryway:

1. Choose **Create > Lights > Photometric Lights > Presets > 75W Bulb**.

This creates a light object with a typical wattage.

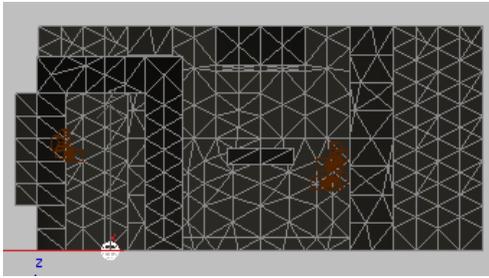
2. In the Top viewport, move the cursor over the alcove, and then click to position the light.

The light is now in the alcove.



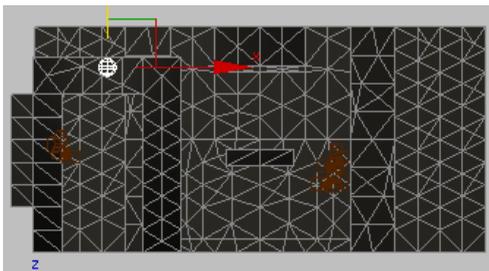
*Positioning the alcove light*

If you look at the Left viewport, however, you will see that the light is on the floor.



By default, the alcove light is created at the level of the floor.

3.  Right-click the Left viewport to activate it. Turn on Move, and then move the new light up to the level of the ceiling.



Alcove light moved to ceiling level

If you were to render the scene now, it would be very dim.

Adding a light turns off the default lighting. Once you add a light, all the lighting for the scene must come from light objects that you place yourself. (The rendering also shows what appears to be a bit of a light leak above the door frame. Don't worry about this: it won't be apparent once you add more lights.)

### Add an overhead fixture:

For overhead lighting in the living room, you will use a prepared light assembly from a separate MAX file.

1.   On the Create panel, turn on Lights. Choose Photometric from the

drop-down list, turn on one of the light object buttons, and then turn on the AutoGrid toggle. It doesn't matter which button you turn on. You are not going to create a light from scratch. However, AutoGrid should be on so the merged light-fixture assembly will align with the ceiling.

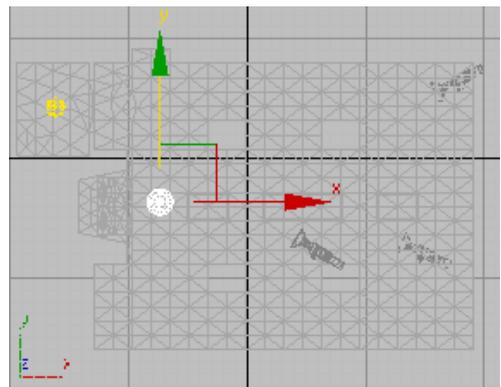
2. Move or resize your 3ds Max window so you can also see a Windows Explorer window.
3. Right-click a viewport and choose Unfreeze All from the Display (upper-right) quadrant of the quad menu.
4. Drag the file *ceiling.pendant.max* from the *tutorials\lights* directory onto the Camera02 viewport in the 3ds Max window.

AutoGrid doesn't work well when the geometry is frozen. A pop-up menu appears, giving you the choice of opening, merging, or cross-referencing the scene with the ceiling pendant.

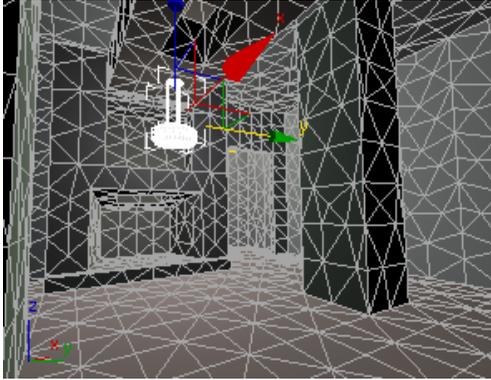
5. Choose Merge File.

The ceiling pendant geometry appears. It is selected and because of AutoGrid, it is aligned to faces in the scene.

6. Drag the light fixture until it is aligned with the ceiling, and move it to a position near the fireplace.



Top plan position of the ceiling pendant fixture



Camera view of the pendant light

Now that you have a single light in the living room, you can make instances of it to provide the room with more light.

#### Freeze the room again:

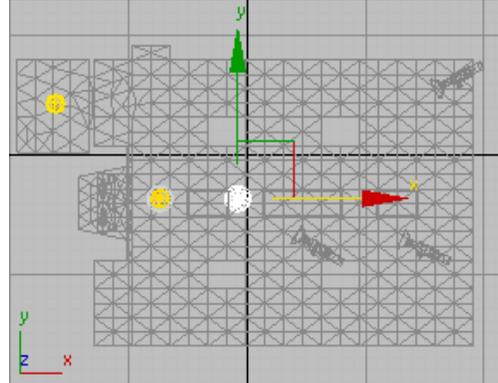
1. Click to select the room object (*Box01*).
2. Right-click a viewport and choose Freeze Selection from the Display (upper-right) quadrant of the quad menu.

This keeps you from selecting and moving the entire room, when you are trying to clone the light fixture.

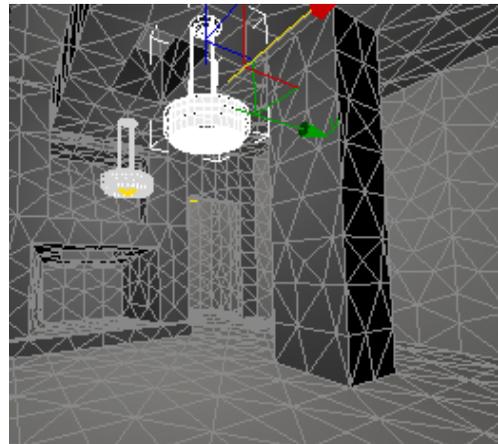
#### Make an array of light instances:



1.  Activate the Top viewport and turn on Move.
2. While holding down the **[Shift]** key, move the light to the right along the X axis. (Watch the Camera02 viewport so the light ends up hanging from the ceiling, and not from the skylight.)



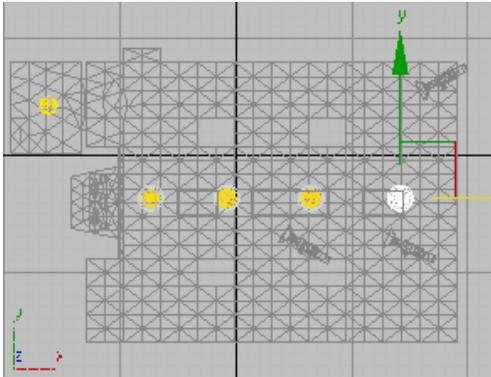
Top plan position of the first cloned light



Camera view of the first cloned light

The Clone Options dialog appears.

3. In the Object group, choose Instance, and then click OK.
4. Repeat steps 2 and 3 two more times, so you have a row of four light fixtures.



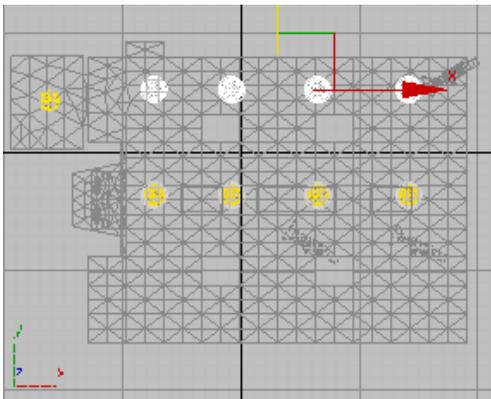
The first row of cloned lights



5. On the toolbar, make sure that the Window/Crossing toggle is set to Window, then drag in the Top viewport to select all four lights.
6. While holding down the **Shift** key, drag the four lights up along the Y axis to add another row, near the far wall.

The Clone Options dialog appears.

7. Make sure Instance is still chosen, and then click OK.



Top plan view with two rows of ceiling lights

#### Render the scene:



- On the main toolbar, click Quick Render. 3ds Max renders the room.



Room lit by all lights (direct lighting only)

Now the living room is illuminated, and you can see the colors on the walls. It still looks rather shadowy, but this is only because the rendering shows direct light only. In real life, objects are illuminated by both direct light and reflected (“bounced”) light. In 3ds Max, you can add reflected light by calculating the scene’s radiosity.



Room with radiosity calculated to provide bounced (indirect) light as well as direct light

The radiosity solution shows that in fact, you might want to turn down the level of the living-room lights before making a final rendering. The lesson *Managing Multiple Lights* (page 691) shows some ways to manage an array of instanced light objects such as those you just created.

**Save your work:**

- Save the file as **room\_with\_lights.max**.

Note: The scene *interior\_with\_lights.max* contains the completed version, and the scene *interior\_with\_lights\_and\_radiosity.max* contains both the completed version and a radiosity solution.

**Summary**

These are the main points of this lesson:

- If the model is to scale, use photometric lights.
- If you are lighting an indoor scene, position the lights and fixture assemblies as you would in the actual building, and use radiosity to model bounced light.

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**Lighting a Close-Up of a Head**

To light a subject, such as a talking head or a still life, it helps to think in terms of how you would light the same subject if you were working on a stage set or in a photo studio. In other words, you can place the lights wherever you want, adjust their intensity, tint their color, and so on. There are some widely used guidelines to lighting this way, and this section introduces them briefly.

Note: As with architectural lighting, you can use photometric lights, but they do the job only if the scene has been modeled to a real-world scale. In this exercise, you will use Standard lights to simulate a 3-point lighting scenario like they do in photo studios and television sets.

**Set up the scene:**

- In the *tutorials\lights* directory, open the file *pito\_head\_shot.max*.

The scene has a camera that is set up to render a head shot of the 3D cartoon character named Pito.

**Look at the default lighting:**

-  On the main toolbar, click Quick Render. 3ds Max renders the camera view.

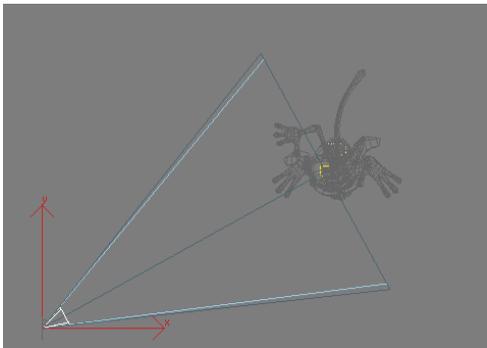


Default lighting of Pito

This is not a bad rendering of Pito, but we can do better.

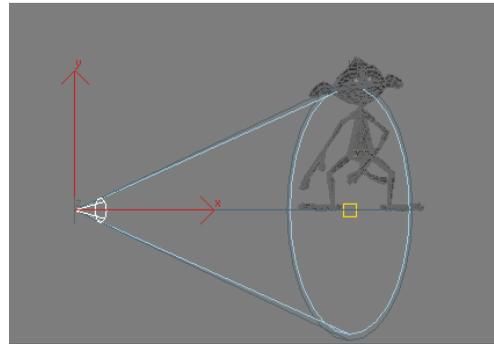
#### Add a light:

1.  On the Create panel, turn on Lights, and then click Target Spot to turn it on.
2. In the Top viewport, drag from the bottom left corner of the viewport to create a light that is aimed at Pito's head.



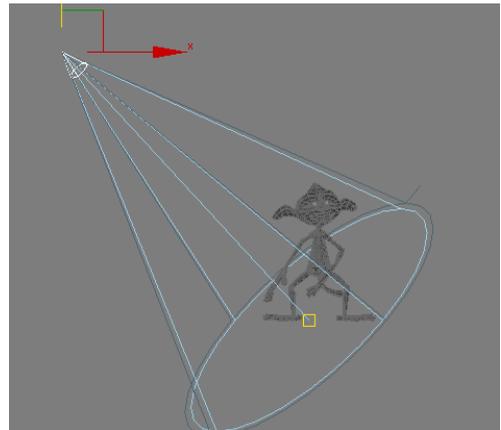
Aiming a target spot light at Pito

3ds Max creates the light. However, it is at ground level.

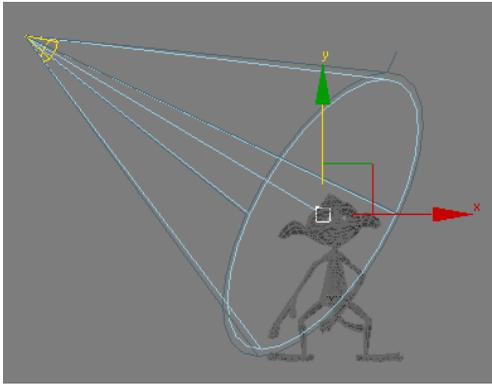


Light is created initially at ground level.

