More about lighting

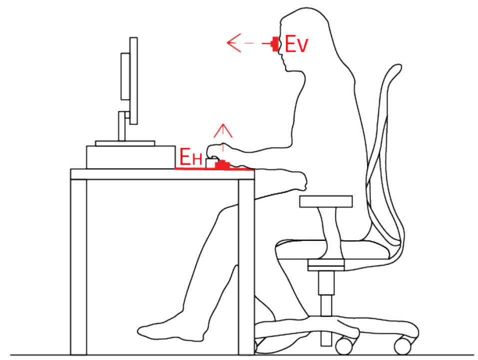
Measuring light

Illuminance (E) is the amount of luminous flux incident on a surface [51], and is measured in lumens per square meter (lux) or lumens per square foot (footcandle). One footcandle is equal to approximately 11 lux.
Lighting designs are concerned with two types of illuminance values:

Horizontal illuminance (E_H) is the amount or level of light incident on a horizontal surface such as a table desk, measured in lux. Appropriate E_H levels are crucial for the visual system and visual task performance. Measurements of E_H should be made by positioning an illuminance meter or other type of sensor face-up, flat on a horizontal surface at the appropriate location.

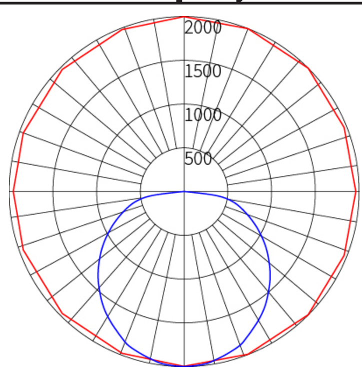
Vertical illuminance (E_V) is light that is received at the eye. These light levels are associated with the circadian system. To measure vertical illuminance, hold the illuminance meter vertical with the sensor facing where the eye is looking. These values can be plugged into the LRC's free access web-based CS Calculator, along with the source SPD, to determine the CS value .

Direction of measuring horizontal illuminance (E_H) (light received on a workplane)



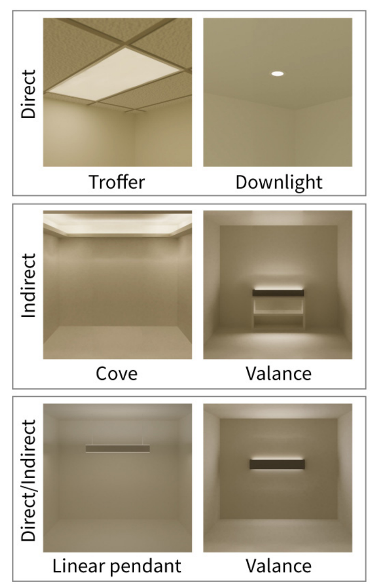
Direction of measuring vertical illuminance (E_V) (light received at the eye)

Lumen output, beam distribution, and position of fixture

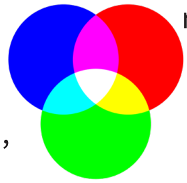


Intensity distribution example

When trying to achieve CS targets in a circadian design, being mindful of a few lighting characteristics can be beneficial to help meet the targets. First, the lumen output of a fixture will indicate the maximum amount of lumens a fixture will produce when it is turned fully on. A light source's distribution and intensity ultimately determine the amount of light that reaches the eye, as illustrated by the "cuts" in the accompanying candela plot. The horizontal cut (shown in red) indicates the shape and intensity of light when viewing the light source from above. Typically, the vertical cut (shown in blue) indicates the shape and intensity of light that is distributed into the space. A thinner distribution will direct light to a smaller area, good for accenting artwork for example. Wider distributions direct light to a greater area. The position and location of fixtures can also change how much light gets to the eye. The terms 'direct' and 'indirect' were coined in reference to light that falls on the work plane, indicating which direction a light fixture projects light. Typical fixtures are placed in the ceiling and send light downward into the space providing 'direct' light, such as a troffer, downlight, and recessed linear. To reduce glare from direct view of the source, lighting fixtures can be hidden in the architecture or fixture housing. If fixtures are oriented upwards, it is considered 'indirect' lighting. Coves and wall valances can hide upward facing fixtures and light will bounce off the ceiling or walls to more gently fill the space with light. Some fixtures can provide both direct (task) illumination as well as indirect (ambient) lighting. An example would be a direct/indirect linear pendant or wall mounted valance. When doing circadian designs, think about where you want light to be and what types of fixtures can achieve this.

