

Rendering Techniques in 3D AutoCAD[®], Part 1

David Cohn

GD111-3 Do you need to create renderings of your architectural projects? Learn how to convert 3D drawings into finished, professional-looking renderings using the tools already built into AutoCAD. In this class, you'll learn all about AutoCAD Lighting, Materials, Textures, and Rendering commands. We'll take several typical architectural models and create finished photo-realistic images..

About the Speaker:

David has more than 20 years of hands-on experience with AutoCAD as a user, developer, author and consultant. He is an independent CAD consultant, a contributing editor to *Desktop Engineering* magazine, the former publisher and editor-in-chief of *CADCAMNet* and *Engineering Automation Report*, the former senior editor of *CADalyst* magazine, and the author of more than a dozen books on AutoCAD. A licensed architect, David was also one of the earliest AutoCAD third-party software developers, creating numerous AutoCAD add-on programs. As an industry consultant, David has worked with many companies including Autodesk. He teaches college-level AutoCAD courses and is always a popular presenter at Autodesk University.

david@dscohn.com

Rendering creates a 2D image based on your 3D scene. It shades the scene's geometry using the lighting you've set up, the materials you've applied, and environmental settings such as background and fog.

There have been rendering tools in AutoCAD for many years, enabling users to create realistic images incorporating materials, multiple light sources, and entourage objects such as trees and people, but those tools remained relatively unchanged since Release 12.

In response to user feedback, Autodesk completely revised AutoCAD's rendering tools as part of the new visualization capabilities introduced in AutoCAD 2007. Those capabilities were further enhanced by the addition of several other new capabilities in AutoCAD 2008, including the addition of photometric lights, more realistic sun and sky backgrounds, and procedural material maps. AutoCAD 2009 makes further changes through the use of the new ribbon bar in lieu of the dashboard. AutoCAD now uses mental ray®, the same rendering engine as 3dsmax®. The new tools make it easier than ever before to add materials and lights to your AutoCAD models so that you can create realistic renderings. If you've used the older rendering tools in the past, the new tools may at first seem to be much different. But in reality, many of the new tools work in a similar fashion to those in previous versions of AutoCAD. And for those who have never rendered before, the good news is that the new rendering tools are much more accessible and easier to use. Many of the options that users had to contend with in past releases are now either unnecessary, or can be ignored initially. Users can simply select one of AutoCAD's new rendering presets to quickly create finished renderings.

There are also new commands that make it easy to walk or fly through your models, something that was not possible at all in previous releases.

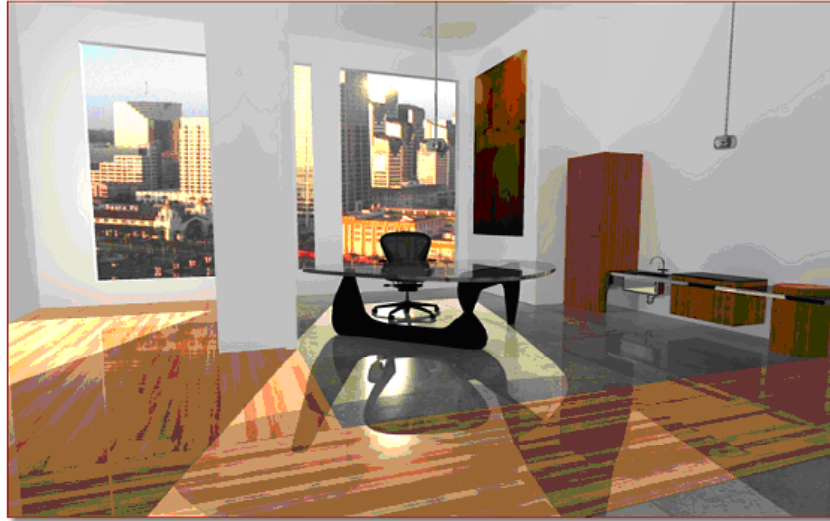
AutoCAD can now display models with realistic materials, lighting, and shadows. The ability to see these aspects of the model depends on which visual style is currently active. A visual style is a collection of settings that control the display of edges and shading in the viewport. Instead of using commands and setting system variables, you change the properties of the visual style. As soon as you apply a visual style or change its settings, you can see the effect in the viewport.

AutoCAD comes with five pre-defined visual styles—2D wireframe, 3D wireframe, 3D hidden, conceptual, and realistic—and you can create and add your own custom visual styles. When you select the realistic visual style, AutoCAD displays your model with materials and shadows. Rendering adds more realism to those materials as well as showing reflection, refraction, and the true effects of lighting.

If you've worked with rendering in previous versions of AutoCAD, you will also notice other changes, most of them for the better (such as being able to adjust lights using properties and grips). But some of the changes may prove a bit daunting at first. Lights and materials in AutoCAD 2007 and 2008 are considerably different from previous versions. If you're working with older drawings that contain lights and materials, you can convert them to the new type:

- **CONVERTOLDLIGHTS** converts older lights to AutoCAD 2007 format
- **CONVERTOLDMATERIALS** converts older materials to AutoCAD 2007 format

Note that procedural materials and material mapping settings do not migrate. Also, some material features are no longer supported, such as material by ACI (AutoCAD color index) association. In addition, the commands for creating and inserting landscape objects—LSNEW, LSLIB, and LSEdit—are no longer included in AutoCAD.