3.  In the Front viewport, use the Move tool to move the spotlight so that it is slightly higher than Pito's head.



4. Select the spotlight target (small yellow square) and move it up to Pito's eye level.

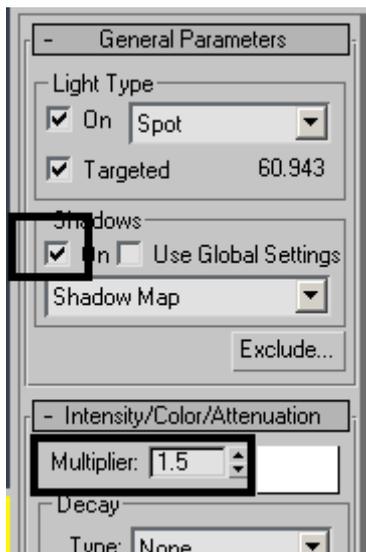


5. Select the spotlight again (the yellow cone).

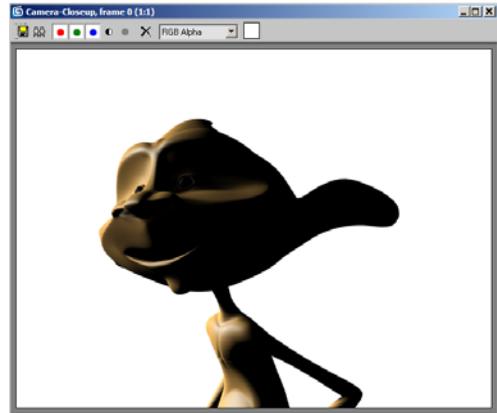


Go to the Modify panel, and on the General Parameters rollout, turn on Shadows. (The default method of Shadow Map will work fine.)

6. In the Intensity/Color/Attenuation rollout, set the Multiplier value to 1.5 to increase the light's intensity.



7.  Right-click the Camera view to make it current, and then click Quick Render.



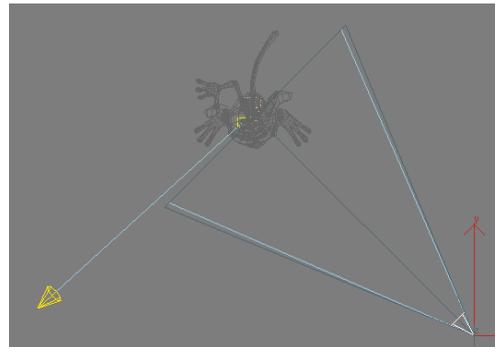
We can see that Pito is illuminated on one side, but the shadow areas are too dark. In general, faces look better and more interesting if they are lit at an angle, but one has to compensate with a fill light to get rid of the dark areas. This is why flash photos usually don't look as good as studio portraits.

#### Add a fill light:

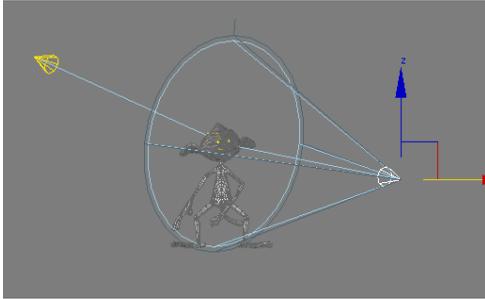


1. On the Create panel, turn on Lights, and then click Target Spot to turn it on.

In the Top viewport, click and drag to create a target spot on the right side aiming at Pito. The two lights can form about a 90-degree angle with Pito's face.

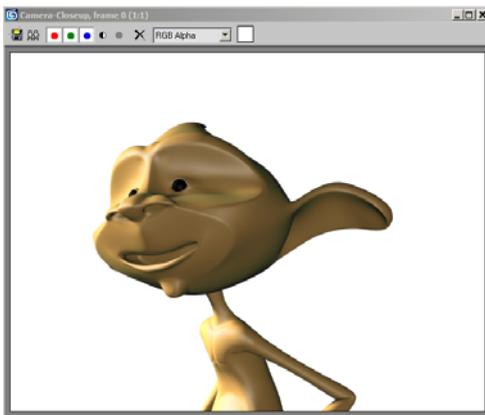


- In the Front view, move the fill light and its target to about Pito's eye level.



-  On the Modify panel, set the Fill light's multiplier value to about 0.6. A fill light is usually less intense than a main light as its purpose is to simulate global illumination (bouncing light).

-  Activate the Camera viewport and then click Quick Render.

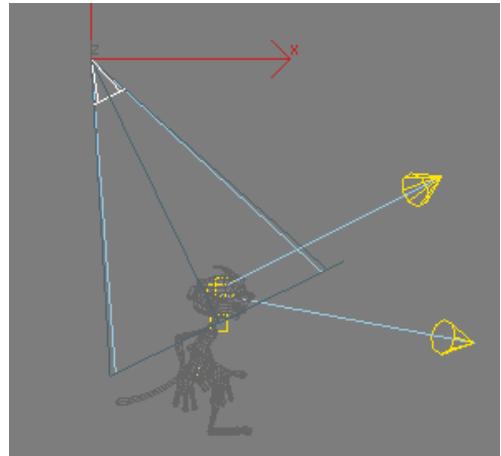


Here is a good, balanced portrait of Pito. Compared to the default light, it is brighter and you can see more detail, but there are shadows enough to make Pito look three dimensional.

### Add a Back Light

A back light's sole purpose is to separate the character from the background. It is a light you place behind the character to emphasize the silhouette against the background. This can be especially useful when shooting a dark-haired character against a dark environment.

-   On the Create panel, click the Lights button and then click Target Spot.
- In the Left viewport, drag from above and to the left of the character to create a light that is aimed at Pito's head.



- With the backlight selected, go to the Modify panel and notice that the backlight's intensity retained the Multiplier value of 0.6 used on the previous light in the scene. Set the Multiplier value to 0.4, as a backlight is typically the least intense of all lights in a scene.

-  Activate the Camera viewport and then click Quick Render.



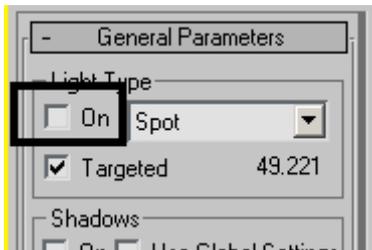
The brighter light, which you created first, is known as the key light. The dimmer light, which you added next, is known as the fill light. For most subjects, you want to have a single key light only, but you can add additional fill lights to illuminate the background or other hard-to-see places to simulate global illumination. You can also vary the position of the key light, to make the image clearer or more dramatic. Finally, you added a backlight to separate your character from the background.

### Experiment:

The best way to understand how an individual light is affecting your scene is to turn off all other lights that are present. Try this:



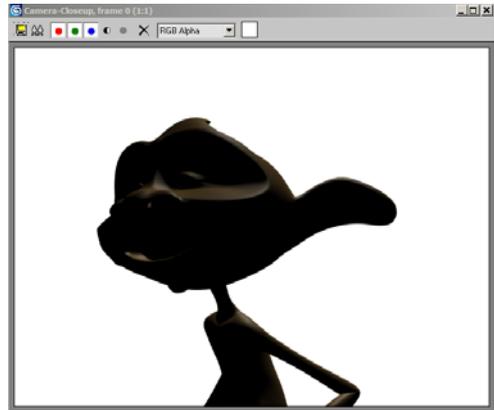
1. Select the Main light (the first light you created) and on the Modify panel, turn the light off.



2. Also turn off the Fill light (the second light you created).



3. With the Camera view current, click Quick Render.



You can now see the individual effect on the back light in the scene.

4. Experiment by turning the three lights you created on and off, in different combinations. When you are done, turn all three lights back on before saving your file.



*The effects of the individual lights on Pito: the Main light (Left), Fill Light (Center) and Back light (Right).*

### Save your work:

- Save the scene as **pito\_lit.max**.

Note: The three-point light version of the scene is in *pito\_head\_shot\_final.max*.

### Summary

If you are lighting a single subject such as a head, use a single key light and one or more fill lights.

The key light is the brightest; the fill lights have a lower intensity.

You can get different effects by changing the angle of the light. Avoid lighting a subject directly from the front.

## Managing Multiple Lights

Interior architectural models typically have a large number of light objects. This lesson demonstrates some ways to manage lights, both when they are instanced and when they aren't.

### Managing Instanced Light Objects

In architectural modeling, it's common to use instanced lights. Instancing allows you to control the properties of all lights of a particular type by editing the properties of just one of them. However, you sometimes want to control lights individually. This section shows you how.

#### Set up the scene:

- In the `tutorials\lights` directory, open the file `instanced_light_array.max`.

Note: All the files necessary to do the tutorials can be found on the program disc. Before doing the tutorials, copy the `tutorials` directory from the disc to your local program installation.

The scene shows a row of six light fixtures and standard free spotlights, aimed at a wall. The lights are instanced.

#### Render the scene:

-  On the main toolbar, click Quick Render.



Wall illuminated by instanced light objects

#### Turn off one light:

-   Click to select the leftmost light (`Fspot01`), and then go to the Modify panel. On the General Parameters rollout, in the Light Type group, click the On toggle to turn it off.

-  Click Quick Render.



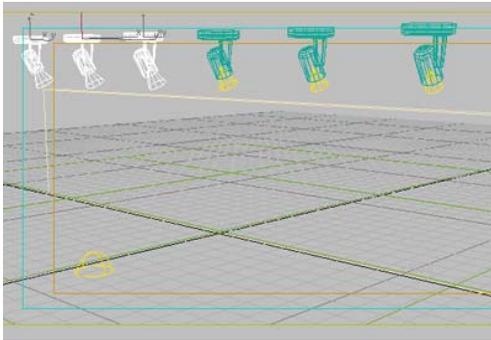
Turning off an instance

Because the lights are instanced, turning off a single light turns off all of them at once.

#### Hide some lights:

- On the Modify panel, turn `FSpot01` back on.
-  On the main toolbar, click Window/Crossing to choose window selection, and then in the Camera01 viewport, drag a selection window to select the leftmost three lights and their fixtures.

Tip: If the toggle is set to Crossing, then you might select the box object as well. Avoid this.



*Lights and fixtures selected*

3. Right-click, and choose Hide Selection from the Display (upper-right) quadrant of the quad menu.

The lights are now hidden.

4.  Click Quick Render.

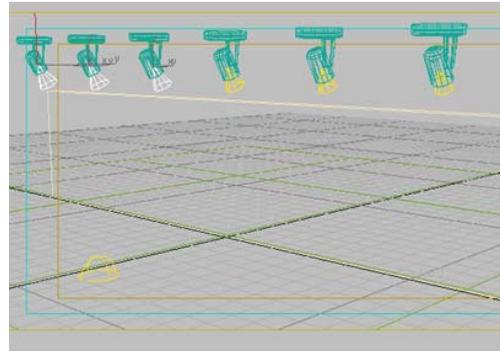


*Rendering hidden lights*

Although the lights are hidden, they still illuminate the wall. Hiding a light has no effect on its light-casting properties.

#### Turn off some lights by making them nonrenderable:

1. Right-click the Camera01 viewport, and choose Unhide All from the Display quadrant.
2. Use click and **Ctrl**+click to select the leftmost three lights, but *not* their fixtures.



*Light objects selected, but not their fixtures*

3. Right-click again, and choose Properties from the Transform (lower-right) quadrant of the quad menu.

The Object Properties dialog is displayed.

4. On the General panel, in the Rendering Control group, turn off the Renderable toggle.

5. Click Quick Render.



*Lights turned off using the Renderable property*

Now you have the desired result. The Renderable toggle can control whether an instanced light casts light in the scene.

#### Save your work:

- Save the scene as **render\_toggle\_light\_array.max**.

#### Using the Light Lister

The Light Lister tool is a sort of master dialog for lights in the scene. For individual lights, it is a shortcut to controls on the Modify panel.

(Its General settings also include settings on the Environment panel.)

### Set up the scene:

- In the `tutorials/lights` directory, open the file `light_array.max`.

The scene is the same as in the previous section, but in this case, the lights are independent objects, not instances.

### Use the Light Lister to dim some lights:

- Choose Tools > Light Lister.

The Light Lister dialog is displayed. There is an entry for each unique light in the scene (instances don't appear on this dialog).



You might have to expand the dialog vertically to see all the rows. As the dialog shows, the scene contains six free spotlight objects, one omni light, and one skylight.

Note: The Light Lister cannot control more than 150 unique light objects at a time. If there are more than 150 unique lights in your scene, the Lister displays controls for the first 150 it finds, and a warning that you should select fewer lights. Select fewer lights and then use the Selected Lights configuration.

- Change the Multiplier value to equal **0.3** for all the free spotlights except the fifth one (`Fspot05`). Leave the Multiplier for `Fspot05` set to 1.0.

Tip: You can use the standard Windows

**Ctrl+C** and **Ctrl+V** to copy and paste values from one spinner field to another.

- Click Quick Render.



Only the fifth light casts a full-strength beam.

### Use the Light Lister to change light colors:

- On the Light Lister, change the Multiplier value for all the free spots back to **1.0**.

- Click the color swatch for the second light, `Fspot02`.

The Color Selector is displayed.

- Change the color of the second spotlight to a light gold: R=255, G=191, B=52. Then click OK.

- On the Light Lister, drag the `Fspot02` color swatch to the `Fspot04` color swatch.

