WHITE PAPER

By Pozeen Lighting University

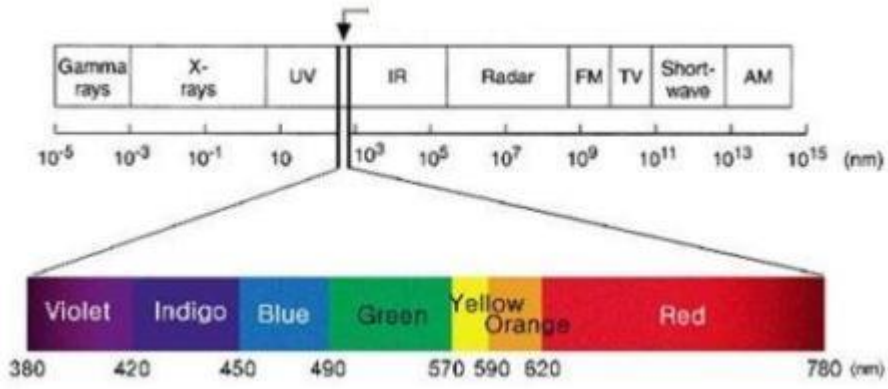
# LIGHTING BASICS

## Introducing Basics of Lighting

# VISUAL LIGHT

- What is the Light?

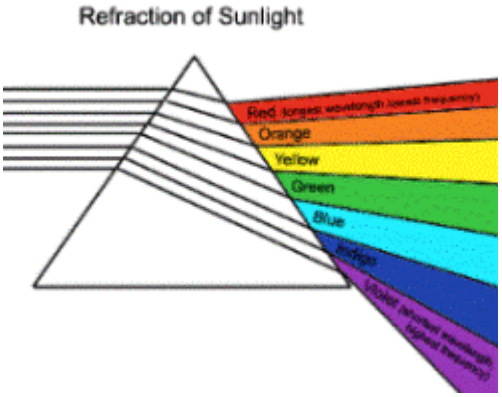
  Light is an electromagnetic (later referred as EM) radiation with a wavelength that is visible to the eye. The visible spectrum is the portion of the EM spectrum that is visible to (can be detected by) the human eye. EM radiation in this range of wavelengths is called visible light or simply light.

  There are no exact bounds to the visible spectrum; a typical human eye will respond to wavelengths in air from 400 to 700 nm, from infra-red to ultra violet range.

- Visible EM spectrum

  The combination of these EM waves produces white light, which is what we see from the sun and from most artificial light sources.

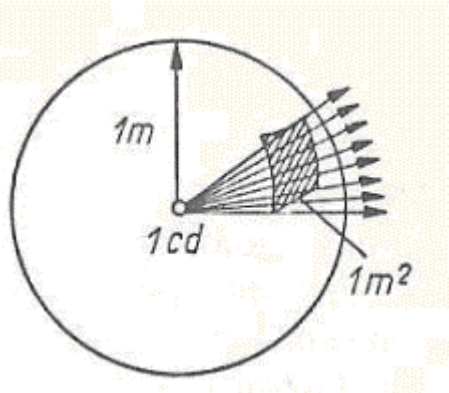



# FOUR BASIC UNITS OF LIGHT

- Radiometry and Photometry

  While radiometry is the measurement of power produced by a source of electromagnetic radiation photometry is the effect of electromagnetic radiation to the human eye or in other words in a visual system.

It is distinct from radiometry, which is the science of measurement of light in terms of absolute power; rather, in photometry, the radiant power at each wavelength is weighted by the luminosity function that models human brightness sensitivity.




- Luminous Flux

  Unit of measurement: lumen [lm]

  All the radiated power emitted by a light source and perceived by the eye is called luminous flux. The unit of measurement is the lumen (lm).

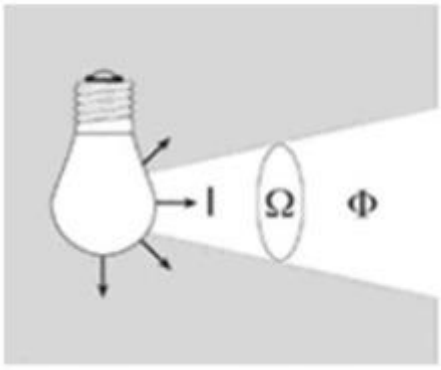
  The visible radiated power of a light source is not expressed in watts but in lumens since the sensitivity of the human eye differs according to the particular wavelength.

  1 lumen is the luminous flux radiated to 1 sr angle by point like light source having 1 candela luminous intensity.