Rendering Basics

Rendering can be a very time-consuming aspect of a project. Because of the subtleties involved, you can spend a lot of time adjusting camera positions, lighting, and materials. In the past, you might spend more time creating a rendering than you spent actually building the 3D model. In addition, when you work with multiple light sources, each of which casts shadows, the computer calculations require a considerable amount of horsepower. Again, the good news is that the new tools in AutoCAD can help shorten this process, because you can now preview many aspects of your final image before actually creating a rendering. And as in previous versions, you can do initial renderings at lower quality settings or render just a portion of the final image, to test your changes before creating a final high-resolution rendering.

The process of creating a computerized rendering involves four steps:

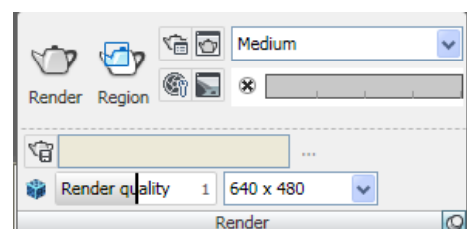
- Create the actual model
- Place lights
- Attach materials to objects in the model
- Render the image

Other than creating the model, these procedures are conceptual rather than discrete sequential steps, and often are performed in an iterative process. For example, you may place some lights and create a test rendering. Then, after viewing the results of your test, you may change some of the lights and render the image again.

There is one last change to be addressed before we proceed. AutoCAD 2009 uses a ribbon bar, collecting tools into task-based panels, eliminating multiple toolbars and reducing screen clutter.

The Render Panel

The Render panel appears on the Output ribbon bar and initially displays in its collapsed state. In this state, you can render an entire view, render a cropped portion of a view, select a render preset, and cancel a rendering task that is in progress. A rendering progress meter, also found in the Render window, displays how far rendering has

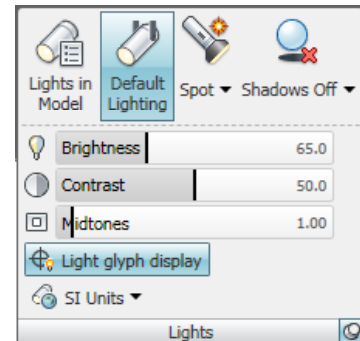


progressed. You can also open the Render Presets Manager where you can create or alter custom render presets, display the Advanced Render Settings palette to adjust more advanced setting, display the Render Environment dialog box where you can set fog and depth of field effects, and adjust rendered exposure. By expanding the Render panel, you gain access to tools to save the rendering to a file, adjust the render quality, and control the resolution of the rendering.

Working with Lights

Placing lights in your model quickly adds a new level of realism. The combination of carefully placed lights and realistic materials quickly turns a flat, shaded image into a close approximation of reality.

When you work in a viewport with a 3D shaded view, the default lighting comes from two distant sources that follow the viewpoint as you move around the model. All faces in the model are illuminated so that they can be seen. You can control the brightness and contrast, but you do not need to create or place lights yourself. The default lighting must be turned off in order to display lighting from user-created lights or the sun.



You place lights using the tools in the Lights panel, found on the Visualize ribbon bar.

User-Created Lights

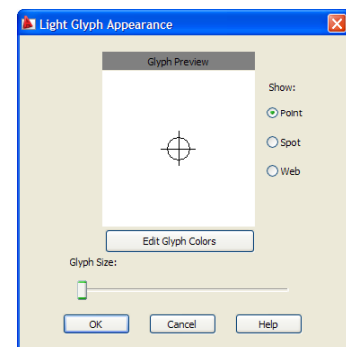
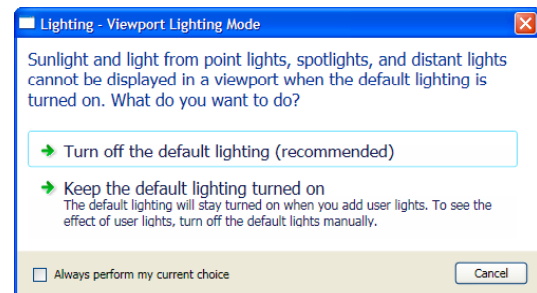
For more control over lighting, you can create point lights, spotlights, web lights, and distant lights to achieve the effects you want. Note that when you place your first light into a drawing, AutoCAD displays a warning dialog to let you know that the effects of lights cannot be displayed in a viewport until you toggle the lighting mode from Default lighting to User light/sunlight.

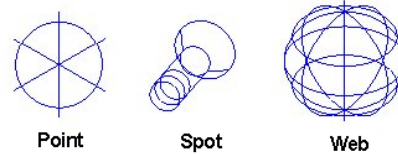
After placing lights, you can move or rotate them with grip tools, turn them on and off, and change properties such as color. The effects of the changes you make are immediately visible in the viewport.

The ability to modify lights using grips and the Properties palette is new beginning in AutoCAD 2007. In previous versions, you could only adjust lights using a special Lights dialog box.

Spotlights, point lights, and web lights are each represented by a different light glyph. Distant lights and the sun are not represented by glyphs in the drawing because they do not have a discrete position and affect the entire scene. You can turn the display of light glyphs on and off while you work. By default, light glyphs are not plotted.

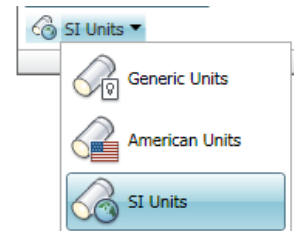
The appearance of light glyphs is controlled from the Light Glyph Appearance dialog box, accessed by clicking the Light Glyph Settings button on the Drafting tab of the Options dialog box.