A Copy Or Swap Colors dialog is displayed.

- Click Copy.

- Drag the `Fspot04` color swatch to the `Fspot06` color swatch. Once again, click Copy when prompted to copy or swap colors.

- Click Quick Render.



Now alternating lights have alternating color.

### Save your work:

- Save the scene as **light\_array\_with\_color.max**.

### Summary

- To control whether a light instance casts a beam, you can use the light object's Renderable property, which is set from the [Object Properties dialog](#).
- The [Light Lister](#) is a convenient overall “console” for adjusting lights in your scene.

Both photometric and standard lights use shadow-mapped shadows by default. 3ds Max offers some alternate ways to generate shadows, as this lesson demonstrates.

### Set up the scene:

- In the *tutorials\lights* directory, open the file *shadows.max*.

Note: All the files necessary to do the tutorials can be found on the program disc. Before doing the tutorials, copy the *tutorials* directory from the disc to your local program installation.

The scene is a classical sculpture against a plain white background. It is lit by three omni lights, but only one of them, *Omni01*, is shadow-casting.

### Render the scene:

-  On the main toolbar, click Quick Render.



The statue's shadow is shadow mapped. It has a fairly sharp-edged outline.

### Create a soft-edged shadow:

1.   On the main toolbar, click Select By Name. Use the Select Objects dialog to select *Omni01*, and then go to the Modify panel.
2. Open the Shadow Map Parameters rollout. Change the value of Sample Range to **10.0**.
3. Click Quick Render.



The edge of the shadow is softer. Shadow-mapped shadows can have soft edges, but ray-traced shadows cannot.

**Use a ray-traced shadow:**

1. On the General Parameters rollout, in the Shadows group, choose Ray Traced Shadows from the drop-down list.
2. Click Quick Render.



This time the shadows are very hard edged.

Note: 3ds Max offers two kinds of ray-traced shadows: Advanced and “regular.” The advanced option has more ways to adjust shadow quality; otherwise, their behavior is similar.

**Make the shadow lighter:**

1. On the Shadow Parameters rollout, in the Shadow Parameters group, change the value of Density to **0.4** (equivalent to 40 percent).
2. Click Quick Render.



The shadow is now lighter. Options on the Shadow Parameters rollout are independent of which kind of shadow you are generating.

**Use an area shadow:**

1. On the Shadow Parameters rollout, change the value of Density back to **0.85**.
2. On the General Parameters rollout, in the Shadows group, change the shadow type from Ray Traced Shadows to Area Shadows.
3. Open the Area Shadows rollout, which is now displayed. In the Basic Options group, make sure that Rectangle Light is chosen. In the Area Light Dimensions group, change the Length and Width to both equal **5.0**.
4. Click Quick Render.



This time the results are even more diffuse than a soft-edged shadow-mapped shadow. Area shadows simulate shadows cast by an area of light, such as a window or skylight, rather than from a point source like a spotlight.

Tip: Photometric lights also provide true area lights and linear lights.

**Save your work:**

- Save the scene as **my\_area\_shadow.max**.

## Summary

Photometric and standard lights both have the same options for generating shadows. The main choices are shadow-mapped (the default), ray-traced, or area. Shadow-mapped shadows can have a soft edge; ray-traced shadows are always sharp edged; and area shadows are diffuse, simulating shadows cast by a light-emitting area.

Each kind of shadow generator has its own settings. The settings not demonstrated in this lesson are mainly for adjusting shadow quality. They are described in the *User Reference*.

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## Lighting a Scene with Standard Lights

In general, photometric lights are preferred over standard lights, because they are physically accurate and behave more like real-world lights, which makes them easy and straightforward to set up. But you might encounter scenes that use 3ds Max standard lights. One situation in which standard lights are the better option, is when the scene geometry is not built to a real-world scale. This lesson demonstrates the use of standard lights.

### Set up the scene:

- In the `tutorials\lights` directory, open the file `memorial.max`.

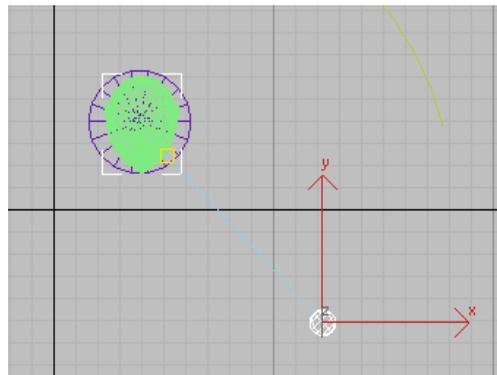
The scene shows a bust on a pedestal, in a semicircular alcove.



*Bust with default illumination*

### Add a photometric light:

1.   On the Create panel, turn on Lights. Choose Photometric from the drop-down list, and then click Target Point to turn it on.
2. In the Top viewport, drag to create the Target Point light, pointing at the bust from an angle.



*Photometric target point light aimed at the bust*

3.  On the main toolbar, click Quick Render.

What happened? The Camera01 viewport shows a well-lit, even brightly lit bust, but the rendered frame is nearly black.

**Diagnose the problem:**

When you encounter a problem with photometric lights, very often it has to do with the scale of the scene. This is indeed the case in this scene.



- Go to the Utilities panel. Click Measure to turn it on, then in a viewport, click the bust model.

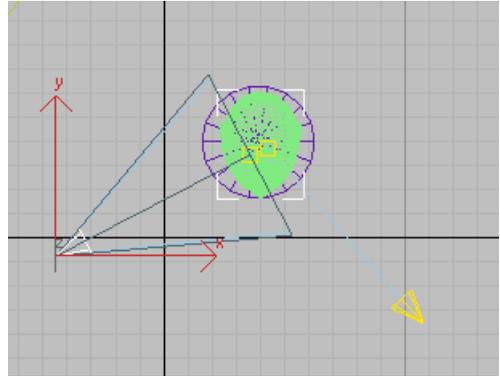
The measurements show that the bust is about 340 units wide by 433 units tall. As one “generic” 3ds Max unit corresponds to an inch, this means in real-world terms, the bust is 28 feet wide and 36 feet tall! It was modeled before 3ds Max had photometric lights, when scale was not an issue. But the default intensity of the Target Point light is nowhere near great enough to illuminate so monumental a sculpture. Rather than increase the value to floodlight intensity, it makes more sense to use standard lights, which don’t depend on scale.

**Add standard lights for key and fill:**

- Delete the Target Point light.



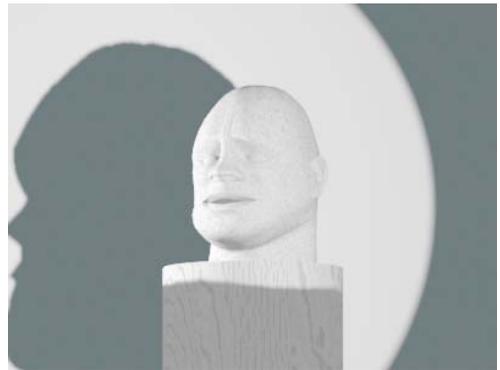
- On the Create panel, use the drop-down list to change the type of lights to Standard. Then click Target Spot to turn on this type of light.
- In the Top viewport, drag to create two spotlights at right angles to each other. Be sure to turn on Shadows (on the General Parameters rollout) for both lights. For the fill light on the right, go to the Intensity/Color/Attenuation rollout and reduce the Multiplier value to **0.4**.



*Two standard spotlights aimed at the bust: the key light is on the left, and the fill light on the right.*



- Click Quick Render.



*Bust rendered with standard spotlights and shadows*

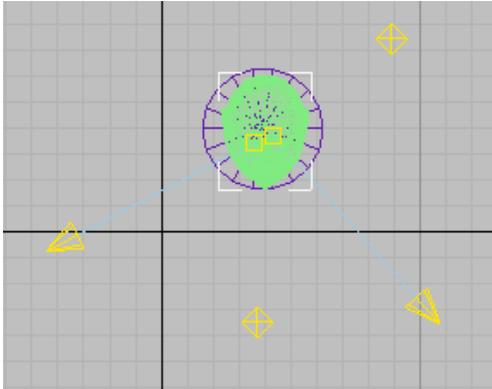
Now the rendering shows an illuminated bust. However, the shadows are very harsh, and the front of the supporting column is poorly lit.

**Add additional fill lights:**

In general, when you work with standard lights, you need to provide more fill than when you use photometric lights. (Standard lights aren’t really suited for radiosity solutions.) In the case of this model, a couple of Omni lights will help improve the appearance of the rendering.

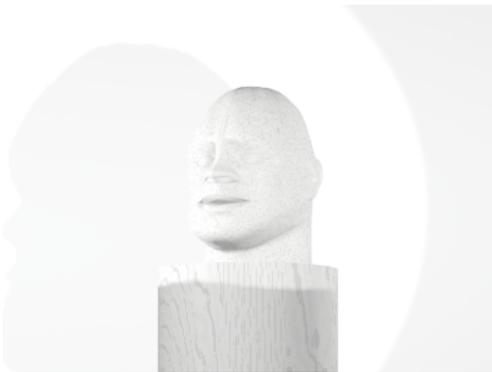
1. On the Object Type rollout, click Omni to turn it on, then in the Top viewport, click to place a new omni light in front of the column, and another just behind the bust, on the same side as the fill spotlight.

These new lights default to a Multiplier value of 0.4, the last value you assigned.



Two omni lights added to provide additional fill and make the shadows less harsh

2.  Click Quick Render.



Additional fill lights make the shadows less harsh.

This is better, but the Omni light behind the bust is a bit too bright.

3.  Select the Omni light behind the bust, and on the Modify panel, change its Multiplier to **0.1**.
4.  Click Quick Render.



Reducing the level of the omni light behind the bust makes the rendering easier to read.

This version of the rendering is a little clearer, and looks more three-dimensional.

#### Save your work:

- Save your scene as **memorial\_with\_standard\_lights.max**.

The file *memorial\_finished.max* has a completed version of this scene.

#### Summary

These are the main points of this lesson:

- Use standard lights if the scene's geometry is not to scale.
- Base the lighting on a customary key and fill light.
- Add Omni lights to provide additional fill and simulate ambient, reflected light. Adjust their Multiplier as necessary.

Tip: Avoid setting a standard light's Multiplier to a value greater than 1.0. This can result in

washed-out areas of the rendering, especially if you plan to transfer to video. Instead of using greater-than-one Multipliers, add more light objects.

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## Introduction to Rendering

To view the final results of your work in 3ds Max as a two-dimensional image or movie, you render the scene. By default, when you render, the software produces a still image at a specific resolution using the default scanline renderer, and displays it in a separate window on the screen. But a wide variety of rendering alternatives is available, and this tutorial will introduce you to some of them.

Skill level: Basic

Time to complete: 2 hours.

### Features Covered in This Tutorial

In this tutorial, you will learn how to:

- Render a still image to the screen and to a disk file in different formats and resolutions
- Use different renderers and presets.
- Render a high-resolution image using multiple computers.
- Render an animation and combine still images into a movie file.
- Use a network farm to simultaneously render different images from an animation.
- Use rendering to create textures for use in games.

### Tutorial Files

Note: All the files necessary to do the tutorials can be found on the program disc. Before doing the tutorials, copy the *tutorials* directory from the disc to your local program installation.

## Rendering Still Images

In some ways, 3ds Max is like a photography studio. You arrange and manipulate three-dimensional objects, lights, and a camera, with the ultimate goal of producing an image that illustrates your message. The act of creating that image is called *rendering*. In this lesson, you'll learn some of the different ways you can use 3ds Max to render.

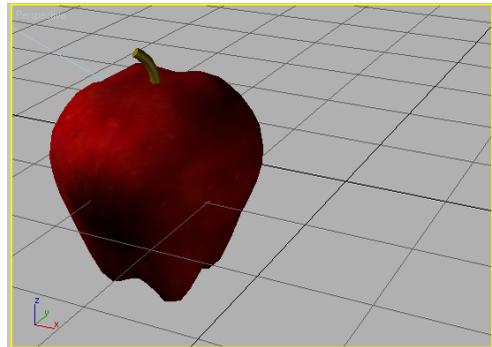
### Set up the lesson:

- On the File menu, choose Open and navigate to the `tutorials\intro_to_rendering` folder. Highlight `rendering_still_images_start.max` and click Open.

The scene contains a textured model of an apple, plus a shadow-casting spotlight, a fill light, and a ground plane.

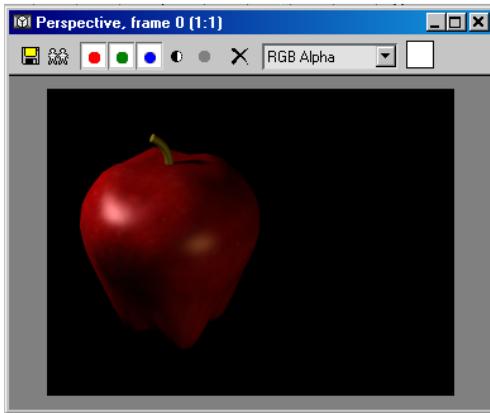
### Render the scene:

1. Make sure the Perspective (lower-right) viewport is active; that is, it has a yellow border. If not, right-click anywhere inside the Perspective viewport.



