

CG Lights

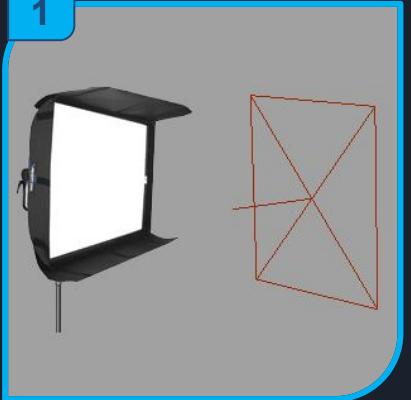


In this lesson, we'll learn about CG lights, how to use them and their similarities and difference to their real-world counterparts

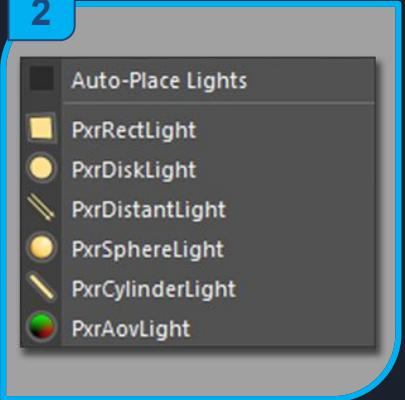
Revision: 001

CG Lights | Contents

1



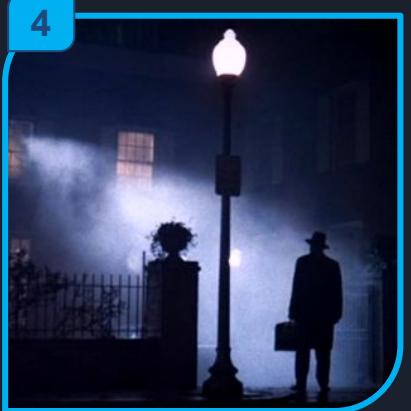
2



3



4



5



This lesson will cover the following:

1. CG Lights vs Real Lights
2. Types of Lights and their settings
3. Shadows
4. Exposure vs Intensity
5. Color vs Temperature

CG Lights|CG Lights vs Real Lights



Josie Williams, Gaffer - Hunter in the Blue Side of Manchester (2020), The Protector (2019)



Rosie Draper - Lighting TD, Avengers: Endgame (2019)

There are many similarities and differences between real world lights and their CG counterparts, so it's important to know what these are in order to get the most out of the tools provided.

Any study of lighting for real world photography or even on a traditional film set can be helpful but the knowledge does not transfer exactly one to one in either direction. It's sort of like a real world soldier playing a first person shooter. Sure they might know how to take apart and put their rifle back together in 12 seconds but can they 360-no-scope an enemy from 300 meters from the back of jeep while your driver avoids a tree?

DID YOU KNOW?

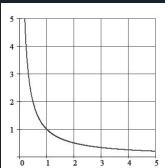
An “on set” lighting artist is called a **Gaffer**. Not only are they artists in their own right but also work closely with the Director of Photography and in most cases are licensed electricians

CG Lights|CG Lights vs Real Lights

SIMILARITIES



Both can have different temperature in order to change the color of the light (Daylight, Tungsten)



Depending on the settings, the light from both will fall at the rate of the “Inverse Square Law”



Both can have “Barn Doors” to help shape the light profile



CG Lights can be set to use the same “exposure” settings as Real world lights

DIFFERENCES



CG lights can be changed to adjust light with linear intensity (Real world lights only measured in F-Stop which is not linear)



CG lights can be set to NOT cast any shadow. Real world lights will always cast a shadow



CG Lights can't fall over and set fire to things



To change the “softness” of shadows from a real world light you must change its size. CG lights can be “cheated” to do this and remain the same size

TERMINOLOGY:

Daylight:

When used in the context of color, “Daylight” refers to a temperature above 5500K and usually a white/blue

Tungsten:

An artificial lighting source (like a lamp or ceiling fixture) that emits heat and produces a “warmer” or reddish colour. It is different from fluorescent lighting (which generates much lower heat), and strobe lighting.

Inverse Square Law:

The inverse-square states that a specified physical quantity is inversely proportional to the square of the distance from the source of that physical quantity.

Exposure:

The amount of light which reaches your camera sensor or film. It is a crucial part of how bright or dark your pictures appear.

Barn Doors:

Barn doors are light modifiers that shape and direct light. They are flexible to use and can create focused light. They also make a variety of shapes.

