An Introduction to Measuring the Quantity of Light

How much light do we need, and how do we get that amount? Those mysteries are explored in this explanation of light levels (illuminance) and light output (luminous flux.)

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Originally published by the Lighting Design Lab, this article explains what you can expect from a lamp's "light output" and the fundamentals of determining light levels.

Luminous Flux (Light Output)

This is the quantity of light that flows out of the lamp, measured in *lumens (lm)*. Lamps are rated in both initial and mean lumens.

Initial lumens indicate how much light is produced once the lamp has stabilized; for fluorescent and high-intensity discharge (HID) lamps, this is typically after burning 100 hours.

Mean lumens indicate the average light output over the lamp's rated life, which reflects the gradual deterioration of performance due to the rigors of continued operation; for fluorescent lamps, this is usually determined at 40% of rated life.

Lamp Lumen Depreciation is the amount of reduction of light output over the rated life of the lamp.

A number of factors affect a lamp's light output over time, including lamp lumen depreciation, the lamp's interaction with the ballast, supply voltage variations, dirt or dust on the lamp, and the ambient temperature in the fixture.

To avoid confusion, note that lumen output is a term also used to describe a fixture's light output, not just a lamp's. Even more factors can affect light output in this case, including the distribution characteristics of the fixture, fixture surface depreciation, and dirt and dust buildup.

Illuminance (Light Level)

This is the amount of light measured on the workplane in the lighted space. The workplane is an imaginary horizontal, tilted or vertical line where the most important tasks in the space are performed. Measured in *footcandles (fc)* (or *lux* (lx) in metric), light levels are either calculated or, in existing spaces, measured with a light meter. A footcandle is actually one lumen of light density per square foot; one lux is one lumen per square meter. One footcandle is roughly 10 lux. Like lumens, footcandles can be produced as either initial or maintained quantities.

Initial footcandles indicates a light level after new lamps are installed.

Maintained footcandles indicates a light level after light loss factors are considered over a period of time. Light loss factors include those affecting light output (see above) and also room surface reflectances, room size/proportions and dirt and dust buildup. While light output may describe either the output of a light source or fixture, maintained footcandles always takes into account the efficiency of the fixture in transmitting light to the workplane.

The formulas for calculations involved in predicting light levels is:

Footcandles (fc) = Total Lumens (lm) ÷ Area in Square Feet

1 Lux (lx) = 1 Footcandle (fc) x 10.76

Lux = Total Lumens ÷ Area in Square Meters

The human eye is a sophisticated piece of machinery; it is able to adjust to a wide range of light levels, including about 10,000 footcandles on a sunny day to about 0.01 footcandles under full moonlight. However, minimum light levels are needed for humans to perform certain tasks at their best. People can see under moonlight, for example, but they would find it very difficult and fatiguing to try to read a book.

While light levels are important, lighting design must transcend the workplane and address the entire space, viewing all surfaces that reflect light (the entire space) as part of the lighting system itself. We'll address that shortly. For now, consider this timeline, which reveals the progression of recommended light levels for office work

Finding the right light level in that range for a given application, in turn, is based on several factors: time, size, contrast, brightness and age.

The amount of time available to perform a task is critical in determining the proper light level. The less time there is to perform a task, the more light is required for that task to be completed efficiently and accurately.

Size matters when it comes to lighting tasks. The larger an object appears visually, the easier it is to see it. The smaller the task is visually, the more light is required to perform it properly.

Contrast deals with how well the task stands out from its immediate surroundings. This is a function of color. Blue and yellow have the greatest contrast. The less contrast there is, the more light is required to complete the task as required. Contrast is related to brightness. Too little or too much brightness decreases contrast.

Finally, the age of the worker must be considered. As the eye ages, vision capabilities typically deteriorate and so higher light levels are needed for older people. A 60-year-old man may need as much as 15 times more light than a 10-year-old child to perform the same task.

Activity	Light Level (fc)	Light Level (lx)
Fine Machine Work	300	3,000
Reading #2 Pencil	30	300
Stairways	5	50
Inspection (Simple-Difficult)	30-500	300-5,000
Reading a Telephone Book	50-100	500-1,000