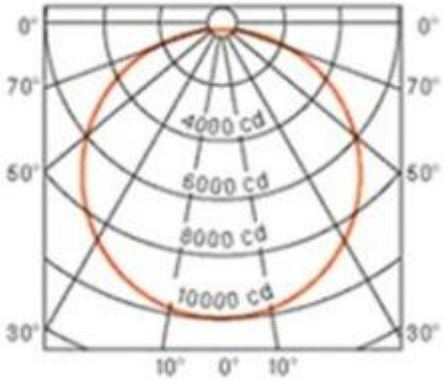
- Luminous Intensity

  Unit of measurement: candela [cd]

  A light source emits its luminous flux in different directions (solid angle; the unit of measurement is the steradian sr) and at different intensities. The visible radiant intensity in a particular direction is called luminous intensity (I). The unit of measurement is the candela (cd). The sun is a natural incandescent source (at about 5800 K on the surface), so is a candle flame. The most common man-made source is the tungsten filament light bulb at about 2854 K.

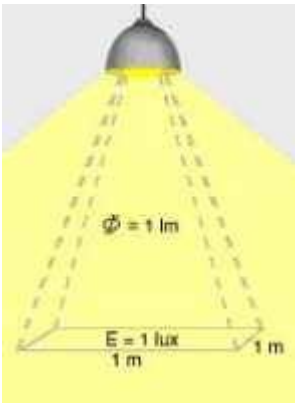



$$I = \frac{\Phi}{\Omega}$$




- Illuminance

  Unit of measurement: lux [lx]




  Illuminance E indicates the degree to which an area is illuminated. It is the ratio between luminous flux and the area to be illuminated.

  The unit of measurement is the lux (lx). An illuminance of 1 lx occurs when a luminous flux of 1 lm is evenly distributed over an area of 1 square meter. In practice, however, it is unlikely that the luminous flux will be so evenly distributed over the illuminated area that all the points in this area will have the same illuminance value.

  For humans, light is not visible until radiation enters the eye. Luminance is the only variable that can be perceived by humans. The table on the right side shows some general illuminance values.

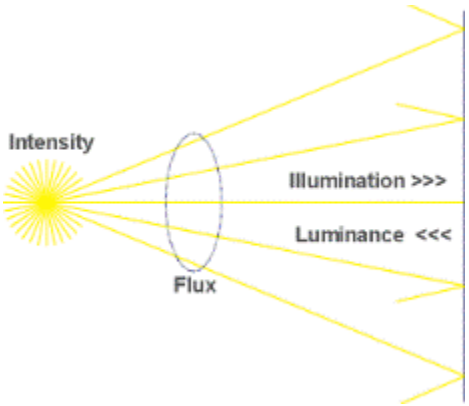
| Light source | Average luminance [cd/m2] |
|---|---|
| Sun at high noon | 1,6 ~ 109 |
| Xenon short-arc lamp | 1,5 ~ 108 - 2,7 ~ 109 |
| Metal halide short arc lamps HMI, HTI | 5 ~ 107 – 1~ 108 |
| Metal halide lamps HQI | 5,3 ~ 106 |
| Incandescent lamps clear | 2 ~ 106 – 2~ 107 |
| Incandescent lamps frosted | 5 ~ 104 - 4 ~ 105 |
| Low-pressure sodium lamp | 7,5 ~ 104 |
| Fluorescent lamp / Compact fluorescent lamp | 1,2 ~ 104 - 1,4~104 |
| White illuminated cloud | 1 ~ 104 |
| Candle | 7.500 |
| Clear Sky | 3.000 - 5.000 |
| Moon | 2.500 |
| Glow discharge lamp | 200 - 600 |
| Night sky | 10-3 |

- Luminance

  Unit of measurement: candelas per square meter [cd/m2]

  The luminance of a light source or an illuminated area is a measure of how much the eye

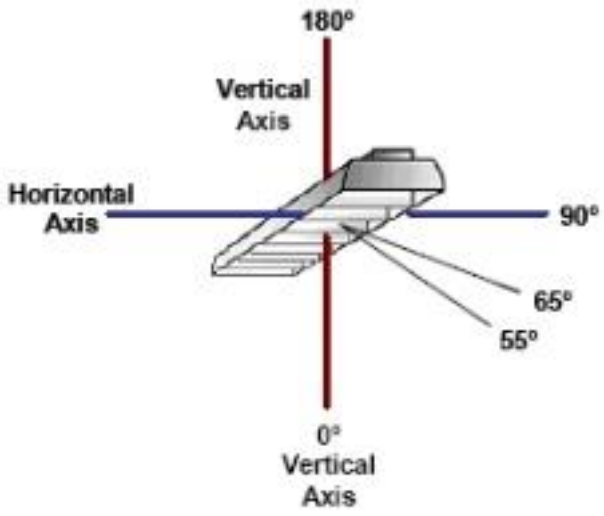
is stimulated and therefore of how great an impression of brightness is created in the brain. Let ' s assume we are looking at an illuminated (or self-luminous) area from a particular direction. The luminous intensity of this area divided by its size apparent to our eyes is its luminance L. It is measured in candelas per square meter (cd/m2).