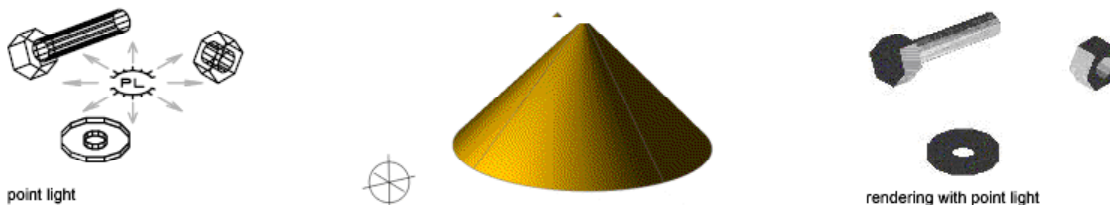
For more precise control over lighting, you can use photometric lights to illuminate your model. Photometric lights use photometric (light energy) values that enable you to more accurately define lights as they would be in the real world. For example, you can specify that a light uses a 75W bulb and adjust the lamp intensity of the bulb in Cadela, Lumen, or Lux units. Photometric lights are new beginning in AutoCAD 2008.

Previous versions of AutoCAD used just one type of lighting. Starting with AutoCAD 2008, however, you can select International (SI) lighting units, American units of measure, or standard (generic) lighting (the type of lights used in AutoCAD 2007). The type of lighting used is controlled using the LIGHTINGUNITS drop down at the bottom of the expanded Lights panel.



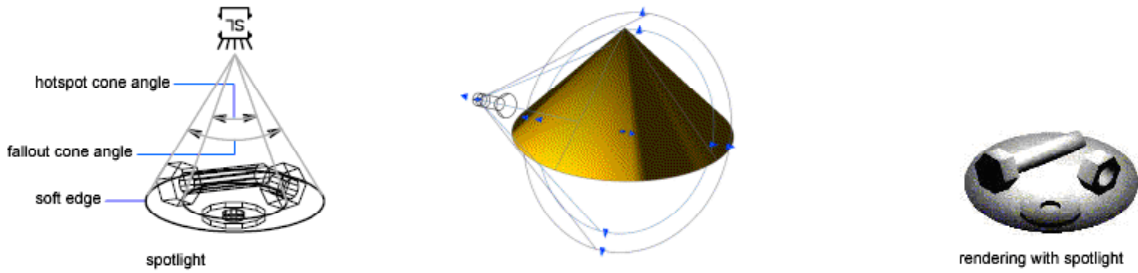
When placing standard lights, you can specify that the intensity of light diminish over a distance, with the attenuation specified as the inverse of the linear distance from the light or the inverse square of the linear distance from the light, or that the intensity not diminish at all. The intensity of light from photometric lights always diminishes over a distance according to the inverse square of the distance. Lights created in AutoCAD 2008 and 2009 are now photometric by default.

- **Point Light** A point light radiates light in all directions from its location and does not target an object. Use point lights for general lighting effects. You can create point lights using the POINTLIGHT command or by selecting a point light from the Lights panel.



You can also create a target point light, either by using the TARGETPOINT command or by changing the Targeted property of the point light from No to Yes. The difference between the target point light and a point light is the additional target properties that are available.

- **Spot Light** A spot light emits a directional cone of light. The light in the central portion of the cone is brighter than the light around the edges of the cone. You can control the direction of the light and also adjust the angle that defines the size of the central portion of the cone, or *hotspot*, and the angle that defines the outer extents of the cone, or *falloff*. The greater the difference between the hotspot and falloff angles, the softer the edge of the light beam. If both values are nearly equal, the edge of the light beam is sharp. Values can range from 0 to 160 degrees. Spotlights are useful for highlighting specific features in areas of your model. You can create spotlights using the SPOTLIGHT command or by selecting the spot light from the Lights panel.



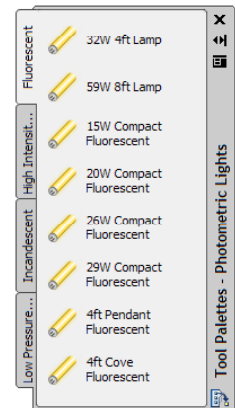
You can also create a free spotlight, by using the FREESPOT command. A free spotlight is similar to a spotlight, but without a specified target.

- Weblight** A web light is a 3D representation of the light intensity distribution of a light source. Weblights can only be created when LIGHTINGUNITS is set to SI or American units. Photometric weblights can be used to represent non-uniform (anisotropic) light distributions derived from data provided by manufacturers of real-world lights. This gives a far more precise representation of the rendered light than either spot or point lights are capable of.

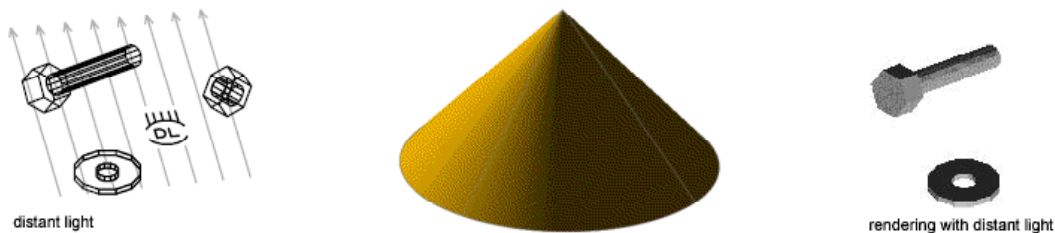
This directional light distribution information is stored in a photometric data file in the IES format using the IES LM-63-1991 standard for photometric data. You can load photometric data files provided by various manufacturers under the Photometric Web panel in the Properties palette for the light.