2.  Press **Shift+Q** or click the Quick Render button on the main toolbar to render the viewport.

In a few moments, a default rendering of the apple scene appears on the screen.



This rendering has several characteristics, all of which you can change:

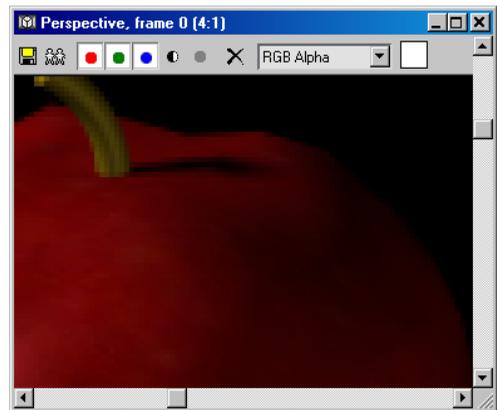
- It appears in the *rendered frame window*. The text in this window's title bar tells you that you're currently viewing frame 0 as rendered from the Perspective viewport, and the window is displaying the image at a zoom ratio of 1:1, or normal magnification.
  - Its resolution is 320 pixels in the horizontal dimension and 240 pixels in the vertical dimension, or 320 x 240 for short.
  - It uses the *default scanline renderer*. This is the renderer that most 3ds Max artists employ, but others are available. One of these is mental ray, a powerful renderer that is included with the software. You'll take a quick look at mental ray shortly.
3. Close the rendered frame window by clicking the X button in its upper-right corner.  
The most efficient way to work with 3ds Max is to use keyboard shortcuts whenever possible. The default shortcut for the Quick Render command is easy to remember.
  4. On the keyboard, press **Shift+Q**.  
The scene is rendered again, exactly the same as before.

### Use the rendered frame window tools:

The rendered frame window has a number of tools you can use to work with the image and view it in different ways. Most of these are available as buttons in the toolbar, which is highlighted in the illustration above. In this procedure, you'll try out a few of the other, mouse-related functions. You'll find detailed descriptions of all of the controls in the [Rendered Frame Window topic](#).

1. Click in the window to activate it, and then rotate the mouse wheel forward and back.

If you're not using a wheel mouse, you can zoom the window by pressing and holding the **Ctrl** key and then clicking the left mouse button to zoom in, or the right mouse button to zoom out.



*The rendered frame window zoomed in*

This zooms the image in and out about the mouse cursor position. The current zoom ratio appears at the right end of the text in the window title bar. You can zoom between 1/8 and 64 times actual size.

You can change the window size using standard Windows methods, such as by dragging the lower-right corner.

2. When zoomed in, you can pan the image by pressing and holding the middle mouse button

(or wheel button), and then dragging in the window.

If you're not using a three-button mouse, pan the image by pressing and holding the **Shift** key and the left mouse button, and then dragging in the window.

- Return to the 1:1 zoom ratio, and then, without holding down any keys, right-click and hold in the image portion of the window.



A temporary window appears, showing general image data such as the resolution, as well as specific information about the pixel currently under the mouse cursor.

- Still holding down the right mouse button, drag the mouse so that the cursor is over a lighter part of the image, such as the specular highlight on the apple.

The color swatch at the right end of the toolbar changes visibly to a light red color. This color remains when you release the mouse button.

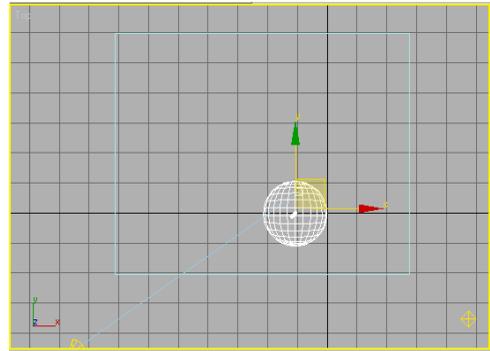
- Close the rendered frame window.

#### Render with a different keyboard shortcut:

Did you notice that the apple is off-center? There are different ways to fix this; you'll do so by moving the apple. You'll also learn about using the Render Last command.

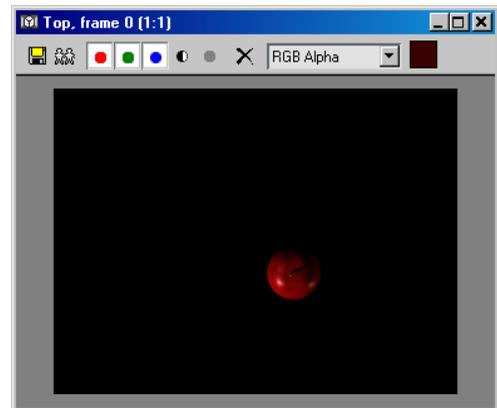


- On the toolbar, click the Select And Move button, and then move the mouse cursor into the Top viewport.
- Position the mouse cursor over the apple (the round, wireframe object), press and hold the left mouse button, and then drag slowly to the right. As you drag, watch the apple in the Perspective viewport. When the apple is near the center of the viewport, release the mouse button.



Because you were working in the Top viewport, it is now the active viewport.

- Render the image by pressing **Shift+Q**.



The program renders the view from the Top viewport. The Quick Render command always renders the active viewport. However, you probably wanted to see the Perspective-viewport image. This is a common error in 3ds Max. Fortunately, the program offers a way around it, called Render Last.

- Activate the Perspective viewport and render again.

The new image replaces the previous one in the rendered frame window.

- Close the rendered frame window.

6. Activate any other viewport, and then press the **F9** key.

This executes the Render Last command, which renders the same viewport that you rendered most recently in the current session, no matter which viewport is active. It's not available from the toolbar, but if you remember the keyboard shortcut, you can save time when working in different viewports.

7. Press **Ctrl+Z** to undo the apple move. You might need to press it more than once.

### Explore rendering options and presets:

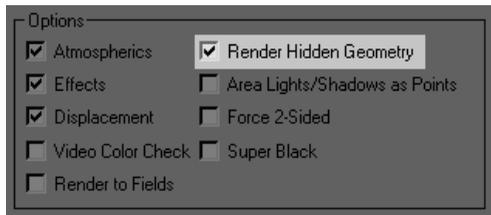
In this procedure, you'll try a couple of options for rendering objects that don't normally appear. The scene you loaded contains a hidden object and an object that faces away from the camera. Neither has shown up in the renderings so far.

1. Press **F10** to open the Render Scene dialog.

The dialog opens to the Common panel.

Available here are controls for changing output size, rendering to disk, and more. You'll look at some of these shortly. Right now, we're interested in the rendering options.

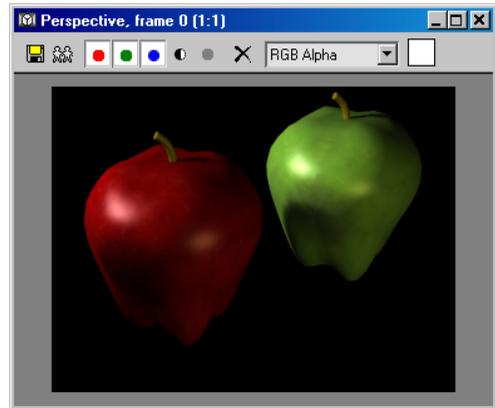
2. In the Options group, turn on Render Hidden Geometry.



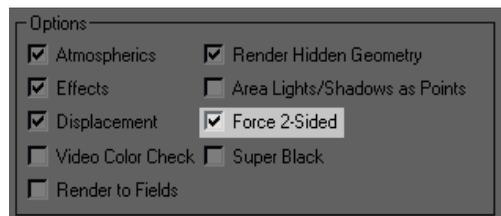
3. Render the Perspective viewport. If the Perspective viewport is active, you can do this by clicking the Render button at the bottom of the dialog. If a different viewport is active, first choose Perspective from the Viewport drop-down list to the left of the Render button.



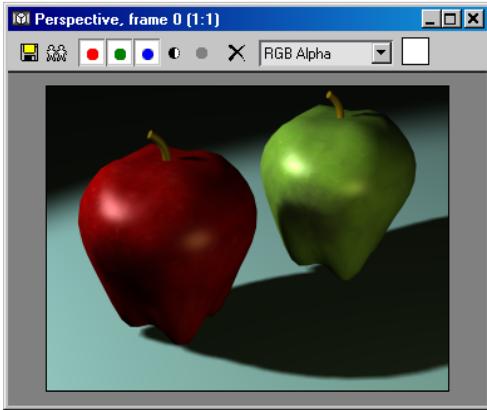
A second, green apple appears in the rendered image. If your scene contains objects that you want to appear in the rendered image but not in the viewport, you can hide them, and then use this option when rendering.



4. In the Options group, turn on Force 2-Sided.



5. Render the Perspective viewport again.



The ground plane appears in the rendering, with the apples casting shadows on it. This object isn't hidden, but because it's facing away from the "camera," it doesn't normally show up when you render. This option is a handy way to make sure all objects in the scene show up in the rendered image, no matter which way they're facing.

A handy feature in 3ds Max lets you save a custom rendering setup as a preset for use with other scenes. You'll try it now.

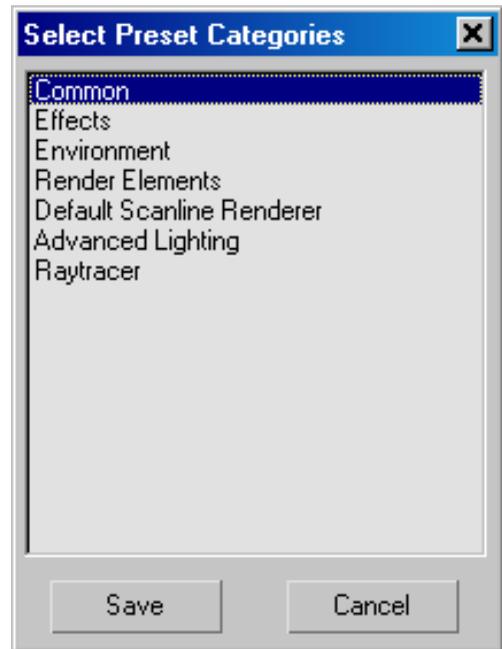
- At the bottom of the Render Scene dialog, click the Preset drop-down list, and then choose Save Preset.



The Render Presets Save dialog appears.

- Enter **Hidden+2-Sided**, and then click Save. The Select Preset Categories dialog appears, with a list of the different panels on the Render Scene and Environment And Effects dialogs. You can store any combination of panel settings in a preset. By default, all are highlighted, but for this exercise, you're interested in saving only the settings on the Common panel.

- Click Common, the first item in the list, and then click Save.



The preset is saved, and then appears in the Preset list.

- In the Options group, turn off both Render Hidden Geometry and Force 2-Sided.
- Click the Preset list, and then choose the Hidden+2-Sided item.

The Select Preset Categories dialog appears, showing only the Common item. If you save a preset with multiple panels, you can choose specific ones for selective loading.

- Click the Load button.

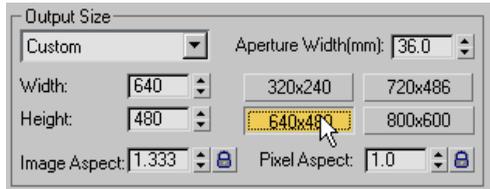
The software loads the preset, and according to its settings, turns on both Render Hidden Geometry and Force 2-Sided again.

**Change the output size:**

Until now, you've been rendering to the screen at a relatively small size: 320 x 240. 3ds Max lets you

render at any size up to 32,768 x 32,768, however, and in a number of different file formats.

1. Still on the Render Scene dialog, in the Output Size group, click the 640x480 button.



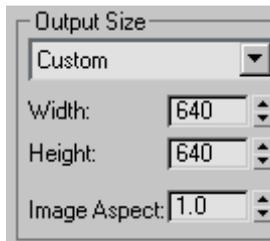
The new output resolution appears in the Width and Height fields.

2. Render the Perspective viewport.

The software renders the image at the new, larger size. It takes a bit longer, but is much easier to see.

The Image Aspect value, below the Width and Height fields, is currently 1.333. This is the ratio of width to height. You can alter it by changing one of the dimensions.

3. Increase the Height value to 640.



The Image Aspect is now 1.0, which means that the width and height are the same, resulting in a square image.

4. Render the Perspective viewport.

The software divides the added height evenly between the top and bottom of the image, so there are now 80 additional pixels both above and below the original image.

**Tip:** When rendering to nonstandard aspect ratios, the Safe Frame option helps you preview exactly how the final render will appear. Right-click the viewport label (“Perspective”), and then choose Show Safe Frame from the menu. The outer frame shows you the area that will render; the others are used when creating video content.

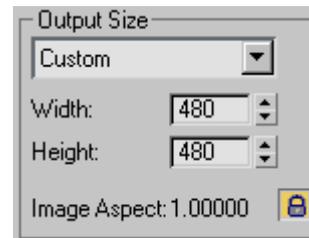
You can also change the dimensions by adjusting the Image Aspect value; this always affects only the Height value. If you try it now, be sure to set Image Aspect back to 1.0 when you’re done.

