



USING LIGHT ATTENUATION

This tutorial will teach you how to achieve different lighting effects by manipulating the attenuation of point and spot lights.



ESTIMATED TIME REQUIRED

30 Minutes

LEARNING GOALS

In this tutorial you will learn how:

- Mirai's different light properties affect light attenuation.
- To set attenuation properties for point and spot lights.

UNDERSTANDING LIGHT ATTENUATION

Light attenuation is the property of light that causes it to diminish in intensity with increasing distance from the source. It's the reason that you have an easier time reading the newspaper while sitting next to a lamp rather than across the room from it.

In the real world, light intensity diminishes in proportion to the square of the distance from the source (that is, it falls off quadratically). In a virtual environment, this rate of falloff is often too fast. Therefore, Mirai lets you set any rate of falloff that you desire. For any point or spot light in your scene, you can specify a precise rate of attenuation. You do so by defining several properties that work in conjunction with each other.

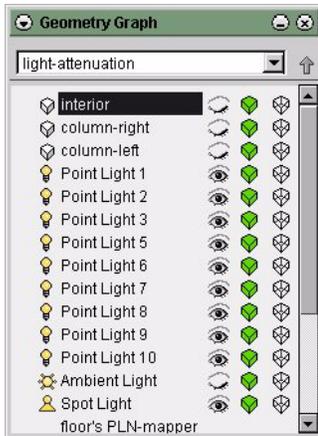
EXPERIMENTING WITH LIGHT ATTENUATION

You can adjust light attenuation numerically or interactively (that is, using your mouse). You can see the effect of changes to light attenuation while viewing your scene in the Geometry viewer with shading and scene lights turned on. As you adjust attenuation, you'll notice a change in the falloff of the light on the surfaces of your models. For example, the "pool" of light on an object's surface will grow smaller or larger as you numerically or interactively adjust light attenuation properties.

You can try this for yourself in the practice scene:

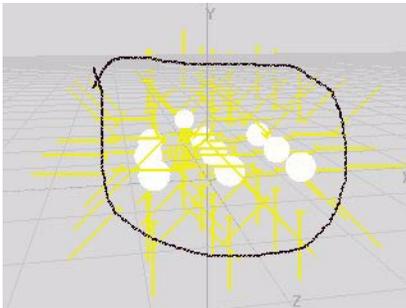
- 1 In one of your configurations, open up the following windows:
 - The Geometry editor
 - A Scene Graph
 - A Geometry Graph (You open this window by clicking Ctrl [R] on the Geometry editor, then clicking on *New Graph*.)
- 2 Use *Options>Render Domain>Mirai* to put the Geometry editor in the Mirai domain.
- 3 Use the *Options>Scene Lights* to illuminate objects using the scene lights.

4 Use the Geometry Graph to make the spot light and all of the point lights visible.



5 Select all of these lights using the 3D lasso:

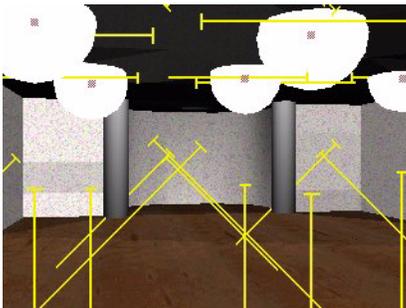
- [R] on the point element sensitivity icon.
- Ctrl+Alt [L] on the Geometry editor, then Hold [L] and draw a lasso around the lights.



6 Keep the light collection selected, then use the Geometry Graph to make the “interior,” “column-left,” and “column-right” objects visible.

7 Press Alt-s to turn on shading for all objects.

8 With the light collection still selected, move the camera inside the room.



Notice that the nine point lights illuminate the main interior of the room—one for each recessed panel in the ceiling—and one spot light illuminates the alcove along the back wall. The scene’s designer gave all the lights the same value for *Brightness* in the Attributes editor, 0.75. This value represents the lights’ brightness at a specified distance (see the *Distance* property below). For this scene, this means that the lights will radiate a brightness of 0.75 at the distance specified in the *Distance* property. Because the

lights are attenuated, this also means that each light will grow steadily brighter than 0.75 as you move toward each light's origin and steadily dimmer than 0.75 as you move away from the *Distance* threshold.