Light that uses a photometric web can be added to a drawing by using the WEBLIGHT or FREEWEB commands. A weblight targets an object whereas a freeweb light does not.

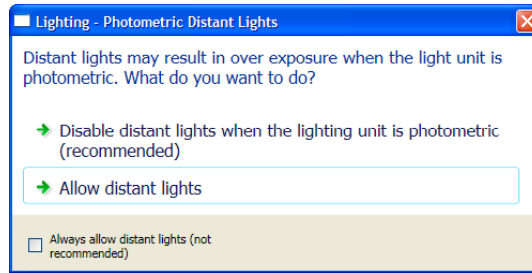
Commonly used lamps for defining photometric lights—including fluorescent, low pressure sodium, incandescent, and high intensity discharge—are available on the Photometric Lights tool palette.



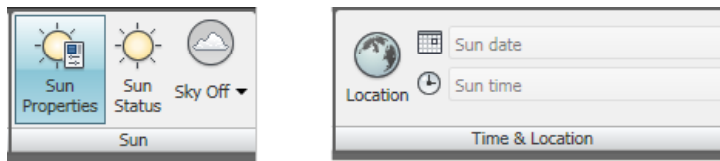
- Distant Light** A distant light emits light that travels in parallel rays in one direction and does not diminish over distance; it is as bright on each face it strikes as it is at the source. You specify a FROM point and TO point anywhere in the viewport. There is no glyph to represent a distant light in your drawing. Distant lights are useful for uniformly lighting objects or a backdrop. You can create distance lights using the DISTANTLIGHT command or by selecting the distant light from the Lights panel.



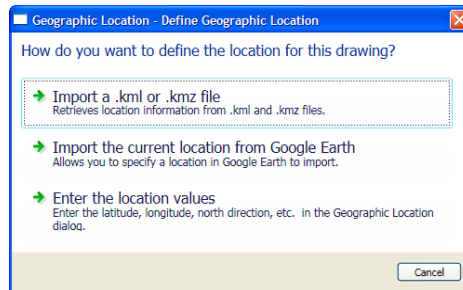
Distant lights are not physically accurate, however. For that reason, you cannot select the distant light from the Lights panel when LIGHTINGUNITS is set to generic, although you can still enter the command at the command line. If you do so, however, AutoCAD displays a warning.



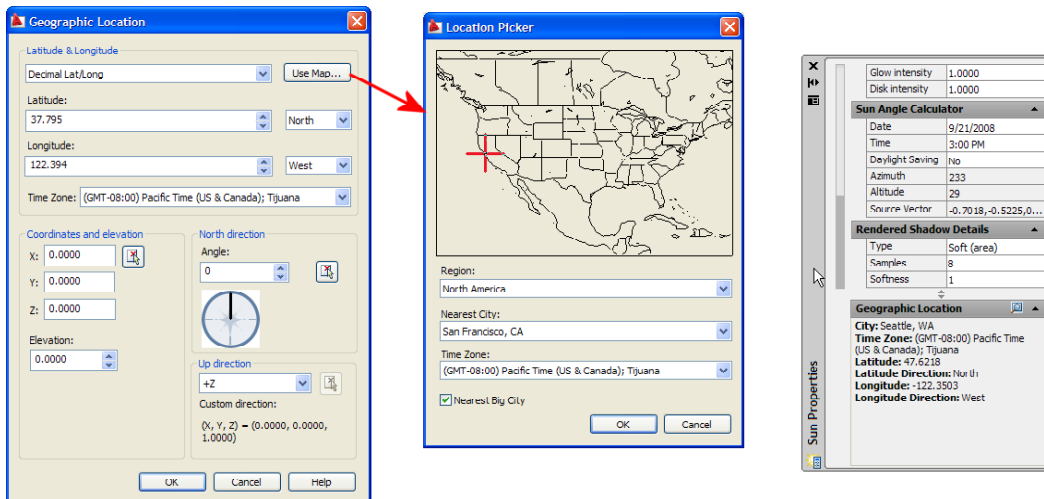
- Sunlight** The sun is a light that simulates the effect of sunlight and can be used to show how the shadows cast by a structure affect the surrounding area. The rays of the sun are parallel and have the same intensity over any distance. The sun properties are controlled using the Sun panel on the Visualize ribbon bar while the angle of light from the sun is controlled using the settings in the Time & Location panel.



When you click the Location button, you can choose the method you want to use to define the location for the drawing:



Select Enter the Location Values to specify the geographic location within AutoCAD. You can then specify latitude and longitude, or click the Use Map button to select the location using a map.

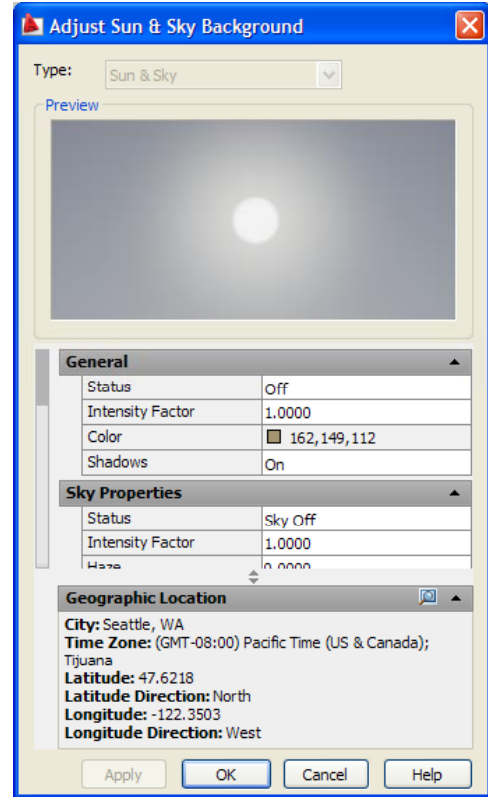


Once selected, the sun properties can be changed in the Sun Properties palette.