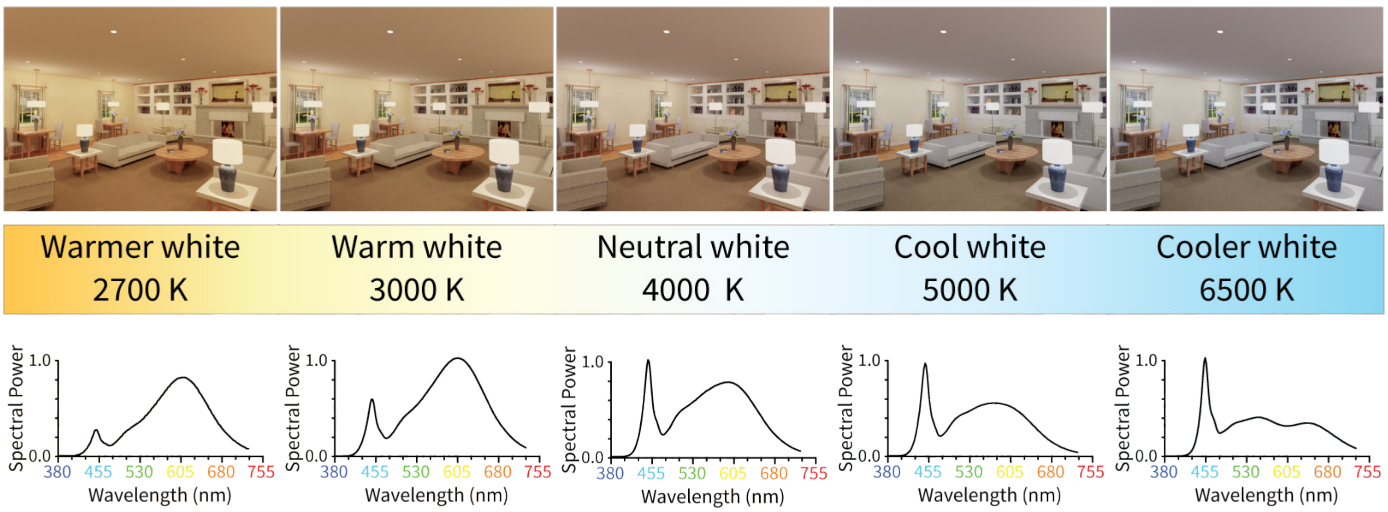


Correlated color temperature (CCT)- Ranges of white light

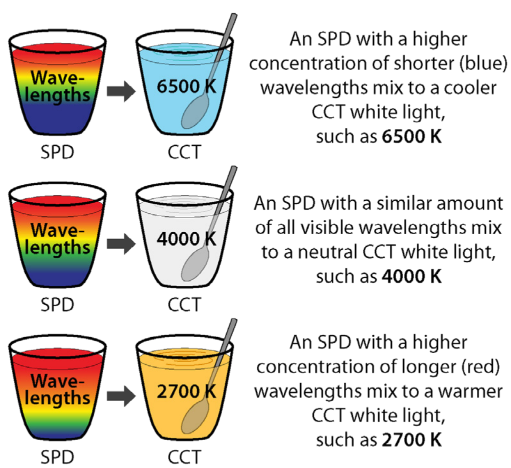


Color is a pigment of the imagination resulting from the interplay between electromagnetic radiation in the visible spectrum (380–780 nm) and the retina's cone photoreceptors. What is commonly referred to as "white light" — whether "soft," "cool," or "daylight" — is actually composed of a mixture of short, medium, and long wavelengths that can be roughly classified as resembling the colors blue, green, and red, respectively (see figure).

When mixed, white light is created and classified as correlated color temperature (CCT) and expressed in units of kelvin (K), ranging from the slightly reddish-yellow appearance of 2700 K (warmer white) to the sky-bluish appearance of 6500 K (cooler white). Generally speaking, warm light sources are those with CCTs < 3500 K and cool light sources are those with CCTs > 5000 K. The CCT along with brightness have an impact on CS as well as aestetics of how a space looks and feels (see examples below).



SPD, or spectral power distribution graphs the relative amount of energy each wavelength has in a light source. Each light source is made up of a combination of wavelengths (x-axis), ranging in strength, which is indicated by relative spectral power (y-axis). With white light being a combination of the spectral power of the many wavelengths, it is possible to many SPDs classified as the same CCT. SPD curves with a similar trend that appear to be the same tint will can be classified under the same CCT, but can possess different



qualities that can affect outcomes such as CS. With this being the case, it is important to use the correct SPD of sources used in a design to determine its CS contribution more accurately. The warm-white 2700 K shows a larger area of contribution from the longer wavelengths, and less contribution from the shorter wavelengths making it appear to have a yellower tint. Inversely, a cool-white 6500 K shows a greater peak in the shorter wavelengths, and a smaller area of long-wavelength contribution making it appear to have a bluer tint. In lighting designs, a static or tunable CCT approach can be used. A **static CCT system** in circadian design refers to using a single CCT that dims throughout the day to achieve vertical illuminance to reach CS targets. A **dynamic CCT system** refers to using multiple CCTs that can also dim. Cooler CCTs will generally reach a CS greater than 0.3 at lower light levels (compared to warm CCTs) which can be desired in some solutions that need lower horizontal light levels for visibility or energy savings. Creating a dynamic environment by changing the color temperature of the lighting in the space and/or dimming the light output throughout the day will provide a robust schedule that is beneficial for the circadian system to synchronize to the solar day.

References

[51] Purves D, Augustine GJ, Fitzpatrick D, Hall WC, LaMantia A-S, McNamara JO, Williams SM (2004) Neuroscience, Sinauer Associates, Sunderland, MA, US.