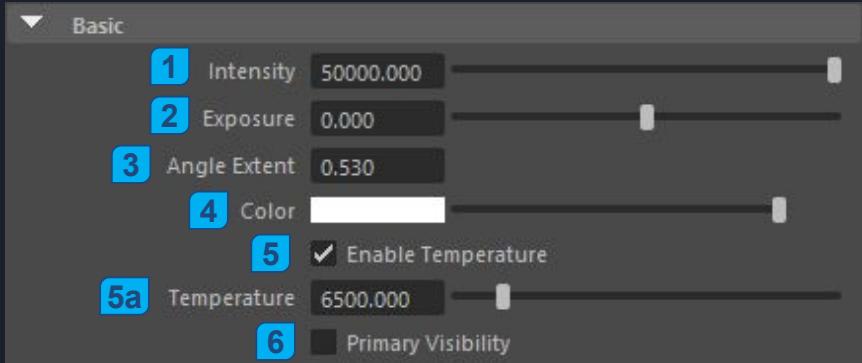
CG Lights|Types of Lights

UNREAL ENGINE	RENDERMAN	Real World Equivalent
		Directional Light Distant Light The Sun
		HDRI Backdrop Dome Light Ambient or Environment Light
		Rect Light Rect Light LED Panel
		Spot Light Disk Light Spot Light
		Point Light Sphere Light Welders Arc or Candle
		Emissive Material Mesh Light Any Shape that emits light

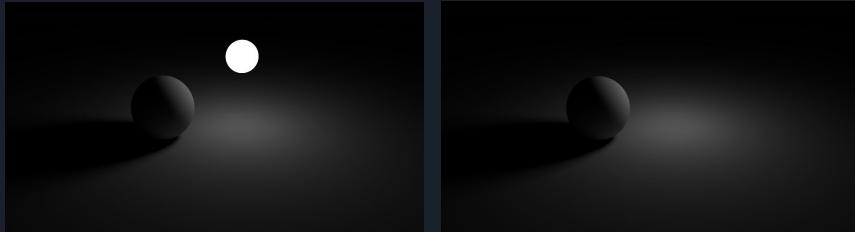
Light can be handled in many different ways when lighting a CG scene, but most rendering engines (real-time and offline) will have a set few that can all be set to emulate real world lights or be changed to do things that real world lights can NOT do.

The Lights listed here are examples from 2 popular real-time and offline renderers respectively. Both of these engines have more lights than these, but these are good selections of the most common.