Sun and sky are the primary sources of natural illumination in AutoCAD. Whereas the rays of the sun are parallel and of a yellowish hue, the light cast from the atmosphere comes from all directions and is distinctly bluish in color. When using photometric lighting, more sun properties are available.

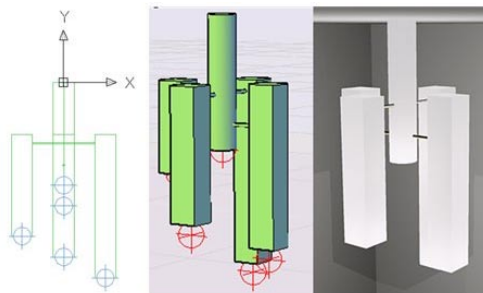
The option to choose the sky background is only available when the using photometric lighting. When available, you can have a sky background or a sky background and illumination. The sun and sky background can be interactively adjusted in the Adjust Sun & Sky Background dialog box, which can be activated by clicking the button on the Sky Properties title bar in the Sun Properties palette. This dialog box enables you to control general sky properties, the appearance and location of the ground plane (horizon), haze, the scale and appearance of a sun disk, and other sky and background settings. Note that you can also access this dialog box from the View Manager dialog box.

Including sky illumination adds extra light to a scene, simulating the effect of light scattered by the atmosphere throughout the scene.



Using Luminaire Objects

AutoCAD enables you to embed photometric lights in blocks that also contain geometry, thus creating light fixtures that model both the physical and photometric properties of actual lighting fixtures. After modeling the 3D representation of the light, select the photometric lights from the Photometric Lights tool palette, position them within the model of the physical light, and then create a block of the light objects and 3D representation of the lights to create the light fixture with photometric properties.



Controlling the Location and Properties of Lights

With the exception of the sun and lights in blocks and xrefs, each light you add to the drawing is listed by name and type in the Lights in Model palette. When a light is selected in the list, it is selected in the drawing and vice versa. Once selected, all of the properties of the light can be changed in the Properties palette. You can also use grip tools to move or rotate the light and change some other properties, such as the hotspot and falloff cone in spotlights. You can see the effect on the model as you change the properties of a light.

You can control any of the following properties individually for each light in the drawing:

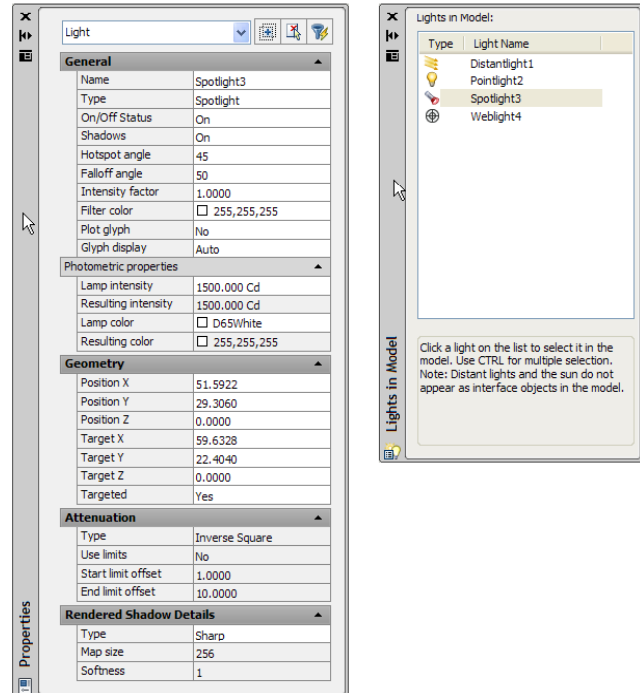
- **Type** Specifies the type of light: point light, spotlight, web light, or distance light.
- **Status** Controls whether the light emits light when the default lighting is turned off.
- **Shadows** Controls whether the light casts shadows. To be displayed, shadows must be turned on in the visual style applied to the current viewport.
- **Intensity** Sets a multiplier that controls the brightness. Intensity is not related to attenuation.
- **Color** Sets the color of the light emitted.

In addition to these settings available for all lights, some lights provide additional settings. For example, for standard lights you can control the attenuation for point lights and spot lights (which controls how light diminishes over distance; the farther away an object is from a light, the darker the object appears) and use limits to control the start point and end point of light. Limits work like clipping planes to control where light is first emitted and where it stops. The use of limits can increase performance by removing the need for AutoCAD to calculate light levels where the light is already practically invisible.

For photometric lights, you can control the lamp intensity and lamp color. AutoCAD additionally calculates and reports the resulting lamp intensity (the product of lamp intensity and intensity factor) and resulting color (the product of the lamp color and filter color). After a light has been placed in a scene, the position and target can be modified. The light, which is represented by a light glyph, can be repositioned after it is placed in the drawing. The light can be moved and rotated, and the target can be modified. When the light glyph is selected, grips are displayed.