You can lock the aspect ratio so that changing one dimension automatically adjusts the other.

5. Click the lock button to the right of the Image Aspect field.

Image Aspect becomes a read-only field.

6. Set the Height value to 480.



Both Height and Width change to 480.

7. Render the Perspective viewport.

The output image is still square, but smaller.

### Change the output location:

Until now, you’ve been rendering only to the screen. In this procedure, you’ll learn about rendering to a disk file, and find out how to turn off screen output.

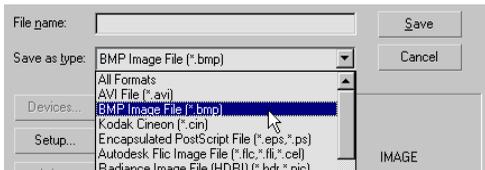
1. In the Render Output group, near the bottom of the Common Parameters rollout, click the Files button.

The Render Output File dialog appears.

- If necessary, change the output location to `|3dsmax9|images|`.



- Click the drop-down-list next to Save As Type, and choose BMP Image File (\*.bmp).



This is the Windows Bitmap file format, commonly used for image files in Windows.

- Click in the File Name field, and type **apples**. Press the **Enter** key.
- The BMP Configuration dialog appears. Accept the default choice, RGB 24 bit, by clicking OK.

The dialog closes. Nothing has rendered yet, but in the Render Output group, Save File is now available and enabled, and the read-only below it shows the output path and file name. These features become available only after you specify file output properties with the Files button.



- Render the Perspective viewport using any of the methods you've learned so far.

The software renders the image to both the rendered frame window and the specified file. You can see the latter with the View Image File command.

- From the File menu, choose View Image File. Use the View File dialog to open the *apples.bmp* file.

A new window opens showing the rendered image. It's exactly the same as the rendered frame window, except that its title bar shows the name of the file rather than the rendered viewport.

- Close both windows.

The software automatically appended the *.bmp* filename extension when you specified the file type. You can also specify the file type explicitly by including the extension in the file name.

- Click the Files button again, and change Save As Type back to All Formats (at the top of the list). Then change the file name to **apples.tga**. Press **Enter**.
- The software recognizes that you want to render the image in Targa format, and displays the Targa Image Control dialog. The Targa image format supports the alpha channel, which allows transparency effects when compositing the rendered image.
- Click the OK button to accept the Targa image defaults.
- Near the bottom of the Render Output group, turn off Rendered Frame Window.
- Render the Perspective viewport.

The software renders the image to the specified file, but not the rendered frame window. You can see the Targa image file with the View Image File command.



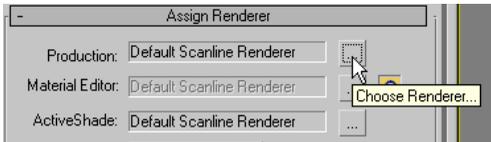
If you click the Display Alpha Channel button on the window toolbar, you can see a tiny bit of transparency (black) in the upper-right corner. This is where the ground plane ends, showing the background, which is usually transparent.

- Close the image window.

**Use a different renderer:**

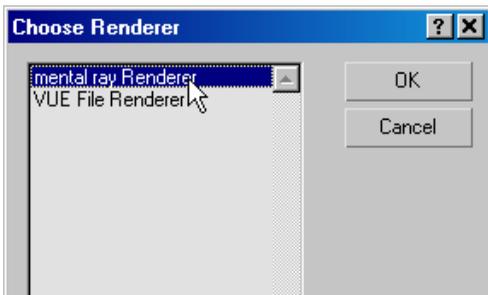
Included with 3ds Max is a powerful, sophisticated renderer called mental ray. Full exploitation of its capabilities is beyond the scope of this tutorial, but basic usage is straightforward.

1. In the Render Output group, turn off Save File and turn on Rendered Frame Window.
2. Scroll down to the Assign Renderer rollout and click the rollout title bar to expand it.
3. Click the top Choose Renderer button, to the right of Production.



The Choose Renderer dialog appears.

4. In the list, click the mental ray Renderer entry to highlight it, and then click OK.



”mental ray” appears as the production renderer.

5. Render the Perspective viewport.

The software renders the image to the rendered frame window. During the rendering process, you can see the small rectangles, or “buckets,” into which mental ray subdivides the image, appear one by one.

In the final image, the red and green apples and the ground plane all appear, because mental

ray supports the same options as the default scanline renderer.

Other renderers are available as plug-ins; after installation, they appear on the Choose Renderer dialog.

6. Restore Default Scanline Renderer as the production renderer.

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## Rendering an Animation

There are some specific techniques to learn for rendering your animation into a movie file. You can render directly to a movie format such as AVI, or you can render a sequence of still image files to file formats such as TGA and then use the RAM Player to save them into a movie. The latter method is the recommended choice. It’s a few steps more than rendering directly into a movie, but it gives you more control over file size and quality of output, plus if you have frames with artifacts or other errors, you can repair or remove them.

**Warning:** The next lesson will take a long time to render. Depending on the speed of your PC, it can take several hours or more to render the individual frames.

### Set up the scene:

- From the `tutorials\full_house` directory, open `full_house_walkin_start_render.max`.

If you get a Units Mismatch dialog, choose Adopt The File’s Unit Scale and click OK. In general, when encountering this dialog, choose Adopt Unit Scale.

This is a large file, so it will take a while to load. This file has stored all the radiosity rendering information, so the render times will be quicker.



This file is similar to the one created in the earlier walkthrough lesson. It has been reduced from 730 frames to 257 frames to shorten the total rendering time.

#### Render to an image sequence:

1. If the Camera viewport isn't active, right-click in it to activate it.
2. From the Rendering menu, choose Render.  
Next, you'll define the animation range.
3. On the Common tab of the Render Scene dialog, in the Time Output group, choose Active Time Segment.

This option automatically renders all currently playable frames. Alternatively, you could choose Range or Frames and set the frame range to render.

4. In the Render Output group, click the Files button.  
The Render Output File dialog opens.
5. Navigate to a directory where you want to save your work. You can use the Create New Folder button to establish a new location, if necessary.

**Warning:** Make sure you don't choose a directory on a DVD drive or some other write-protected location. Also make sure you choose a location with plenty of free space.

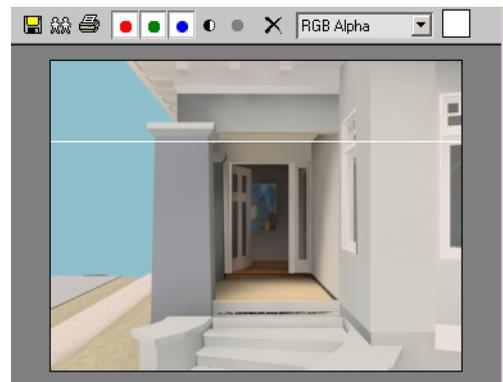
Next you'll define the type of still image file to render.

6. In the Save As Type field, click the drop-down arrow and choose Targa Image File, (\*.tga ...).  
This is a high-quality file type, good for this kind of rendering.
7. In the File name field, type **my\_walkin.tga**, then click Save.

After you click Save, you see a format-specific dialog that asks you to specify attribute and information settings. You can accept the default values, and then click OK.

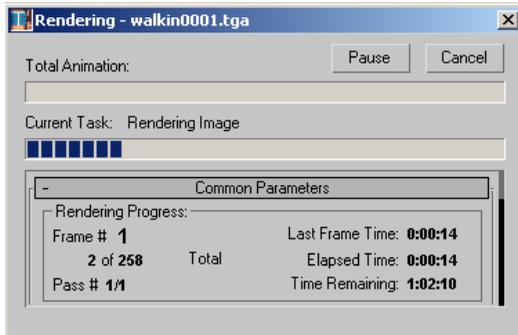
When you render an still-image sequence, as in this case, the software automatically appends the first part of the file name with a four-digit frame number. So the first frame will be *my\_walkin0000.tga*, the second will be *my\_walkin0001.tga*, and so on.

8. Make sure Save File is turned on in the Render Output rollout, and that the Viewport field at the bottom of the Render Scene dialog reads Camera03 (not Top, Front, or Left), then click Render.



The Rendering dialog appears, or you may first see a Raytrace Messages dialog. Wait for a short while as the first frame is rendered. You will see the Last Frame Time, Elapsed Time, and Time

Remaining values change after the first frame finishes.



If you did see the Raytrace Messages dialog, click the Raytracer tab of the Render Scene dialog, and then turn off Show Messages.

- Allow at least four frames to render.
- At this point, you can go away and return once your rendering is complete.

Tip: You could also sit and watch the rendering for errors or improvements. In the real world, this can be a good idea; to study what you are creating.

When the rendering is finished, the target directory contains the 258 output files.

### Convert an image sequence into a movie:

- From the Rendering menu, choose RAM Player.

The RAM Player loads still image sequences into memory and plays them so you can watch them as a movie. It actually lets you load two different sequences and then compare them visually, but you won't use that functionality here. You'll simply use the RAM Player to save the files into an AVI file.

-  On the RAM Player toolbar, click Open Channel A.
- In the Open File Channel A dialog, navigate to the sequence of TGA image files. Highlight the

name of the first file in the sequence, then turn on Sequence, and click Open.



Now the RAM Player will load the sequential image files, rather than just the first one.

The Image File List dialog appears. Here you can use the Every Nth and Multiplier fields if you need to speed up or slow down your animation. If your animation is too slow, change Every Nth to 2 or 3. If your animation is too fast, increase the Multiplier.

- Click OK.

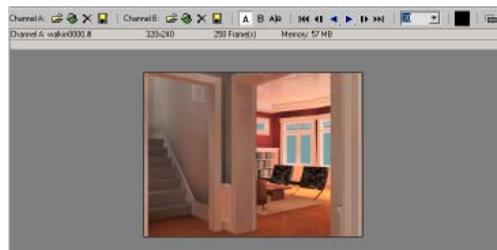
The RAM Player Configuration dialog appears. Here you can observe and adjust your memory usage. Loading this sequence takes about 57 MB. There are also tools here to resize your animation, specify a range of frames to use, and split the alpha (transparency) information into a separate file.

- Increase the Memory Usage to its maximum for your system, then click OK.

The RAM Player loads the file into memory. In the Loading dialog, observe how much memory is being used and remains available.

If it looks like you are about to run out memory, click Stop Loading. If you have a low-memory system, reduce the number of frames to load and try again.

-  On the RAM Player toolbar, click the Play button and watch the movie play.



7.  On the RAM Player toolbar, click the Save Channel A button.  
The Save File dialog appears.
8. Choose AVI as the file type, and give the animation the name **my\_walkin.avi**. Click Save.  
The Video Compression dialog appears. Here, you can choose a codec (compression/decompression type) and adjust the quality of the file. To reduce file size, lower the quality.
9. Click OK to continue.
10. When the file conversion is finished, close the RAM Player, and then from the File menu, choose View Image File. Play your finished AVI file and observe the results.

## Summary

You have learned how to render your animation to a sequence of still image files. This allows you better control for later correction of your animation. You also learned how to assemble the still image sequence into a movie file, such as AVI or QuickTime, using the RAM Player.

## Creating an Animated Shadow Study

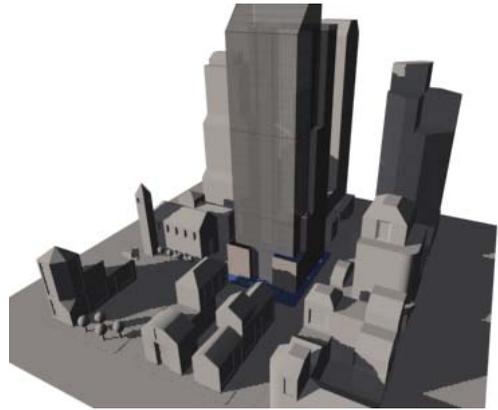
In addition to animating a camera, you can animate the Daylight system's time of day. This is a good way to create a shadow study.

### Set up the scene:

- From the `|tutorials|high_rise|` folder, open `cityscape.max`. If you encounter a File Unit Mismatch message, choose Adopt Unit Scale, the second choice.

This is a scene of nine city blocks, with a skyscraper at the center. The scene contains a

Daylight system. The Daylight system is set to position the scene at the latitude of San Francisco, California, and the sun is set at 0700 hours, about the time of dawn on a winter day.



### Animate the daylight:

1.  Make sure Select Object is active on the toolbar.
2. In the Left viewport, click the sun object in the viewport to select it.  
Daylight01 appears in the name field on the command panel.
3. Open the Motion panel.
4. On the Motion panel, scroll if necessary to the Control Parameters rollout.
5.  Turn on the Auto Key button.  
 The button, the track bar, and the border of the active viewport all turn red.
6. Drag the time slider to frame 5, and then on the Control Parameters rollout, change the Hours value to **8**.

The spinner arrows of the Hours, Minutes, and Seconds fields are now bracketed in red, indicating that you have set a key to animate the time of day.