To summarize all this, the intensity (I) of the source is candelas, the flux () transmitted through space is lumens, the light illuminating a surface (E) is lux (lumen/ m2), and the light reflected from an area, the luminance (L) is candela/m2.

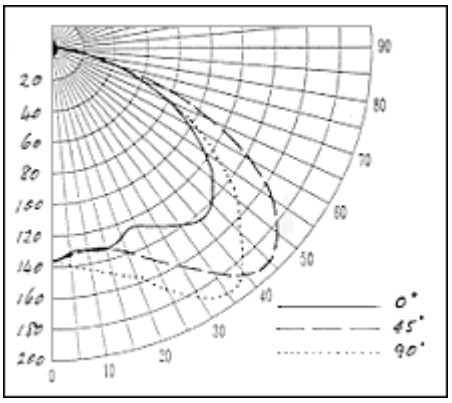
## LUMINOUS INTENSITY DISTRIBUTION CURVE

Luminous intensity distribution curves are typically represented in polar plots because this format allows us to visualize both the orientation and the light distribution of the light fixture. The candlepower distribution of a light fixture depends upon reflector design, shielding type, and lamp-ballast selection. (figure right top) It is assumed that the light fixture position is at the crossing of two axes (horizontal and vertical), and that 0° (nadir) is beneath the light fixture. Other angles, which represent the various placements of a photocell as it moves in a circular pattern around the light fixture, are marked on the graph as well.




If the distribution of light is not symmetrical in all directions around the vertical axis, such as

for a 2ft. x 4ft. light fixture, candlepower values may be taken in a number of vertical planes through the light fixture (figure right below). The planes shown in photometric reports are 0°, 22.5°, 45°, 67.5°, and 90°. The planes most commonly used in lighting practice are 0° or parallel to the lamp axes, 90° or perpendicular to the lamp axes, and at an angle 45° to the lamp axes.



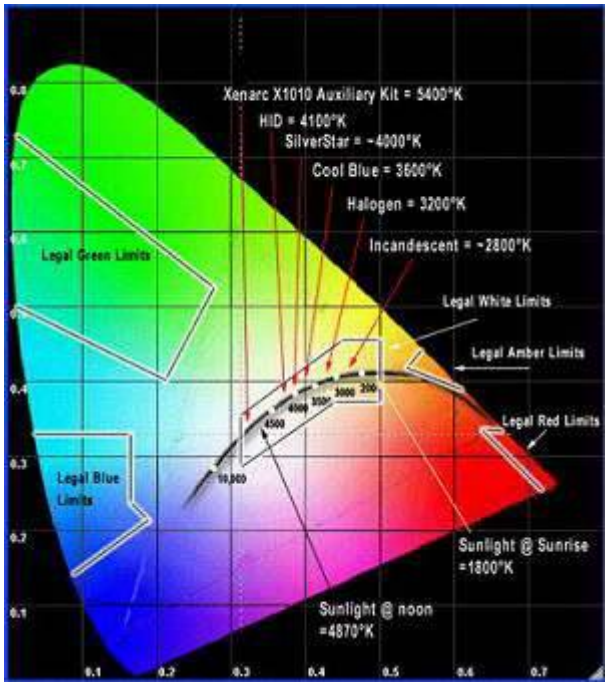

## COLOR TEMPERATURE

- Color Temperature

  Unit of measurement: Kelvin [K]

  The color temperature of a light source is defined in comparison with a “black body radiator” and plotted on what is known as the “Planckian curve” as seen in below figure . The higher the temperature of this “black body radiator” the greater the blue component in the spectrum and the smaller the red component.

  An incandescent lamp with a warm white light, for example, has a color temperature of 2700K, whereas a daylight fluorescent lamp has a color temperature of 6000.




- Light Color

The light color of a lamp can be neatly defined in terms of color temperature. There are three main categories here:

Warm White <3000 K

Bright White 3000 to 4500 K

Day Light >4500 K

Despite having the same light color, lamps may have very different color rendering properties owing to the spectral composition of their light.

## LUMINOUS EFFICACY

- Luminous efficacy

Unit of measurement: lumens per watt [lm/W]

Luminous efficacy indicates the efficiency with which the electrical power consumed is converted into light. It is measured in lumens per watt (lm/W). The luminous efficacy of conventional incandescent lamps (such as R5 W) is typically 10 lm/W, that of tungsten-halogen lamps (such as H7) 26 lm/W, and that of gas discharge lamp (such as D2S) 91 lm/W.