- 9 [R] on the light collection, then [R] on *Attenuation*. Clicking [R] calls up the following dialog box, which lets you numerically adjust attenuation settings.

The dialog box is titled "Choose new attenuation parameters:". It contains five input fields: "kc" with value 0.0, "kl" with value 0.7999999, "ks" with value 0.2000000, "unit dist" with value 4.5, and "attenuate?" with a checked checkbox. At the bottom are "Set Attenuation" and "Cancel" buttons.

- 10 For now, just look at the dialog box in order to view the properties that determine attenuation:

- *kc*

kc is a constant for limiting attenuation falloff. If this value is larger than zero, it will cause the light to have a certain minimum level of brightness regardless of how great the distance from the source.

- *kl*

kl is a factor that defines the linear falloff of the light. This factor diminishes the light's intensity according to the formula $I/kl*d$, where *I* represents the intensity of the light and *d* represents the maximum distance which the light radiates. Values that are large in comparison to *kc* and *ks* result in a gradual falloff in intensity.

- *ks*

ks is a factor that defines the quadratic, or squared, falloff of the light. This factor diminishes the light's intensity according to the formula $I/ks*d^2$, where *I* represents the intensity of the light and *d* represents the distance. Values that are large in comparison to *kc* and *kl* result in a very rapid falloff in intensity.

- *Distance*

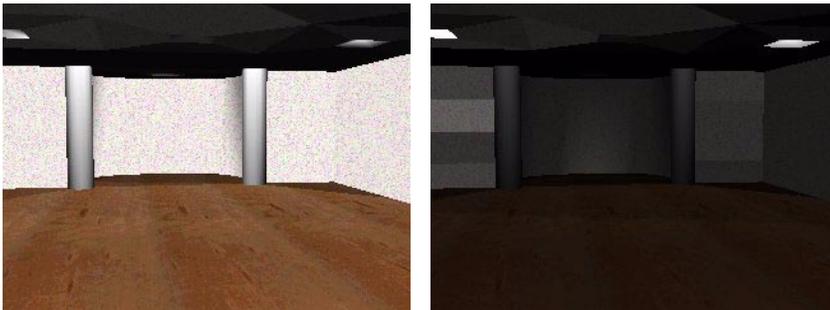
Distance, as discussed, lets you specify the distance (in world units) that a light will radiate its assigned *Brightness* value.

- 11 [L] on the *Cancel* button to close the dialog box.

- 12 [R] on the light collection, then [L] on *Attenuation*. Clicking [L] lets you interactively adjust the lights' attenuation using the mouse.

Move your mouse from left to right. As you do so, you'll notice a change in the falloff of the lights' intensity. As you move the mouse to the right, the attenuation increases; less light reaches the interior faces and they dim noticeably. The opposite occurs when you move your mouse to the left.

The image on the left demonstrates low attenuation; the image on the right, high attenuation.



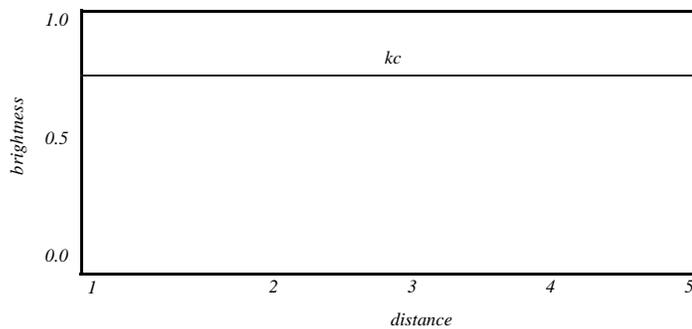
- 13 With your mouse far to the left and the scene at its brightest, [L] to exit attenuation mode. Attenuation should now be at the lowest possible setting.
- 14 [R] again on the light collection, then [R] on *Attenuation* to bring up the Attenuation Properties dialog box. It should now include the following values:

Choose new attenuation parameters:

kc kl ks	1.0	0.0	0.0
unit dist	4.5		
attenuate?	<input checked="" type="checkbox"/>		

Buttons: Set Attenuation, Cancel

The values for kc , kl and ks read 1.0, 0.0, and 0.0, respectively. As kc , the constant, is the only property with a non-zero value, there is effectively no falloff for the lights' intensity.