7. Drag the time slider to frame 10, and then change Hours to **9**.
8. Continue dragging the time slider in five-frame increments, then increasing the time of day by one hour at each increment. Stop when the time is **17 hours (5 P.M.)**. This should be at frame 50. You have set 10 keyframes (and 3ds Max has automatically set one at frame 0, as well) to track the course of the sun through a day. Drag the time slider and watch the Left viewport. The sun moves smoothly: 3ds Max interpolates from one keyframe to the next so each frame is different, even if it doesn't have a key on it.

#### Set the animation range:

As the animation only lasts 51 frames (0 to 50), you don't need the full default range of 101 frames.

1.  Click Time Configuration. The Time Configuration dialog is displayed. (This button is at the extreme lower right of the 3ds Max window.)
2. In the Animation group, change the value of End Time to **50**, and then click OK. Now the range of frames is no greater than the length of the animation.

#### Save your work:

- Choose File > Save Copy As. In the file dialog, name the file **my\_shadows.max**, and then click Save.

**Important:** Save Copy As does not open the copy. The active file is still *cityscape.max*.

Tip: Always save your scene file before you render.

#### Render the animation:

Rendering the animation takes about half an hour on a high-speed system. If you want, you can skip these steps and just view the file *shadow\_study.avi*,

provided with the other tutorial files. See “View the animation,” below.

1. Choose Rendering > Render.

The Render Scene dialog is displayed, with the Render panel active.

2. On the Common Parameters rollout, in the Time Output group, choose Active Time Segment: 0 To 50.

In the Output Size group, make sure that the resolution is 640x480.

A smaller size would render more quickly, but the shadows don't show up as well.

3. On the Render Output rollout, click the Files button.

A Render Output File dialog is displayed.

4. Enter a name for the animation, and choose one of the animation formats from the Save As Type drop-down list, and then click Save.

You can render an animation to either the AVI or MOV (QuickTime®) formats. After you click Save, you see a format-specific dialog that asks you to specify the animation's compression. You can accept the default values, and then click OK.

Note: In practice, it's a good idea to avoid rendering directly to movie formats such as AVI or MOV. Instead render to sequentially numbered still image frames, and then convert them to a movie format as a second step. This has practical value if you need to correct mistakes in individual frames, without having to re-render the entire animation.

5. Open the Assign Renderer rollout and confirm that the Default Scanline Renderer is the production renderer. If you see mental ray renderer click Choose Renderer and change the renderer back to the Default Scanline Renderer.

Note: The mental ray renderer does not support the IES Sun lighting.

6. Leave the other Render Scene settings as they are, make sure *Camera02* is the active viewport, and then click Render.

3ds Max renders the animation. This takes a while (about a half hour on the high-speed system), so this is a good point to take a break.

#### View the animation:

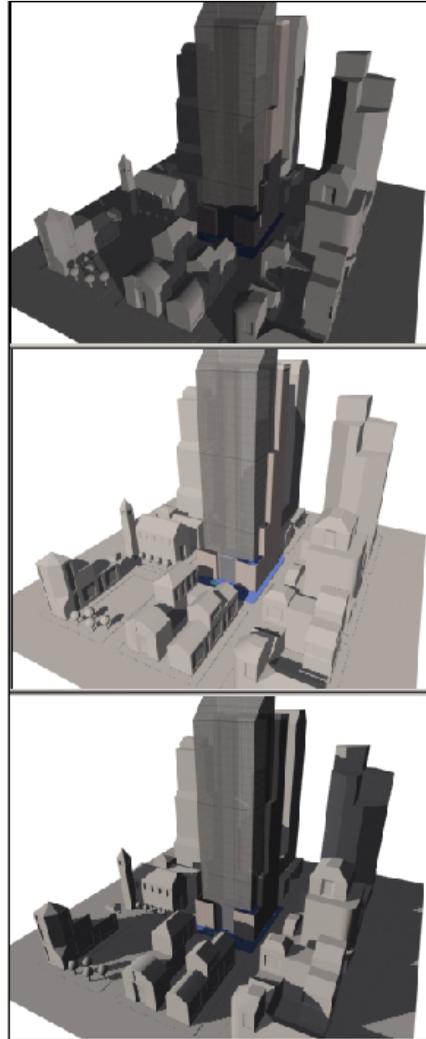
1. When rendering is done, choose File > View Image File.

A View File dialog appears.

2. Choose the file you just rendered, and then click Open.

Tip: You can also choose *shadow\_study.avi*, which is provided with the other tutorial files.

Depending on the movie type, a Media Player or a QuickTime viewer is displayed, which lets you play the animation.



## Summary

You can create a shadow study by animating the time of day of a Daylight system. To do so, use the Auto Key button, and change the hour at regular intervals of frames. (The longer the interval, the slower the animation will play.)

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## Rendering with mental ray: Final Gather and Global Illumination

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### Interior Architecture Rendering Tutorial

The following tutorial allows you to become a mental ray wizard for interior architecture in two two-hour sessions. Enjoy the trip.

The scene used for the tutorial, shown below, incorporates an interior room with daylight/sunlight. All materials use the new mental ray Arch & Design material that's part of mental ray 3.5 and is included in 3ds Max.



Next we show the scene rendered, without any global illumination. It is quite dark, as sun hits only a part of the scene. This is ideal for testing global illumination algorithms, as the dark parts will get all their light indirectly.



Scene rendered

Tip: To achieve optimal performance, we recommend that you use the mental ray [Arch & Design material](#) wherever possible. This material uses sophisticated importance-sampling techniques that can produce substantial overall speedup. A performance factor of up to 10 times is possible for final gather, especially glossy floors as well as materials with weak reflections. Improvement can be even greater with more bounces.

Skill Level: Intermediate to Advanced

Time to complete: Three to four hours.

## Features Covered in this Tutorial

The tutorial consists of four sections:

- The first section describes final gather (often shortened as FG), including multibounce.
- The second section describes photons. Due to being the first global-illumination technique implemented in mental ray, the mental ray interface groups photon techniques under the GI heading.
- The third section shows how to combine final gather and photons to get better performance.

- The last section briefly shows how to combine final gather and ambient occlusion.

## Tutorial Files

All the files necessary to do this tutorial can be found on the program disc. Before doing the tutorials, copy the *tutorials* directory from the disc to your local program installation.

## In This Tutorial

*Final Gather (page 713)*

*Final Gather and Ambient Occlusion (page 721)*

*Photons (page 723)*

*Photons and Final Gather (page 730)*

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## Final Gather

Final gather shoots rays into the scene. For each pixel (surface point on the geometry like walls) it shoots many rays into the scene. It measures the brightness of the rays to compute how much light gets to a given surface point.

### Set up Final Gather:

1. From the *tutorials\mental\_ray\* folder, open the scene file *fg+gi\_start.max*.

The scene is set to render with mental ray.

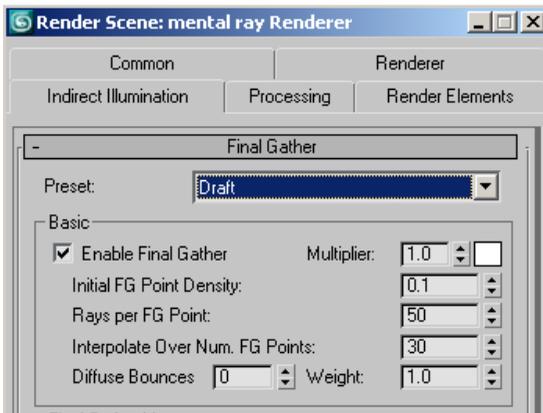
2. Press **F9** to render the scene.

As shown in the previous section, the interior is very dark, with daylight coming in from the window.



Scene rendered

3. Press **F10** to open the Render Scene dialog. On the Indirect Illumination panel > Final Gather rollout, turn on Enable Final Gather and then choose the Draft preset.



Activate FG

4. Click the Render button to compute an image.

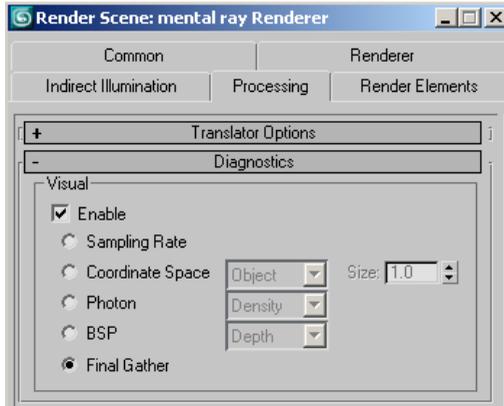
Final gather provides more realistic lighting, allowing the daylight to illuminate the darker portions of the scene.



#### Visualize Final Gather points:

To best understand and use final gather, it helps to have a notion of the underlying concepts. You'll start with final gather points.

1. On the Processing panel > Diagnostics rollout, turn on Visual > Enable and then choose Final Gather.



*FG diagnostic enabled*

## 2. Render the scene again.

Each final gather point is displayed as a green dot.

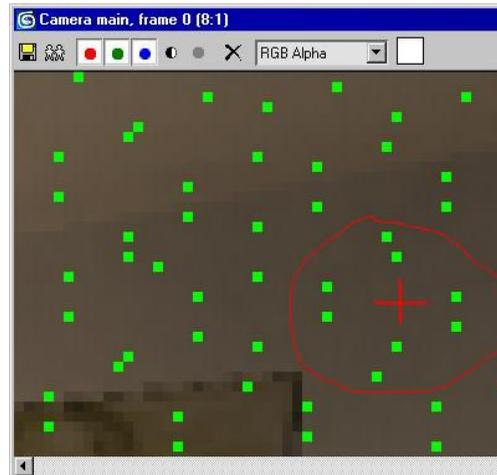


At each final gather point mental ray shoots a bundle of rays into the scene to check how much light is hitting the point. You control the number of rays with the Rays Per FG Point setting.

### Interpolate FG Points:

One of easiest-to-understand parameters is Interpolate Over Num FG Points. This determines how many FG points are used to compute the final result. By default the parameter value is 30, which causes 29 neighbors to be combined with each FG point.

The following illustration shows a zoomed area of the image. One pixel is marked with a red cross. The eight closest FG points are inside a red outline. If Interpolate Over Num FG Points is set to 8, mental ray would take these eight points to interpolate.



*Eight points (green) interpolated to get color at red cross*

The following images show the results of setting Interpolate Over Num FG Points to values between 1 and 200.



*Interpolate Over Num  
FG Points=1*

*Interpolate Over Num  
FG Points=5*



*Interpolate Over Num  
FG Points=30*

*Interpolate Over Num  
FG Points=200*

Feel free to try each of these to see the results on your screen.

At 1 the image is very noisy; at 5 it's a bit smoother but still noisy. At 30, the rendered image looks quite realistic, and at 200 the result is absolutely smooth. The great news is that increasing Interpolate Over Num FG Points costs very little

performance: Setting it to 200 takes, at most, only a few minutes longer to render than at 1, even with large, complex scenes that take a long time to render.

So why not always use 200? Because interpolation removes local details. For example, the ceiling near the window looks very flat in the 200 image.

Interpolation is the best choice when you need a noiseless image but long rendering times aren't practical.

### Density

The next parameter we discuss is Initial FG Point Density. This is the density of the final gather points grid, which covers the entire image. Density species the grid spacing. The following images start with the Draft preset and vary only the density. Note that Noise Filtering is off (None).

Density varies from 0.01 at the top to 4.0 at the bottom. As the value increases, so does the number of green dots (final gather points) in the diagnostic images.

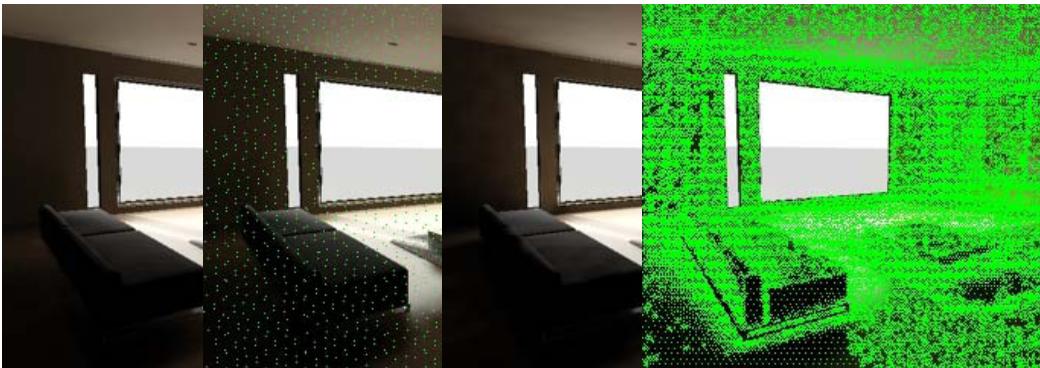


*Initial FG Point  
Density=0.1*

*Initial FG Point  
Density=0.1  
(Diagnostic)*

*Initial FG Point  
Density=1.0*

*Initial FG Point  
Density=1.0  
(Diagnostic)*



*Initial FG Point  
Density=0.1*

*Initial FG Point  
Density=0.1  
(Diagnostic)*

*Initial FG Point  
Density=4.0*

*Initial FG Point  
Density=4.0  
(Diagnostic)*

This image shows perfect details already, but it also introduces some noise. Increasing the interpolation is one way to resolve the noise. An alternative way is shown below.