CG Lights|Common Settings on all Lights

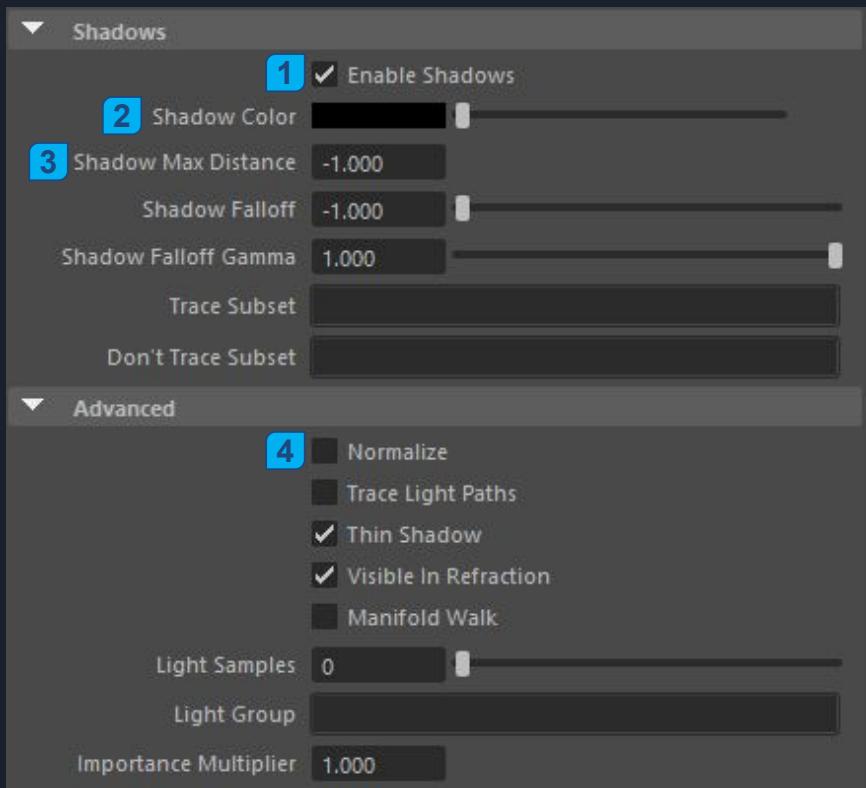


6 - Primary visibility on/off



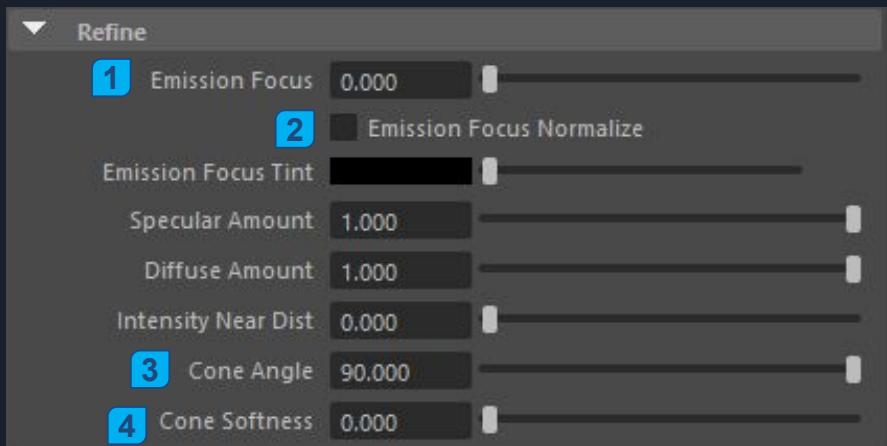
- 1) **Intensity:** This is how bright the light is in a linear scale. This means that 2500 would be exactly half as bright as 5000 with no other changes
- 2) **Exposure:** This is a measurement that follows the inverse square law and is mapped to work like a "real" light. an Exposure of **4** is much more than double of an exposure of **2**. A little bit goes a long way.
- 3) **Angle Extent:** This is ONLY a setting on the Distant light. Higher values soften the shadow edges (light rays become less parallel) while lower values make it sharper. Larger values increase shadow softness by increasing the angle of its light. Note that increasing this parameter also increases the amount of light in the scene and you may need to significantly reduce the light intensity/exposure to compensate or you may use **Area Normalize** to prevent changes in illumination. (Sun=0.53)
- 4) **Color:** This is akin to adding a "Gel" or colored glass over the light. It changes color of the light. Note that just like with "real" lights, when you add something anything in front of the light (even things that transparent) you will be darkening the light source, so you may notice a change in brightness when you change the color. You can plug a texture into this slot to act a "projector" of sorts.
- 5) **Temperature:** With this enabled you will be able to set the temperature of the light in Degrees Kelvin.
- 6) **Primary visibility:** By enabling this you will be able to see the light source in the render. See example images.

CG Lights|Common Settings on all Lights



- 1) **Enable Shadows:** Disabling this will mean that any objects that block the light will not cast a shadow. Can be useful when you don't want to cast any new shadows but need to increase the overall general brightness of a render
- 2) **Shadow Color:** This will artificially change the color of any shadows caused by this light.
- 3) **Shadow Max Distance:** This limits the Distance. This can be used to artificially reduce the distance shadows are cast. This can increase render speed as it will not calculate shadows outside this distance
- 4) **Normalize :** When normalize is enabled, the amount of light contributed to the scene will not change as you change the angleExtent or its physical size of the light source or its physical distance relative to an object. This makes it easier to adjust highlight size without changing scene lighting.

CG Lights|Common Settings on all Lights



- 1) **Emission Focus:** This controls the spread of the light. Higher numbers will focus the light towards the centre
- 2) **Emission Focus Normalize:** When enabled, it will scale the emission focus so that it does not change the total energy output of the light
- 3) **Cone Angle:** Technically, **ANY** light with this settings can be turned into a Spot light. Anything below 90 will lower the angle and turn it into a spot light, with a setting of 0, this would technically turn the light into a laser pointer, while a setting of 45 would be more light that of a car headlight.
- 4) **Cone Softness:** This changes how soft the edge of the spotlight will be. This may be called the **Penumbra** in other software.

CG Lights|Extra Information

The lights and settings discussed so far have only been a fraction of the information needed to fully master Lighting in Renderman.