- 15 [L] on the *Cancel* button to close the dialog box.
- 16 [R] again on the light collection, then [L] on *Attenuation* to interactively adjust the lights' attenuation.
- 17 Move your mouse to the right until the interior surfaces are at a medium-level of brightness (that is, until attenuation is at a medium level.)
- 18 [R] on the light collection, then [R] on *Attenuation* to bring up the Attenuation Properties dialog box. It should now include values that are close to the following.

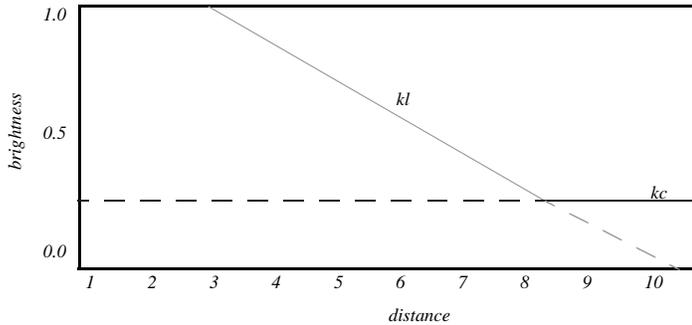
Choose new attenuation parameters:

kc kl ks	0.3279693	0.6720307	0.0
unit dist	4.5		
attenuate?	<input checked="" type="checkbox"/>		

Buttons: Set Attenuation, Cancel

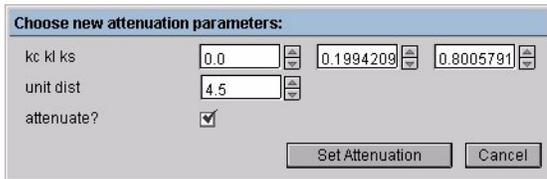
In this example, the values for kc , kl and ks read approximately 0.33, 0.67, and zero. You can see that as you moved your mouse to the right kc was reduced while kl was increased. In effect, there will be linear

falloff in intensity, but it will never drop all the way to zero due to the greater-than-zero value for the constant. These settings graph like this:

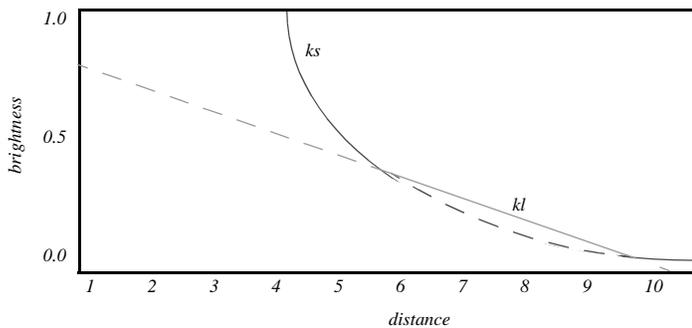


The solid portions of the lines represent the net falloff of the lights. You can see that there is a linear falloff in light brightness until kl crosses kc , at which point the brightness of the light remains constant toward infinity.

- 19 [L] on the *Cancel* button to close the dialog box.
- 20 Use the *Attenuation* command again to interactively adjust the lights' falloff. This time set attenuation quite high (that is, move your mouse far to the right).
- 21 Bring up the Attenuation Properties dialog box again to see the effect on each properties value. You should now see values close to these:



The values for kc , kl and ks now read approximately 0.0, 0.20, and 0.80. You can see that as you moved your mouse to the right kc shrank to zero, kl to nearly zero, and ks grew greatly. In effect, there will be no constant (intensity will continue to falloff as it approaches infinity). There will be a small amount of linear falloff in intensity, but quadratic falloff will predominate. This effect graphs like this.



