How is Light Measured and Quantified?

Without a source of light, we cannot see; without surfaces to reflect light, there is nothing to see. The terms below describe this relationship between a source of light, the surfaces which reflect light, and how we see light.

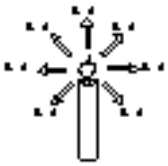
Luminous Flux (Φ)

1

Lumen (lm) A lumen is the total amount of light energy given off by a source.

This quantity is typically used to rate the output of lamps. For example, the flame of a candle generates about 12 lumens. A 60 watt incandescent lamp, such as the type you would find in your home, is rated at 890 lumens.

Luminous Intensity (I)

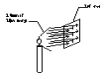


1

Candela (cd) A candela describes the intensity of light in a particular direction.

The familiar candle flame generates one candela in all directions and is actually the basis for defining what a candela is. Candela are used to rate the output of luminaires.

Illuminance (E)



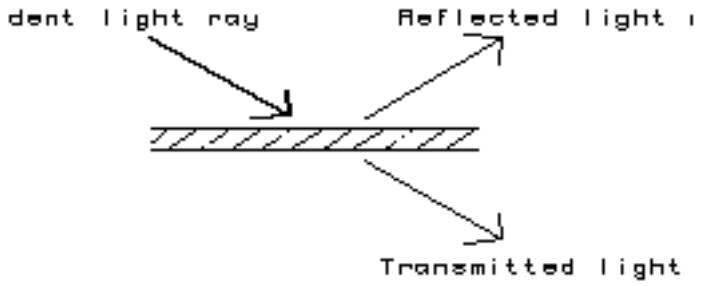
1

Footcandle (fc) A footcandle is the amount of light which falls on a surface.

It is equal to the number of lumens striking a surface divided by the area of the surface. Footcandle values can be determined for both horizontal surfaces, like a desktop, and vertical surfaces, like a chalkboard.

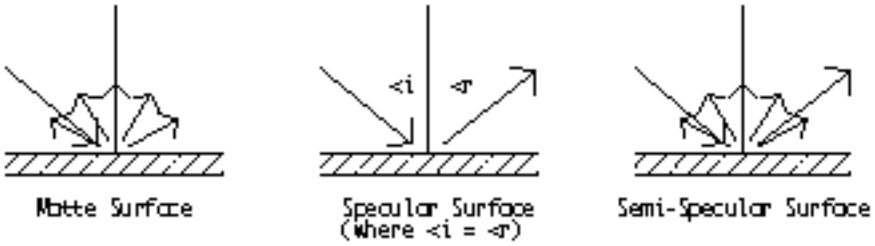
Lumens, Candela, and Footcandle are Related by the Unit Sphere

The unit sphere is an imaginary sphere with a one foot radius and describes the relationship between lumens, candela, and footcandles. Imagine a candle flame centered in a globe that is one foot in radius. That point source of uniform intensity equal to one candela produces an amount of light flowing through one square foot of area on the sphere equal to one lumen. The amount of light incident on one square foot of area on the sphere is equal to one footcandle. Since the area of the sphere is equal to 4pi, then the total luminous flux flowing through the sphere is equal to 4pi lumens, and the total illuminance on the sphere is equal to 4pi footcandles for a one candela source.



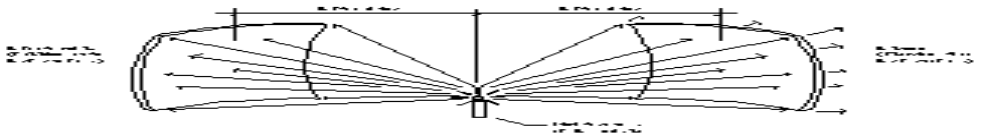
Luminance and Exitance

Luminance and Exitance values are measured or calculated values used to quantify the amount of light leaving a surface. Luminance values are measured in candela/SF and are used to describe light which leaves a surface in a directional manner. Exitance values are measured in lumens/SF and are used to describe light which leaves a surface in a diffuse manner.