By selecting the light with a right-click, a shortcut menu is displayed that provides the following options for adjusting the placement of the light:

- **Move** Activates the MOVE command. Used to change the position of the light.
- **Rotate** Activates the ROTATE command. Used to change the orientation of the light. In addition, you can use the ROTATE, 3DROTATE, and ROTATE3D commands.
- **Flip** Rotates the target of the light in the opposite direction.



Working with Materials

Attaching realistic materials to objects in your model truly brings those objects to life. By attaching materials and adjusting the way that they appear on those objects, you make the flat surfaces appear to be made out of real brick and mortar. You attach materials using the tools on the Materials panel located on the Visualize ribbon bar.

AutoCAD comes with a library of more than 400 predefined materials.

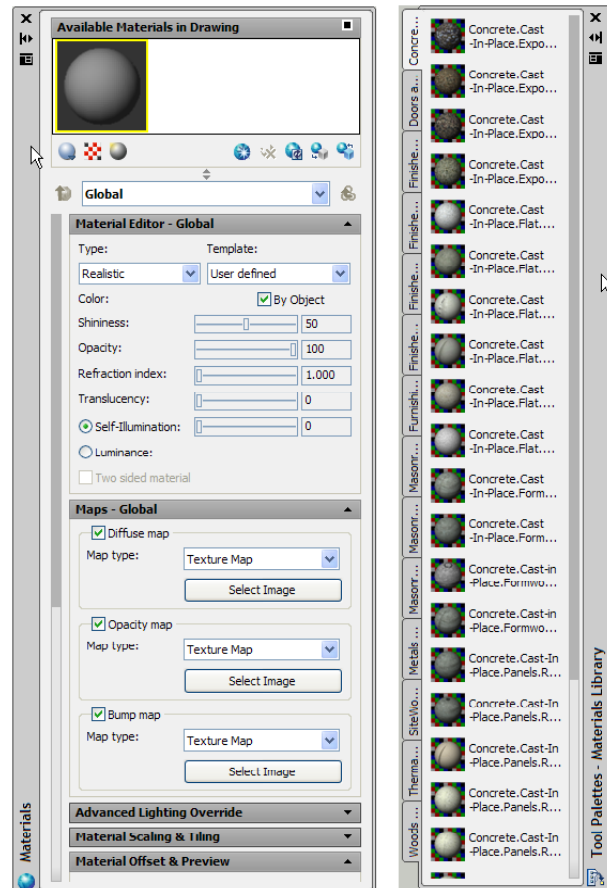
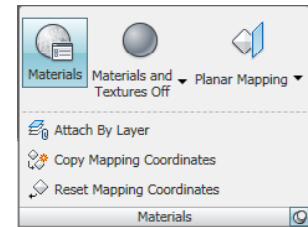
Note that in order to utilize all of those materials, however, you must install the material library (by selecting a check box on the same screen in which you specify that you want to install the Express Tools during installation of the AutoCAD software). If you don't install the materials library, you will have a smaller subset (less than 100) of materials available. You can install the materials library by using Add/Remove Programs to install additional AutoCAD components.

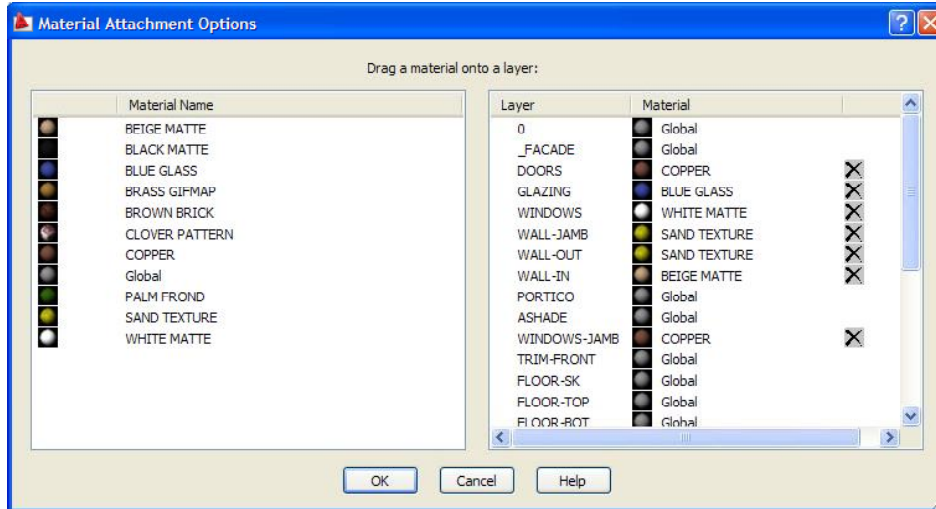
The materials available in the current drawing appear in a Materials window. The GLOBAL material is always in the drawing and is the default material for all objects that have not yet been assigned a material. The materials in AutoCAD's material library are available on tool palettes. In order to use a material in a model, you must first add that material to your drawing, which you can do by either dragging the material from the tool palette directly onto an object, into the Materials window, or simply into the drawing. Once a material is added to the drawing, it is also displayed as a swatch in the Materials window.

Applying Materials to Objects and Faces

You can attach a material to an object, individual faces, or to all objects on a particular layer.

- To attach a material to an object, simply drag the material onto the object. You can also click the Apply Material to Objects button in the Materials window, and then select the objects to which you want the material attached.
- To attach a material to an individual face, press the CTRL key while dragging the material onto the face of an object.
- To attach materials to objects by layer, use the Material Attachment Options dialog box (displayed by clicking the Attach By Layer tool in the Materials panel of the ribbon bar).