For more information, below is the links to Renderman official documentation for all their lights, as well as links for Unreal and Unity Lights:

RENDERMAN

- Rect Light: <https://rmanwiki.pixar.com/display/REN/PxrRectLight>
- Disk Light: <https://rmanwiki.pixar.com/display/REN/PxrDiskLight>
- Dome Light:
<https://rmanwiki.pixar.com/display/REN/PxrDomeLight>
- EnvDay Light:
<https://rmanwiki.pixar.com/display/REN/PxrEnvDayLight>
- Sphere Light:
<https://rmanwiki.pixar.com/display/REN/PxrSphereLight>
- Mesh Light:
<https://rmanwiki.pixar.com/display/REN/PxrMeshLight>
- Distant Light:
<https://rmanwiki.pixar.com/display/REN/PxrDistantLight>
- Portal Light:
<https://rmanwiki.pixar.com/display/REN/PxrPortalLight>
- AOV Light: <https://rmanwiki.pixar.com/display/REN/PxrAOVLight>
- Shadows: <https://rmanwiki.pixar.com/display/REN/Shadows>

UNREAL ENGINE

- Directional Light:
<https://docs.unrealengine.com/en-US/Engine/Rendering/LightingAndShadows/LightTypes/Directional/index.html>
- Sky Light:
<https://docs.unrealengine.com/en-US/Engine/Rendering/LightingAndShadows/LightTypes/SkyLight/index.html>
- Spot Light:
<https://docs.unrealengine.com/en-US/Engine/Rendering/LightingAndShadows/LightTypes/Spot/index.html>
- Point Light:
<https://docs.unrealengine.com/en-US/Engine/Rendering/LightingAndShadows/LightTypes/Point/index.html>
- Rect Light:
<https://docs.unrealengine.com/en-US/Engine/Rendering/LightingAndShadows/LightTypes/RectLights/index.html>



- Types of Light:
<https://docs.unity3d.com/Manual/Lighting.html>

CG Lights|Shadows



Released in 1994, The Shadow is based on the pulp fiction character of the same name. His superpower was controlling shadow and darkness



[Youtube Link:
Jack vs the Ninja](#)

A creative take on the use of light and shadow



Contrast has a noir atmosphere aesthetic. The player must solve puzzles that require movement between the physical world, which is represented as 3D, and shadows, which are represented as 2D.

DID YOU KNOW?

The first person to calculate the size of the planet Earth with a high degree of accuracy used simple geometric equations and measurements of shadows. Eratosthenes, the head librarian of the Great Library of Alexandria, performed this feat over 2,000 years ago, around 250 BCE.

Shadow manipulation can be an extremely powerful tool for a Lighting artist.

Shadows have been used in games and film since the very beginning for everything from hiding mistakes to narrative plot reveals, and shadows can even be a character in and of itself.

We will cover how Pixar's RenderMan uses shadows, but once you learn your chosen engine you will find that they all have own tricks. But for the most part, light is light and most techniques can be duplicated or faked in any engine.

CG Lights|Shadows

Light Filters

PxrGoboLightFilter

Projects a painted texture in front of the light.

PxrCookieLightFilter

Similar to the PxrGoboLightFilter but with more options and flexibility.

PxrBlockerLightFilter

Uses a "rod" like object to block light. The blocker can be shaped into an irregular shape and is then placed next to the object where you want to block the light.

Rod Light Filter

This is similar to the above PxrBlockerLightFilter but with more controls and flexibility.

PxrRampLightFilter

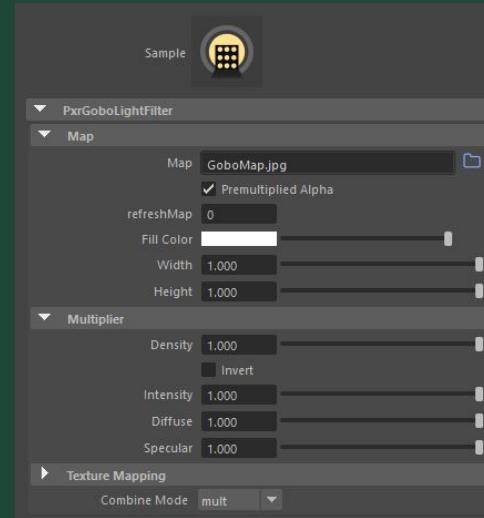
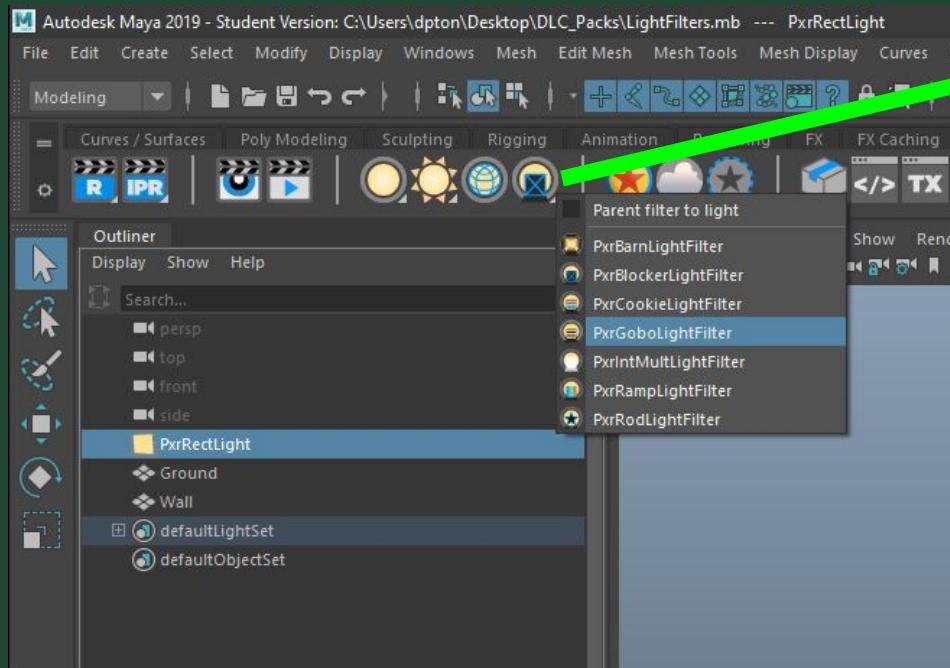
Uses a ramp to control the light. This allows more complex control of color, intensity, and more