Again, the solid portions on of the lines represent the net effect on the falloff of the lights.

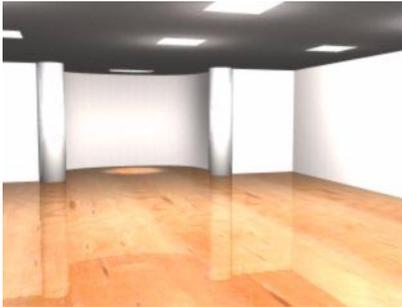
RENDERING

Although you can use the real-time feedback to set light attenuation, its effect is best seen by rendering a test frame.

22 First, render a test frame at low attenuation (with your mouse far to the left):

- Use the *Attenuation* command to set attenuation with the mouse, then Ctrl [R] on the Geometry window and select *Render*.

Depending on how far to the left you moved your mouse before rendering, you'll see results like the following.



You can see that the intensity of the lights with low attenuation falls off quite slowly. All the surfaces reflect back light of high intensity, especially the columns, which are so bright that they are washed out. The lights that illuminate the right wall cast a large pool of light that reaches the floor.

The light falloff in this render would graph much like the second graph above: There is some linear falloff, but kc , the constant, causes the lights to maintain a minimum brightness no matter how great the distance from their source.

23 Render a test frame at high attenuation (with your mouse far to the right).

Depending on how far to the right you moved your mouse before rendering, you'll see results like the following.



The intensity of the lights with high attenuation falls off much more rapidly than that of the lights with low attenuation. The surfaces reflect back light of lower intensity, which diminishes rapidly the greater the distance from the light source. For example, the recessed panels in the ceiling reflect a searing intensity, but this intensity quickly diminishes as the distance increases from the light source. The pool of light on the right wall is much smaller than it was in the test frame rendered with low attenuation.

The light falloff in this render would graph much like the third graph above: There is a mixture linear and quadratic falloff with no constant value for brightness.

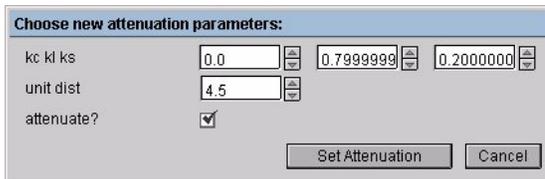
The ideal setting for attenuation depends on the effect you're trying to create.

- 24 Try rendering several more test frames with different attenuation settings until you get a result you like. Try for a setting that sufficiently illuminates all the surfaces without washing out those near the light source:



SETTING ATTENUATION NUMERICALLY

- 25 [R] on *Attenuation* command to bring up the Attenuation Properties dialog box.



With the exception of *Brightness*, the above dialog lets you edit all of the values that control attenuation. The values you enter for kc , kl , and ks must total 1.0; however, if the values you enter do not, Mirai will automatically adjust them for you so that they do.

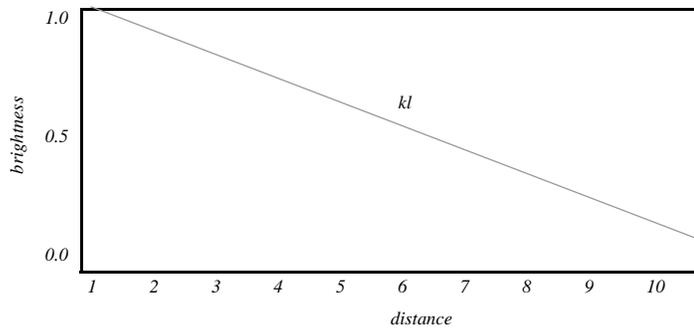
When you adjusted attenuation interactively above, your mouse movements automatically updated the values for kc , kl , and ks . The value for distance, however, remained constant. You *cannot* interactively adjust the distance value. However, in another scene you might want to edit it numerically in order to scale the radiance distance of a light so that it is proportional to the rest of your scene.