Higher density shows more detail. Whenever you need more detail in a scene, increase the density.

### Rays Per Point

Each FG point shoots a bundle of rays into the scene. You can specify the number of rays with the Rays Per FG Point parameter. Using a low value is faster but can generate noise. A high value can reduce or eliminate noise, but takes longer to compute. To show how this influences rendering, start with the Low preset and then turn off interpolation by setting Interpolate Over Num. FG Points to 1.

Set Rays Per FG Point to 1 and then render.

Here you see individual FG points, with each FG point shooting exactly one ray.



*Rays Per FG Point=4*

*Rays Per FG Point=50*



*One ray per FG Point*



*Rays Per FG Point=500*

*Rays Per FG Point=10000*

The image with 10,000 rays can take some time to render. The image is quite good without any interpolation. Adding a bit of interpolation can resolve any remaining noise.

### Density versus Rays

When should you increase grid density, and when should you increase the number of rays per FG

point? Why not have a single control? And when should you modify the number of rays per FG point?

More rays are required for scenes with a small bright window (high contrast inside the scene).

Fewer rays are required for a scene with even illumination, like a white office room with many light sources at night (no daylight).

Typical values are:

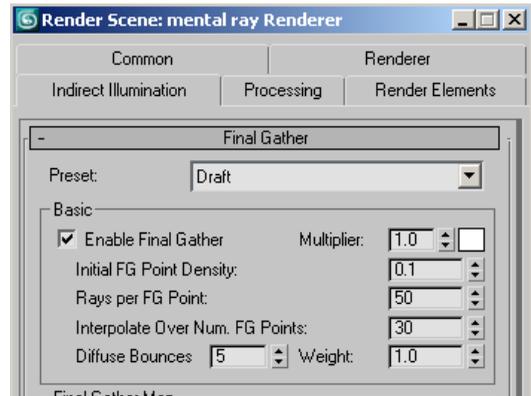
- fewer than 50 rays for even illumination (low contrast)
- 100-500 for average scenes
- 1,000-10,000 for high-contrast scenes

The scene for this tutorial has very high contrast, with close to 100,000 lux in the sun near the window. The rest of the scene receives no direct illumination, because there are no light sources inside the room.

### Multibounce

The image still has dark corners. This is because we've been using final gather with no bouncing of light from one object to another. For example, illumination of a windowless hallway comes only from light bouncing several times: from window to wall to wall to hallway. In our scene, the area behind the sofa needs several bounces to "see" the sun.

To solve this we increase the Diffuse Bounces value to 5:



More bounces will distribute light correctly in the scene. For average scenes, five bounces are sufficient. Extremely white scenes could require up to 10 bounces, while dark-textured interiors might not need more than three.

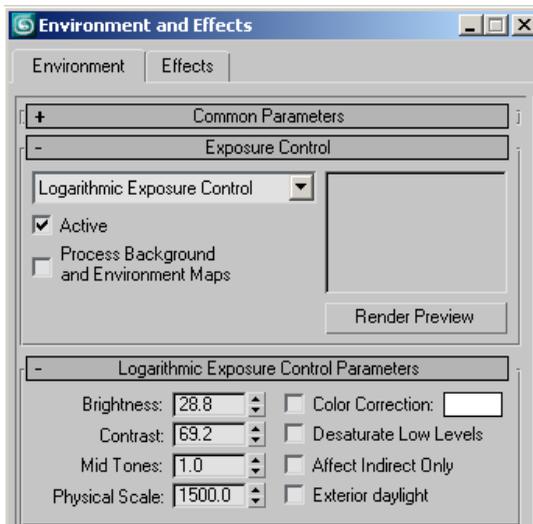
Increasing the number of bounces increases rendering time. Using five bounces needs roughly five times as long to render.

1. Try a test rendering with the Draft preset and Diffuse Bounces set to 5.

This produces a fairly bright image.



If that's too bright, adjust the Logarithmic Exposure Control > Brightness setting. The default value is 65.5, but in this scene it's set to 28.8.



It's generally good practice to test total brightness with a draft rendering. Adjusting the exposure control is then easy.

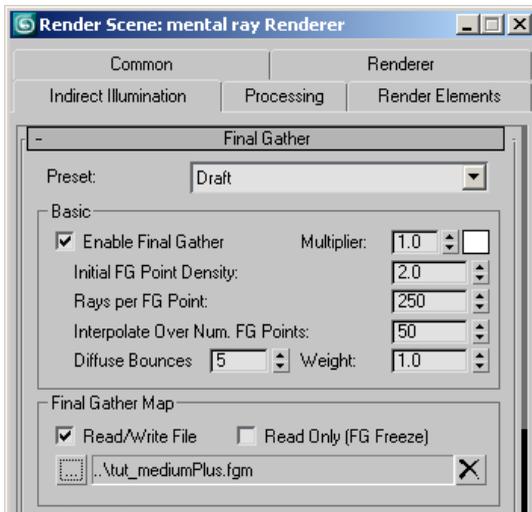
Later you can add detail (density) and reduce noise by adjusting interpolation and increasing the number of rays per FG point.

2. The Medium preset can help reduce noise and artifacts. Choose the Medium preset, set Diffuse Bounces to 5, and then render.



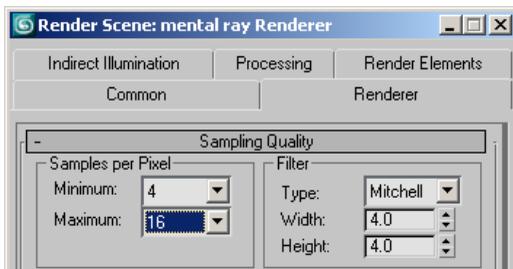
The image looks quite good, but to improve quality further you can:

- increase density to see more details, such as contact shadows.
  - increase interpolation to get a smoother image.
  - increase the number of rays.
3. The Medium preset didn't show significant noise, so increase Initial FG Point Density (this controls lighting detail) to **2.0**, and Interpolate Over Num. FG Points to **50**. Also, turn on Final Gather Map > Read/Write File, click the ellipsis [...] button, and enter the file name **tut\_mediumPlus.fgm**. This saves the final gather information to disk, so you can then quickly try different values for interpolation.



*Initial FG Point Density=2.0; Rays per FG Point=250*

4. To further improve the image, reduce the aliasing around the window by increasing oversampling (Samples per Pixel) to **4-16**. This works independent of final gathering, for any rendering.



5. Re-rendering with Interpolate Over Num. FG Points set to **100** gives a perfectly smooth image. An even better image can be achieved by increasing Rays Per FG Point.

## Next

*Final Gather and Ambient Occlusion (page 721)*

## Final Gather and Ambient Occlusion

In architectural rendering, one often needs to present a new image to a customer in a very short time. To get this done in a few minutes instead of hours, you can combine final gather with ambient occlusion (AO).

What is ambient occlusion? Briefly, it darkens occluded areas. For example, at the intersection of a wall and a floor, occlusion is higher than in the middle of the floor. Ambient occlusion does not transfer colors between surfaces; it simply darkens them.

To get a quite good image in minutes instead of hours, use final gather with a low density, such as

0.1. This is very fast and distributes light, including colors, in the scene. To get contact shadows and local details, add ambient occlusion. mental ray has special support for ambient occlusion that makes this fast.

The new mental ray Arch & Design material can do AO directly, in a single pass.

#### Use material-based Ambient Occlusion:

1. If not continuing from the previous lesson, from the `|tutorials|mental_ray|` folder, open the scene file `fg+gi_start.max`. Open the Render Scene dialog, and on the Indirect Illumination panel > Final Gather rollout, turn on Enable Final Gather.
2. On the Indirect Illumination panel > Final Gather rollout, choose the Draft preset and set Diffuse Bounces to **5**, if necessary.
3. Open the Material Editor and modify the floor material: On the Special Effects rollout, turn on Ambient Occlusion. Do the same for the wall material.
4. Render the scene.

The image with AO has good contact shadows and edges.

5. A final touch is to reduce the noise on the back side of the sofa. Increase the Interpolate Over Num. FG Points value to **100**.



*FG and AO with more interpolation*

This is the combination of the Draft FG preset with AO. You can also use the Medium preset to improve quality at the cost of rendering time.

### General notes on AO

Make sure AO is applied only locally within a small radius, just to bring out the small details, and let FG handle the coarser transport of light. A good rule of thumb is to set the AO radius to about 4 inches (**100mm**); this is the default setting.

If you think the “darkening” effect of AO is too strong, you can modify the Shadow Color value in the Ambient Occlusion group to a lighter color, such as 50 percent gray (set Value to **0.5**).

### Next

*Photons (page 723)*



*Final Gather only*

*Final Gather combined with ambient occlusion*

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## Photons

Using photons requires a certain degree of expertise, which you'll gain in this lesson. In many cases, final gather and final gather multibounce will suffice and be easier to control, with good performance.

Using photons without final gather rarely gives better results or performance. Combining final gather with photons can give a speedup of up to five times (see below).

### When to use photons

Use photons to distribute energy rapidly in a scene. Photons can easily perform many bounces.

When shouldn't you use photons? Photons don't like to jump through a keyholes. Imagine a dark room that is lit only through a keyhole.

Use photons when a room is rather evenly lit, in which case the photons can replace FG multibounces. Set Diffuse Bounces to 1, and combine it with photons.

### Preconditions for using photons

It is very important to use "physically correct" lights with photons. If the photons shot by the lights do not match the "direct light" shot by the lights, images will not look good.

In 3ds Max, all lights in the Photometric category do this automatically, whereas the standard lights are not guaranteed to perform in the same way, automatically. This is another reason for recommending that you mostly use FG. It works with any light, no matter how "unphysical," since it is concerned only with the transport of light from surface to surface, not the transport of light from the light to the surface.

Also note that the [mental ray Sky light](#) does not shoot photons, which explains why the following

renderings will be darker compared with FG. Until it does, you can use blue tinted photometric area lights in windows as a substitute, although we will not do that here. Also, the color tint is different, as blue light from the sky is missing, and most light (photons) from the sun hit the wooden floor first, which adds a tint.

Regarding interior renderings with lights other than sun/sky: If you plan to use photons, stick to the photometric lights. If you plan to use only FG multibounce, any light will work.

### What are photons?

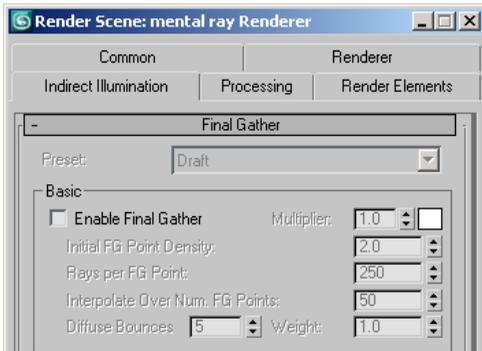
Photons in mental ray simulate real-world photons. They're reflected by mirrors, refracted through glass, and scattered on diffuse and glossy surfaces. The tutorial scene uses mostly diffuse surfaces; the walls in the scene have a heavily diffuse material. The sunlight that directly hits the wooden floor scatters into the room, and photons continue to bounce from wall to wall, due to the bright materials.

Note: For most scenes, using only photons is not the best choice. For best results, combine photons and FG. The goal of this section is to provide information required to understand photons in depth. This serves as a good basis for later combining photons with FG.

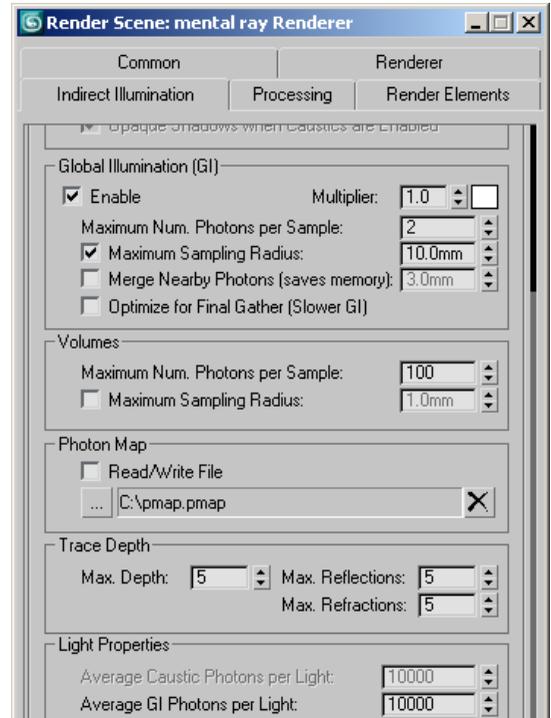
The following steps explain the usage of photons in mental ray. First we show that we indeed have individual photons, and then later we show how to get a smooth image.