Light Filters are used to manipulate lighting results.

In the real world this is often achieved through the use of stencils and gels to change the color, quality, and amount of light in a shot. RenderMan's light filters are a powerful and flexible way to do the same (and even more) in lighting your scenes.

CG Lights| Shadows

Lets Setup a Gobo Filter



Open the LightFilters.mb file

Select the Rect Light in the scene

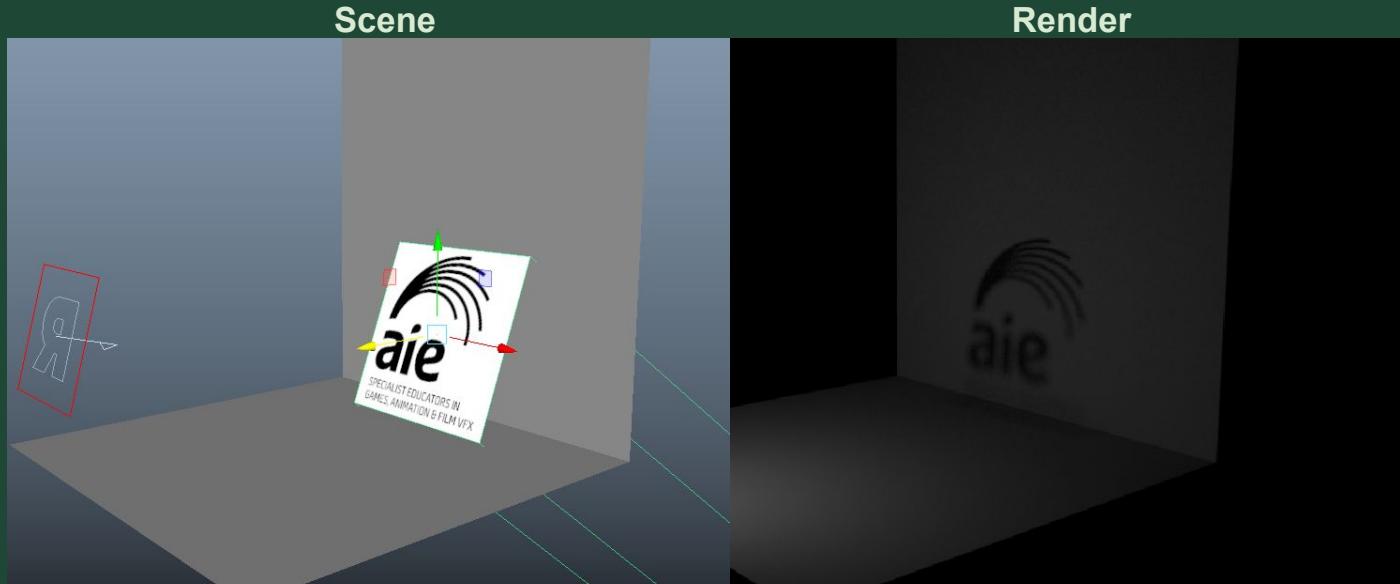
RIGHT click on the light filters icon in the RenderMan Shelf

Select PxrGoboLightFilter

In the Attribute Editor, under the Filter's Shape node, Go to Map and load the file GoboMap.jpg

CG Lights| Shadows

Lets Setup a Gobo Filter



Move, Angle and Resize the Gobo Filter to be close the wall

Now, Render the Scene...

You can see that the Filter does not show up in the scene, only the Shadow it casts.