The left side of the dialog box shows the materials available in the current drawing. The list on the right shows the layers in the drawing. To attach a material to a layer, simply drag it from the list on the left and drop it onto the layer in the list on the right. The material is attached to all objects on the layer whose Material property is set to BYLAYER (the default). To remove a material from a layer, click the adjacent Detach button.

Creating and Modifying Materials

Each material is defined by a number of qualities. The available options depend on the template used:

- Realistic and Realistic Metal templates: materials based on physical qualities
- Advanced and Advanced Metal templates: materials with more options, including properties that you can use to create special effects, such as simulated reflections

You can create and modify materials in either the Material tool palettes or the Materials window. Note, however, that changes you make within the Materials window affect only the current drawing, while changes you make within the Materials tool palettes affect the materials stored in AutoCAD's materials library. Rather than modify materials in the tool palettes, you should first make a copy of an existing material and then modify the copy. You can also create a new material first within the Materials window and then add that material to the tool palette so that it will be available for use in other drawings.

- To create a new material in the Materials window, click the Create New Material button, assign a name and description for the new material, and then define its material qualities.
- To modify a material in the Materials window, simply select the material you want to change and adjust its qualities.
- To modify a material in a tool palette, right-click the material and select Properties from the shortcut menu to display the Tool Properties dialog box.

The controls in the Material Editor section of the Materials window (or Tool Properties dialog box) let you adjust the qualities of the material.

Template specifies the type of material

Color displays the Select Color dialog box, where you specify the color of the material

By Object sets the color of the material based on the color of the object it is attached to

Diffuse	sets the main color of the material (Advanced and Advanced metal templates only)
Ambient	sets the color that appears on faces lighted by ambient light only (Advanced and Advanced metal templates only)
Specular	determines the color of a highlight on a shiny material (Advanced template only)
Shininess	controls the reflective quality of the material
Opacity	controls how much light passes through the surface of the object (not available for metal material types)
Reflection	controls how reflective the material is (Advanced templates only)
Refraction index	controls the bending of light rays as they pass through a translucent material. At a value of 1.0, objects behind the material do not distort, while at 1.5 they would be greatly distorted (Not available for metal templates)
Translucency	controls the percentage of light scattered within the object (Not available for metal material types)
Self-Illumination	controls the appearance that light is being emitted by an object. For example, to simulate neon light, set a value greater than zero. No light is cast on other objects. (Not available for metal templates)
Luminance	causes a material to simulate being lit by a photometric light source; how much light is emitted is a selected value in photometric units. No light is cast on other objects.
Two-sided	sets the property of the material as two sided so that both sides are rendered in the scene

Using Texture Maps

Texture maps add additional realism to a material. Maps assign a pattern or texture to a material's color. The colors of the map replace the material's diffuse color. For example, if you want a wall to be made out of brick, you can choose a map with an image of bricks. This is the most common kind of mapping. You can use most common raster image formats to create texture maps, including BMP, GIF, JPEG, PCX, PNG, TGA, and TIF.

You can also use a procedural map, such as checker, marble, noise, speckle, tiles, waves, and wood. The procedural maps have properties that you can adjust, such as the size and spacing of grain in a wood material, to achieve the desired effect.

Maps can also be used to achieve other effects, and you can use more than one map for the same material:

- **Diffuse map** provides a pattern of colors for the material. You can select an image file as a texture map or a procedural map to assign a pattern or texture to a material's diffuse color. The colors of the map replace or partially replace the material's diffuse color component. Mapping the diffuse color is like painting an image on the surface of the object, and is the most common kind of mapping.
- **Reflection map** simulates a scene reflected on the surface of a shiny object. For reflection maps to render well, the material should be shiny, and the reflection bitmap itself should have a resolution of at least 512x480 pixels. (Not available for Realistic and Realistic Metal templates.)

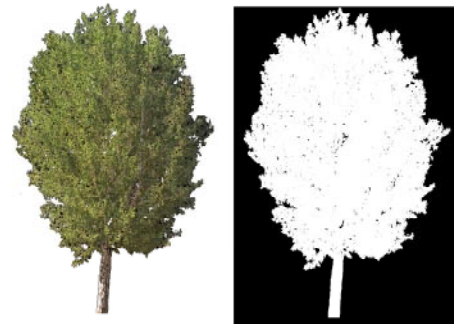
- **Opacity map** creates the illusion of opacity and transparency. Black areas are transparent while white areas are opaque. If the bitmap image is in color, the gray-scale value of each color is used.
- **Bump map** simulates a bumpy or irregular surface. Dark areas are interpreted as low and light areas are interpreted as raised. Bump mapping increases rendering time but adds to the realism of the scene.

For example, you can use a combination of a texture map and an opacity map to create a material that is partially transparent, such as a sign with individual letters, or a tree in which only the leaves and branches obscure objects behind it.



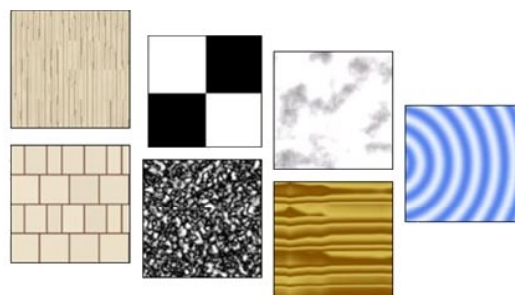
Note that AutoCAD 2006 and earlier versions included a library of landscape objects, such as trees and people, and commands for creating and modifying landscape objects. These commands are no longer available in AutoCAD. If you are working with a drawing that contains these older objects, they will not render properly in AutoCAD 2007 or new versions.