Photometrics

Photometrics tell lighting designers how a particular luminaire will send light. They are based on how the luminaire distributes candela. When represented graphically, the candlepower or photometric distribution curves provide intuitive information to the lighting designer and give an indication of how the luminaire will perform in the space. The actual candela values are used in calculations to predict light levels and/or brightness levels within the space.



Brightness

Brightness is the subjective impression of the amount of light leaving a surface and reaching the eye. Since brightness is based on human response and is dependent on the adaptation level of the eye, it cannot be directly measured. Comparing luminance or exitance values of surfaces (since they can be measured or calculated) within the field of view allows lighting designers to determine the overall comfort of a lighting system.

Glare

Glare, caused by an excessively bright source of light in our field of view, interferes with our visual perception. In most situations, glare is something we would like to eliminate for better visual acuity. *Direct Glare* is caused by the bright source shining directly into the eyes. *Indirect Glare* or *Reflected Glare* is due to light sources reflected from tasks or other surfaces into the eyes.

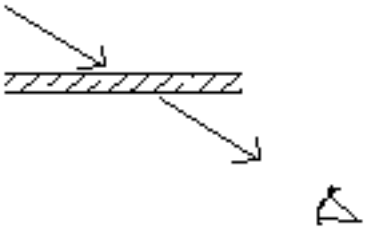
Reflectance (ρ)

Reflectance is the fraction of light exiting a surface compared to the amount of light falling on a surface. Dark and/or textured surfaces absorb a lot of light and therefore have a low reflectance while light and/or smooth surfaces reflect a lot of light and therefore have a high reflectance. Reflectance is a material property and is independent of the amount of light which reaches the surface.

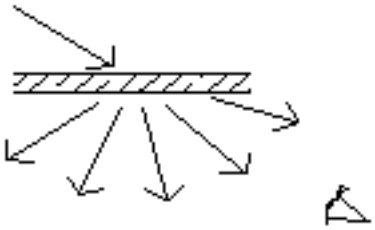
	Material	Reflectance (%)
Metals:	Aluminum, brushed	55-58
	Aluminum, etched	70-85
	Aluminum, polished	60-70
	Stainless steel	50-60
	Tin	67-72
Masonry:	Brick, dark buff	35-40
	Brick, light buff	40-45
	Brick, red	10-20
	Cement, gray	20-30
	Granite	20-25
	Limestone	35-60
	Marble, polished	30-70
	Plaster, white	90-92
	Sandstone	20-40
	Terra-cotta, white	65-80
Glass:	Clear or tinted	5-10
	Reflective	20-30
Paint:	White	70-90
	White porcelain enamel	60-83
Wood:	Light birch	35-50
	Mahogany	6-12
	Oak, dark	10-15
	Oak, light	25-35
	Walnut	5-10

Transmittance (τ)

Transmittance is the fraction of light which passes through an object. It is an important property to consider for glazing design since the transmittance will impact the amount of daylight available for natural illumination. Transmittance is a material property and is independent of the amount of light which reaches the material.



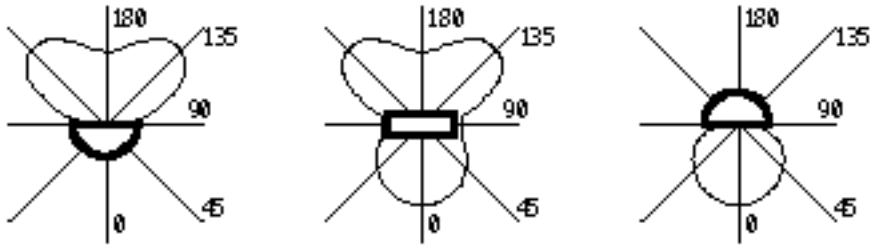
Directional light quantified by luminance.



Diffuse light quantified by exitance.

Specularity

Specularity describes the nature of reflected or transmitted light. A specular surface reflects light in a directional manner such that the angle of reflection is equal to the angle of incidence. A mirror is a specular surface. In contrast, a matte surface, such as a swatch of fabric, reflects light in a non-directional manner. Most surfaces are semi-specular, reflecting some light specularly and some light diffusely. Since semi-specular surfaces are difficult to describe mathematically, they are typically treated intuitively in lighting design practice.



Typical Candlepower Distribution Curves