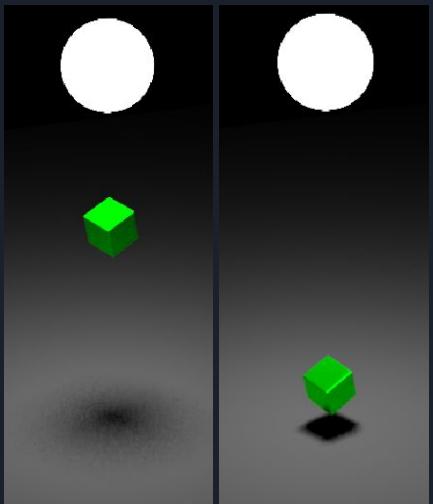
**Filters are linked to lights.
Meaning you can have one
light cast 1 shadow and
another light can cast a
completely different Shadow*

CG Lights|Shadows

Distance

Objects that are close to a light source and further away from the place where the shadow lands will have softer edges

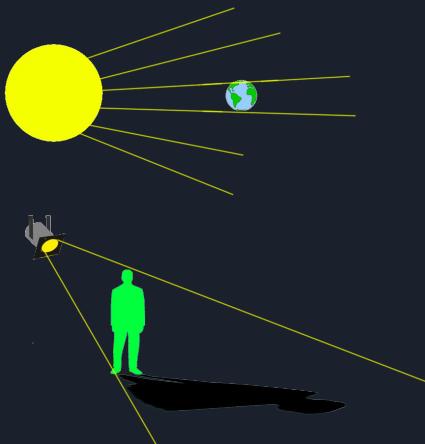
Objects that are further from the light source but closer to the end where they land will have Harder Edges



Angle

The Further away a light source is the narrower its Angle Extent is. The Sun is so far away that is almost parallel by the time it reaches us.

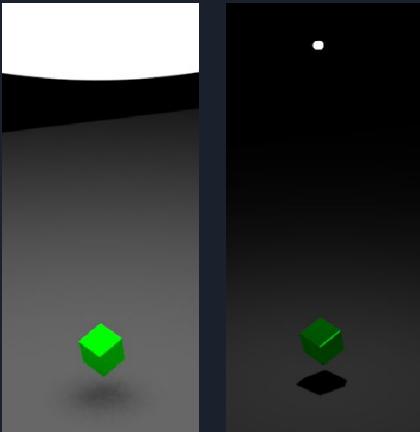
Sun shadows are almost perfectly straight, whereas spot lights that are just above your head will have cast a widening shadow



Size

A large light source will cause objects to have Softer edges, and small yet bright points of light will have hard edges.

The Arc from a welding torch is a Tiny but VERY bright light source so it casts hard shadows, where “ambient light” is a soft light that comes from so many directions, that its like a very large light, so ambient shadows tend to be softer



Whether you are using a Filter or actual geometry to cast a shadow, there are 3 different ways to change the appearance of a shadow.

- 1) Distance From Light Source
- 2) The angle of the Light Photons
- 3) The Size of the Light Source

CG Lights| Shadows

Softer Shadows With the Distant Light

You can not move objects further or close to a Distant Light, as it comes from an infinite distance away and only its angle can be changed. But there is a setting that can fake the effect: **Angle Extent**

*Taken from the official Pixar RenderMan Wiki

Angle Extent

Opening angle of the light source in degrees (Sun=0.53). Higher values soften the shadow edges (light rays become less parallel) while lower values make it sharper. Larger values increase shadow softness by increasing the angle of its light. Note that increasing this parameter also increases the amount of light in the scene and you may need to significantly reduce the light intensity/exposure to compensate or you may use **Area Normalize** to prevent changes in illumination.



Quick Example:

Create a new Scene and put a plane down.

Create a Distance Light and set it to a 45 Degree angle

Put an Object on the Plane and render it to see its shadow

Now, Change the Angle Extent to 100 and see the difference in the soft edge of the shadows