1. If not continuing from the previous lesson, from the `|tutorials|mental_ray|` folder, open the scene file `fg+gi_start.max`. Open the Render Scene dialog, and on the Render Scene dialog > Indirect Illumination panel, turn on Global Illumination (photons).
2. If you're continuing from the previous lesson, on the Render Scene dialog > Indirect

Illumination panel, turn off Enable Final Gather and turn on Global Illumination (photons).



*Enable Final Gather is off.*



*Global Illumination (photons) is on.*

3. Set Maximum Num. Photons Per Sample to **2**, set Maximum Sampling Radius to **10.0mm**, and make sure Light Properties > Average GI Photons Per Light is set to **10000**.

The image isn't smooth yet, but we have brightness nearly everywhere.

- Increase the radius even further:



This image shows the photons. In nature, areas that have a higher density of photons are brighter. The major advantage of photons in mental ray is that they simulate this natural phenomenon, including reflections from metal and refraction through glass.

To get from individual photons to a smooth image, increase the radius and the number of photons looked up.

- Set Maximum Sampling Radius to **100mm** (0.1 meter).



*Maximum  
Sampling  
Radius=  
200.0mm (0.2m)*

*Maximum Sampling  
Radius=500.0mm (0.5m)*

Even with larger Radius settings (see preceding illustrations), the image is nearly identical. Why? Because we need more photons in the lookup. So far we've looked for only two photons, but a medium-quality image needs around 100 photons in the lookup. A high-quality image starts at 1,000 photons in the lookup. The following renderings increase the number of photons looked up, keeping the radius at 0.5 meter.

- Set Maximum Num. Photons Per Sample to **100** and render.



*100 (max.) photons per sample*

This image shows something to watch out for with photons: a light leak. Because mental ray is looking up photons in a large radius (0.5 meters), it might actually pick up some photons that have struck an object on the other side of the wall! This is what causes the bright streak in the far corner.

Otherwise, this image is already quite good, and rendering time is fast. The next step is to further increase the number of photons.

7. Set Maximum Num. Photons Per Sample to **1000** and render.



*1,000 (max.) photons per sample*

The image is now smooth, but looks washed out.

Further increasing the number of photons to be looked up will not increase image quality. We have a total of only 10,000 photons in the whole scene. We simply do not find more than 1,000 photons inside a radius of 0.5m. We could ask for a million, but we will not find more. To find more one could increase the radius, to catch more photons..

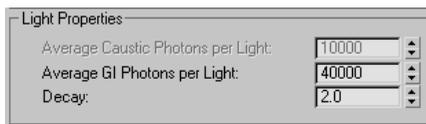
The image with a radius of 0.5m and 1,000 photons to be looked up is smooth, but lacks detail. How to add it?

We can suggest 2 1/2 strategies: The first is to shoot more photons into the scene. This lets you reduce the radius again, resulting in increasingly greater detail. We will describe this shortly with regard to the following three images, with the intent to increase your understanding of photon density versus image quality. The second strategy is to add final gather, which is often the best solution. The additional “1/2” strategy is to use photons for the overall light distribution, and ambient occlusion for the detail.

The silver rule for photons is: Shoot four times more photons from the light to decrease the radius by 2. This keeps roughly the same number of photons inside the area covered by the radius.

### 8. Render three images:

- one with Light Properties > Average GI Photons per Light=**40000** at radius **250mm** (0.25m)



- one with **160000** photons at radius **125mm** (0.125m)
- one with **640000** photons at radius **70mm** (0.07m)



*radius 0.25m,  
40k photons*

*radius 0.125m, 160k  
photons*



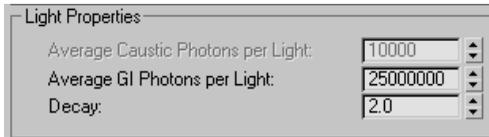
*radius 0.07m, 640k photons*

As the radius gets smaller, the light leak in the rear corner on the right wall shrinks, and, in general, detail returns. However, some low-frequency noise is visible.

This happens primarily because when the radius is smaller we see more detail, including more noise. This leads us to the golden rule for photons: To reduce the radius by 2, shoot 4 x 1.4 times the number of photons, and increase the number in the lookup by 1.4.

You can save and reuse the photon map independent of geometry and image size; doing so can dramatically speed up rendering for a camera walkthrough. Here we save it to try different lookup options to resolve the low-frequency noise. We run once with 2.5 million photons shot from the light source and store it in the photon map file.

9. On the Caustics And Global Illumination (GI) rollout, set Light Properties > Average GI Photons Per Light to **2500000**.



10. On the Caustics And Global Illumination (GI) rollout, in the Photon Map group, turn on Read/Write File and then click the ellipsis [...] button. Specify a path and filename, and then render the scene. The render should take a few minutes.



You can use a saved photon map arbitrarily, even with a completely different scene for artistic purposes. The photon-emission phase takes place instantaneously with a saved photon map. When tuning lookup with a large number of photons, using a photon map can save a great deal of time.

To remove the low-frequency noise you can increase the number of photons in the lookup; for example, to 10000. If the rendering time doesn't go up, it means that there are not more photons inside a 125mm radius. You then need to increase the radius a bit, to get to a point where mental ray finds more photons again.

In this image the low-frequency noise is gone, but the light leak remains.



*Maximum Sampling Radius=70.0mm*

Here the light leak is gone, but noise is visible.



*Maximum Sampling Radius=30.0mm*

How to resolve this? To remove the noise you could increase the radius, but this also causes the light leak. An easy fix would be to place a black object on the outside of the building so photons don't get stored there. If this isn't suitable, you need more photons in the lookup. A frequent misunderstanding is simply to increase the lookup, for example to 20,000

instead of 10,000. This helps only if mental ray indeed finds enough photons inside the radius. If not, you need to shoot more from the light source.

The limit to quality with photon maps is memory. For small radii, mental ray needs many photons. Most 32-bit versions of Windows can access up to two gigabytes of memory, while the extended version allows up to three gigabytes. If you export an MI file to the standalone version of mental ray, you can eliminate the application's (3ds Max) memory footprint, thus making additional memory available to the renderer.

## Photon merging

Photon merging is a new feature in mental ray 3.5 that lets you create an optimized photon map, which enables bringing more photons to dark areas of a scene. Photons inside a given radius are merged, and thus consume less memory. Especially bright areas have many photons close to each other, consuming a lot of memory. Using merging in bright areas reduces memory requirements. You can shoot many more photons before hitting memory limits. Typical values can be 10 million to 50 million photons.

Use photon merging only when a larger number of photons is required. This feature is intended primarily for advanced users. The procedure is:

1. Set the merge radius to 3-5 percent of the regular lookup radius.
2. Massively increase the number of photons shot from light sources.

Using a merge radius larger than 5 percent typically does not help. Shooting more photons from light sources is a must. Merging alone solves memory. Shooting more photons improves quality.

- As an example of photon merging, we can use the current scene, which has 2.5 million

photons. Now try shooting 10 million. Turn on Merge Nearby Photons and set the merge radius to **1.0mm**. The lookup (Maximum Sampling) radius is **30.0mm**, as before.



*Merge radius=1.0mm*

The result shows how you can achieve a new level of quality with merging. As a bonus, you can save the merged photon map just like any other photon map.

The conclusion for photons is that they are useful for distributing energy within a scene. Even a small number of photons can provide beneficial overall illumination. However, the Draft preset for final gather often does the same job more easily. Photon maps can increase memory use and lookup time when details are required.

A better alternative to get details is to combine photons and final gather.

## Next

*Photons and Final Gather (page 730)*

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## Photons and Final Gather

You can combine final gather with photons. Photons correctly distribute energy into the scene, using several bounces. Final gather does lookups into this solution to get an image that has both details and correct bouncing of light within the scene.

When combining photons and FG, the good news is that you don't need a detailed photon solution: Final gather generates the local details. It is thus possible to use a low number of photons. You don't have to use 5 million photons and then combine them with 2,000 FG samples. You can use as few as 5,000-50,000 photons for the overall lighting, and then add FG rays for the details.

### Performance Considerations

Combining FG and photons can give a performance improvement of around five times when it replaces final gather multibounce. Five bounces in FG take roughly five times as long as one bounce (assuming a room with white walls). Shooting photons instead can be done in a few seconds. Whether or not to use photons, then, depends on:

- Are multiple bounces required? Exterior rendering, for example, doesn't need that. Also, bright rooms with a lot of glass work fine with a single bounce.
- Do photons work easily with the scene or do they create photon leaks?

### Becoming an Expert

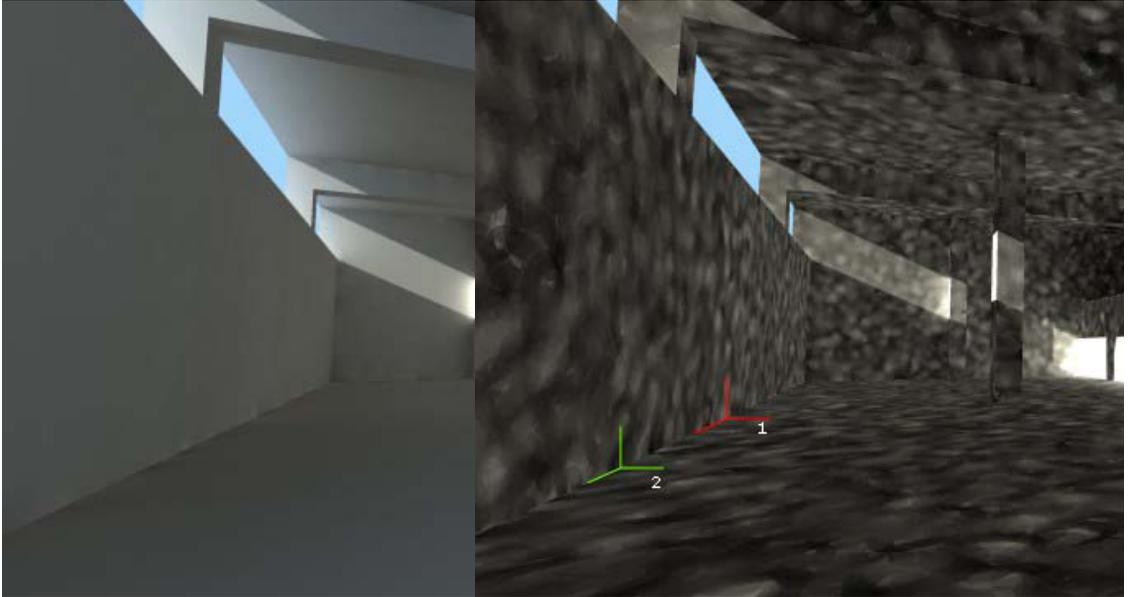
Before combining FG and photons, it's best that you gain experience handling photons. In particular, you need to know how to get a smooth photon solution. To become an expert on FG and photons, study these points:

- Final gather "sees" the photon solution.

- First render with FG off, and make sure the photon solution is smooth. It doesn't have to be as smooth as a solution that only uses photons, but be aware that bright spots, or big jumps in intensity across an edge, are "seen" by final gather. When final gather sees an unsmooth solution, it creates splotches. Increasing final gather quality *cannot* solve this. Shooting 10,000 rays at a bright spot will still see a bright spot.
- Always do the photon test first, and then add FG. Do not ignore this: It is valuable information that can save you days of experimenting.

If you don't follow this advice, combining photons and FG can, in particular, create artifacts along edges.

The following image is from a different scene, not included in the tutorial, to illustrate the effect. You can see artifacts along the edge where the left wall intersects the floor. The scene uses final gather combined with photons.



*Artifacts along edges*

The next image shows the photon solution that's responsible for the artifacts.

*Unsmooth photon solution*

For two of the artifacts we choose a point (red and green) and show what final gather “sees”: a lot of bright photons in one case, and a lot of dark wall in the other. This is the cause of the artifacts.

Always check the photon solution first to insure that photon intensity is reasonable smooth along edges. If it isn't smooth enough, final gather will see it and maintain the jump no matter how high you set final gather quality. If you stick to this formula, you can easily resolve this.

## **Photons, Ambient Occlusion and Beyond**

This possibility is mentioned for completeness. In most cases combining final gather and ambient occlusion (AO) gives better results. You can always use ambient occlusion to add contact shadows to an overly smooth global illumination image: First create a smooth photon-based image, using a few

photons and a large Maximum Sampling Radius setting. Then use the mental ray [Arch & Design material](#), and activate ambient occlusion in it. Details how to add AO are described in the *final gather lesson (page 713)*.

You can also achieve attractive results quickly by combining all three methods:

- Photons, for fast overall transport of light energy
- FG, to smooth the photon solution into medium-size details
- AO, to bring out small details from the medium-sized detail

In other words: Let photons handle things at the meter scale, FG handle things at the 0.1-meter scale, and let AO bring out detail at the centimeter/millimeter scale. This can create fast, smooth, yet detailed renderings.

The approach is the same as that described earlier in this lesson, for photons+FG, except you intentionally use a lower-density and smoother FG solution, which renders faster, with AO added on top.