Landscape objects in those earlier versions of AutoCAD were created by combining a diffuse map and an opacity map, applied to a special type of object. You can still achieve similar results by creating new materials that utilize similar texture maps and opacity maps, and then attaching those materials onto objects in your drawing. Note that in order to see through the transparent portions of the opacity map, you must map the material onto the entire object, not just onto a face. Black represents areas that are transparent while white areas are opaque.



Procedural Maps

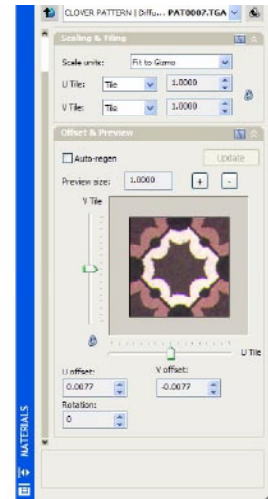
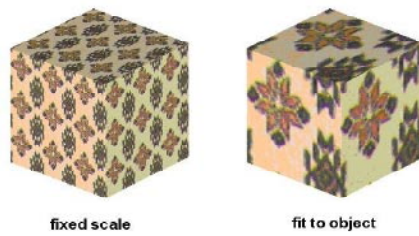
Procedural maps add further realism to a material. AutoCAD includes a number of procedural maps, including checker, marble, noise, speckle, tiles, waves, and wood



Unlike texture maps, which use bitmap images, a procedural map is generated by a mathematical algorithm. As a result, the types of controls vary depending on the capabilities of the particular procedural map. Procedural maps can be generated in two or three dimensions and you can nest additional texture or procedural maps within a procedural map to add depth and complexity to the material.

Modifying Map Properties

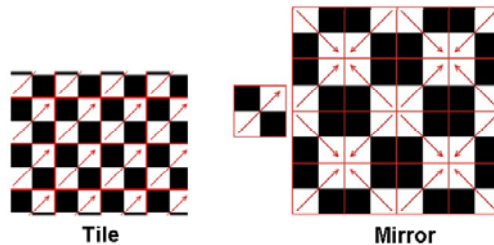
Map properties can be modified to create complex patterns by changing the map settings. Map properties are now controlled within the Materials palette in the Scaling & Tiling area. The controls in this area are only available for texture maps and checker and tile procedural maps.



Each map has its own scaling and tiling factors. You can synchronize the scaling and tiling between all maps by selecting the synchronize icon. When enabled (default, indicated by a connected icon), the

settings and value changes you make affect all map channels. When disabled (indicated by a separated icon), changes you make apply only to the current map channel.

When you select a scale from the Scale Units drop-down, the map is scaled to the face or object using a fixed or real-world scale. When you select Fit to Gizmo, the map is scaled to fit the face or object. You can also use the other controls to adjust the scaling and tiling of a material. You can specify Tile, Mirror, or None for the U and V tile values to adjust the repetition of the pattern. When you select None, the pattern is not repeated. Tile repeats the pattern as a series of tiles while Mirror doubles the map, flips the doubled copy, and then repeats the doubled pattern as a series of tiles.



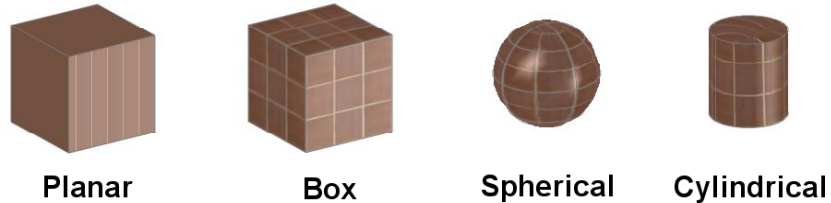
The controls in the Offset & Preview area of the Materials palette let you adjust the position of the starting point of the map and its rotation angle. Again, the small button on the title bar of this area controls whether the changes you make are synchronized to all map channels or only apply to the current map channel.

Preparing Your Own Bitmaps

Most common raster image formats—BMP, GIF, JPEG, PCX, PNG, TGA, and TIF—can be used as maps. You can capture images for use in creating new materials by scanning them or using a digital photo.

Adjusting Material Mapping

After you attach a material with a texture, you can adjust the orientation of the texture map on the objects or faces. Material mapping adjusts the material to fit the shape of the object. Applying the appropriate type of material mapping to an object improves the fit:



- **Planar** maps the image onto the object as if it was projected from a slide projector onto a flat plane. The image is not distorted, but the image is scaled to fit the object. This mapping is most commonly used for faces.
- **Box** maps an image onto a boxlike solid. The image is repeated on each side of the box.
- **Spherical** warps the image both horizontally and vertically. The top and bottom edges of the bitmap are compressed to points at the north and south poles of the sphere.
- **Cylindrical** maps the image onto a cylindrical object so that the bitmap's horizontal edges are wrapped around the object. The height of the image is scaled along the cylinder's axis.

If you need to make further adjustments, you can use the material mapping grip tool that is displayed on the object to move or rotate the map on the object.

In Part 2 of this class, we will look at how to use the other tools built into AutoCAD to create finished, professional-looking renderings. You will learn how to place cameras and create views, render to the screen, save renderings to a file, and redisplay rendered images. You will also learn how to create animations using the AutoCAD Walkthrough and Flythrough tools.