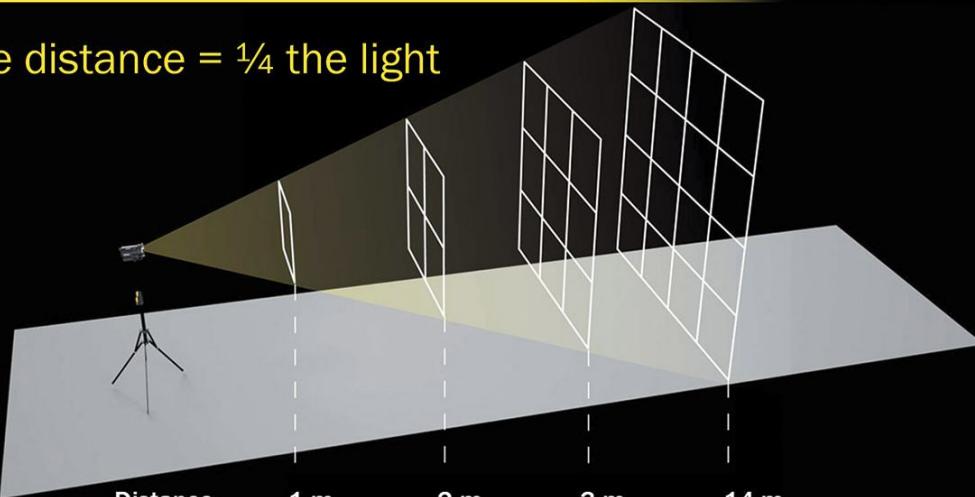
**Note that increasing this parameter also increases the amount of light in the scene and you may need to significantly reduce the light intensity/exposure to compensate or you can use Area Normalize to prevent changes in illumination.*

CG Lights|Exposure v Intensity

Intensity is a Linear Measurement
Exposure uses the Inverse Square Law

Square Law – The Basics: point light source

Twice the distance = $\frac{1}{4}$ the light



Distance:	1 m	2 m	3 m	14 m
Lit area:	1 m ²	4 m ²	9 m ²	16 m ²
Light quantity:	1/1	1/4	1/9	1/16
	100%	25%	11,11%	6,25%

Intensity:
The contribution of this light linearly. The light intensity is computed using physical falloff

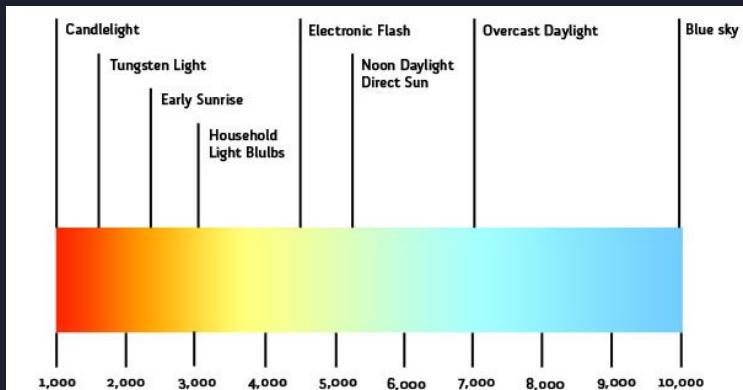
Exposure
The exposure of the light as a power of 2. Increasing the exposure by 1 will double the energy emitted by the light source.

A value of 0 produces an intensity of 1 at the source,-1 produces 0.5.

Real world lighting has high energies and typical exposures are low values while you may have to type a really large number for equivalent Intensity. This is also comfortable to artists familiar with photographic measurements.

CG Lights|Color v Temperature

Color is JUST like putting a Gel over the light source. This means you will block some light and it will be darker. If you want to maintain the same brightness you may need to slightly increase the exposure or Intensity



Unlike a Gel, color temperature does not affect brightness. However you do not have as much color range to work with

Ah, yeah... that make sense!

Ever wonder why the Bottom of the flame is blue and the top is Orange? That's because the Flame is hottest at the bottom and colder at the top. Flame is a perfect example of Light Temperature in action

Color:

Changing the Color of a light is equivalent to putting a Gel in front of the light.

Gels are transparent coloured material used to modify lights for photography, video and theater. Light is projected through the gel to create coloured effects in the scene being photographed.

Temperature:

Changing the temperature of a light will take it from the colder Red spectrum up to the hotter blue spectrum

Like all light, these settings are Additive, meaning that one will NOT override the other, but in fact they colors will add and blend.

Marmoset Toolbag



The following slides will provide explanations to settings for the sky light, lights, and camera needed to complete the tests.

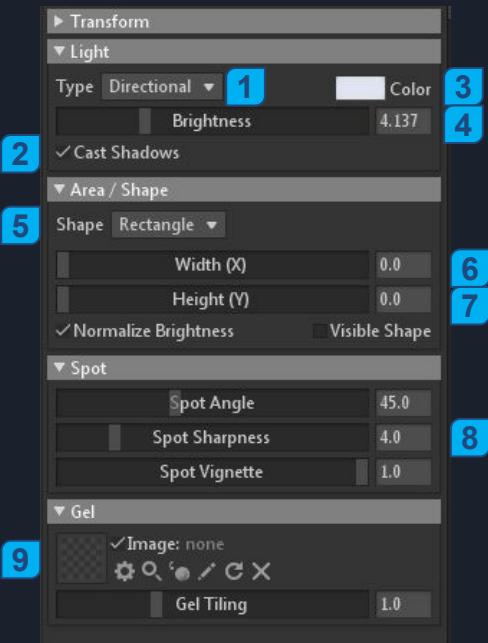
Note: F11 will capture and save the image to your desktop.