Try a few test renders with different values for kc , kl and ks :

- 26 As discussed above, if you enter a high value for kl with low values for kc and ks , you'll get a very gradual falloff. Try entering 0, 1, and 0, respectively, for kc , kl , and ks . When you render, you should see something like this:



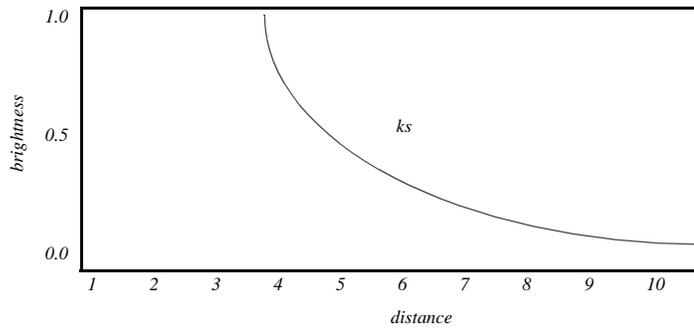
This results from a purely linear falloff which graphs like this:



27 On the other hand, if you enter a high value for k_s with low values for k_c and k_l , you'll get a very rapid falloff. Try entering 0, 0, and 1, respectively, for k_c , k_l , and k_s . When you render, you should see something like this:



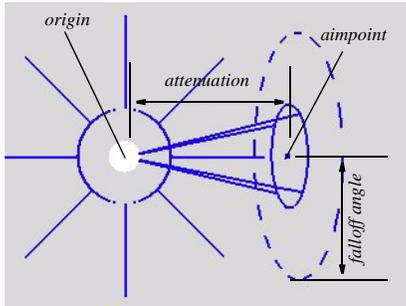
This results from a purely quadratic falloff which graphs like this:



Continue to experiment as you like with other attenuation settings. You might try achieving a different effect by using different attenuation settings for the lights that illuminate the walls and those that illuminate the center of the room.

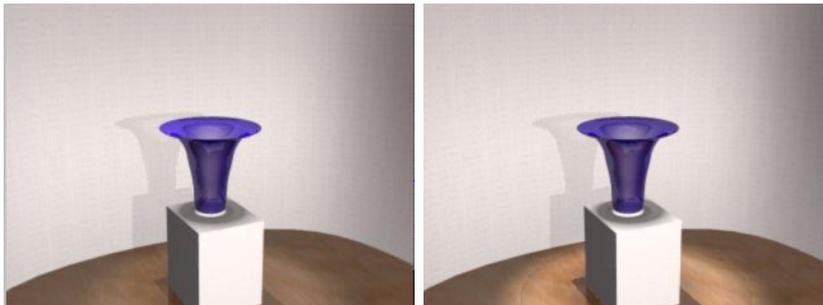
A NOTE ON SPOT LIGHTS

It's possible to adjust the falloff *angle* of the of a spot light using the *Falloff Angle* command. Falloff angle should not be confused with attenuation.



As the figure above shows, falloff angle affects the falloff of the light between the aimpoint and the edge of the falloff angle. Attenuation, on the other hand, affects the falloff of light between the origin and the aim point. You can see the effect of attenuating spot lights in the practice scene:

- 28 Make the “pedestal” and “vase” objects visible.
- 29 Move the camera in for a close view of these objects.
- 30 [L] on the point element sensitivity icon, then [R] on the origin of the spotlight (which is positioned over the alcove) and [L] on *Attenuation*.
- 31 Move your mouse back and forth and you'll see the light's falloff change.
- 32 Render a test frame of the vase and pedestal with attenuation set to high and low values, so that you can see the effect more clearly (the effect is quite subtle when viewed in OpenGL). You should get results similar to these:



You can see that when the spot light's attenuation is high (left) that the top portion of the vase is brightly lit, but as you move down the vase and pedestal, the light falls off rapidly and these surfaces are less brightly lit.

When the spot light's attenuation is low (right), the light falls of much more gradually. The surfaces of the vase and pedestal are lit relatively evenly, and the light is still bright enough when it strikes the floor to leave a very pronounced spot pattern.