CG Lights|Marmoset Toolbag Sky Light



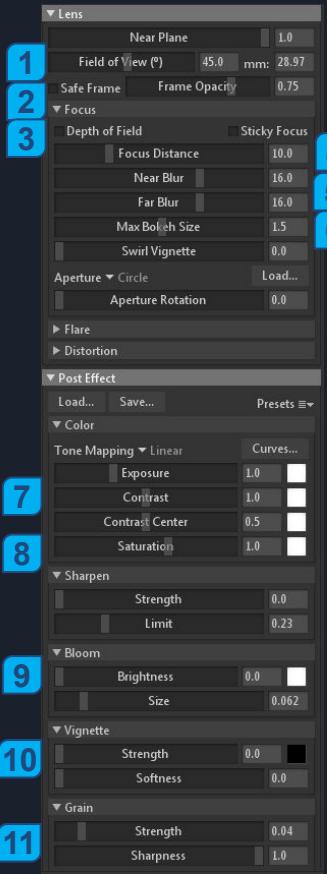
- 1) **Image:** Loads a custom sky light background, which will also be used to light the scene. Use a 360 degree panoramic HDR image for best results.
- 2) **Presets:** Opens the sky library which allows for switching between, download, and load sky lighting presets.
- 3) **Brightness:** Sets the exposure of the image based lighting, child lights, and background image.
- 4) **Child-Light Brightness:** Sets the exposure of child lights in relation to the master sky brightness settings.
- 5) **Rotation:** Sets the sky direction. Applies the sky lighting, child lights, background image and objects parented to the sky object, **Sky rotation can be set via Shift+LMB Drag in the viewport as well.**
- 6) **Light Editor:** Gives a preview of the current sky lighting image, and **also creation (left click) movement (left button drag) and deletion (right click) of child lights.**
- 7) **Mode:** Sets the presentation mode for the background image. "Colour" draws a constant colour as the background, "Sky" draws the image into the background unmodified, and "Blurred" and "Ambient" sky both render convoluted versions of the image.

CG Lights|Marmoset Toolbag Light Settings



- 1) Types: Sets the lighting method. Directional lights cast lights from a singular direction at infinity, spot lights cast light from a singular direction as well but have a cone-shaped falloff, and omni lights cast light in all directions.
- 2) Cast Shadow: Determines whether or not objects in the scene occlude lights.
- 3) Color: Sets the color and intensity of the light
- 4) Brightness: Sets the intensity and color of the light
- 5) Shape: Determines the geometry of the light source
- 6) Width: Sets how large the light source is, which in turn defines how blurry the shadows are.
- 7) Length: Sets how much the light is stretched along the x and y axis, useful for creating non-spherical lights such as fluorescent tube lighting.
- 8) Spot angle, sharpness, and vignette: These settings only apply to spot lights. They set soft width, softness and shape respectively.
- 9) Gel: Ability to load and tile an image to mask the light shape.

CG Lights|Marmoset Toolbag Camera Settings



- 1) Field of View: Controls how much of the scene is visible by setting the vertical field of view of the lens (in degrees). Lowering the value provides a narrower view while increasing the value provides a wider view.
- 2) Safe Frame: Previews the region of the viewport that will be present in exported screenshots and videos.
- 3) Depth of Field: Enables the depth of field effect, which blurs areas in front or behind the focus point. This setting has an adverse affect on performance.
- 4) Focus Distance: Determines the location of the focal point in relation to the camera. **This focus distance can also be set by middle-clicking on an object in the viewport**
- 5) Near and Far Blur: Sets how much blur is applied to the areas in front and behind of the focal point respectively.
- 6) Max Bokeh Size: Sets the maximum amount of blur. This setting has an adverse affect on performance, the higher the value the more expensive the effect is to render.
- 7) Contrast: Sets the disparity of value between light and dark
- 8) Saturation: Controls the vibrancy of colour in the rendered image
- 9) Bloom: Sets the intensity of the bloom effect, which blurs the rendered image and then adds it on top of the original image to simulate glow from bright light sources (or Vaseline on a camera lens).
- 10) Vignette: darkens the edges of the frame
- 11) Grain: Sets how much noise applies to the image to simulate film grain

CG Lights|Marmoset Toolbag Resources

For additional information on marmoset toolbag, videos and tutorials can be found on their website here:

<https://marmoset.co/resources/>