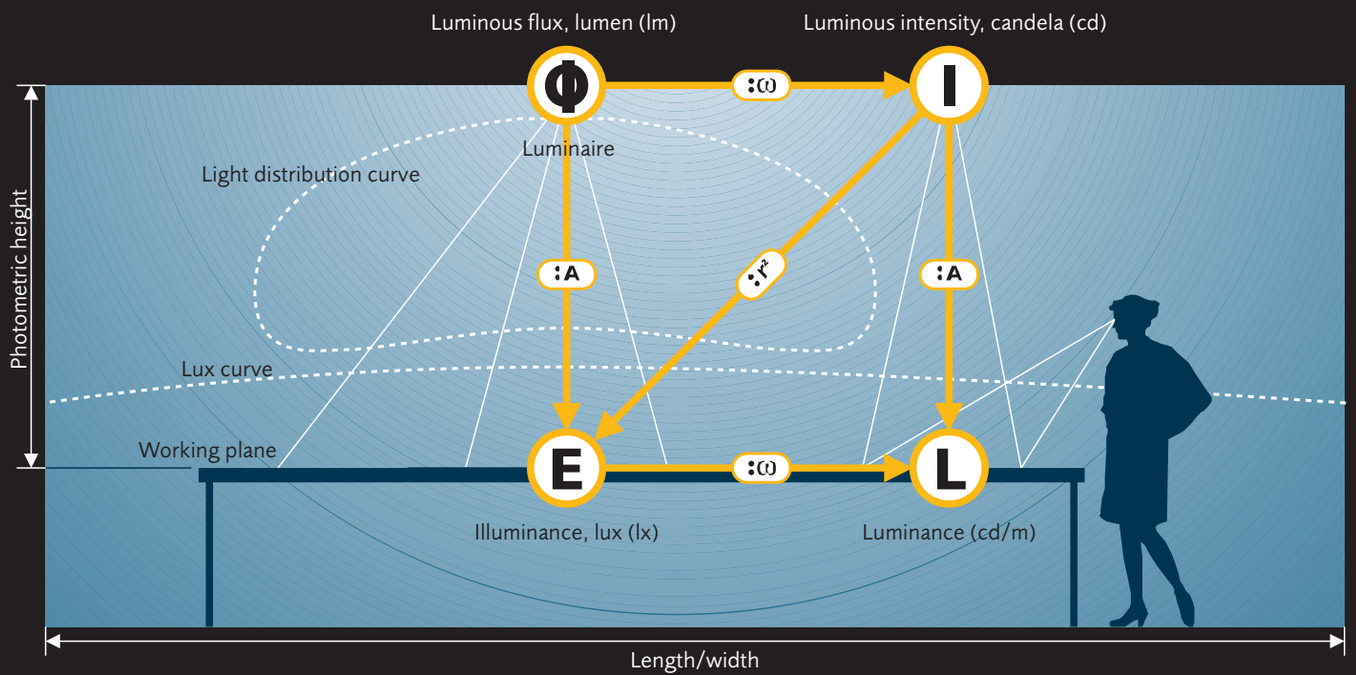
Series (2):

Photometric quantities in a space



Utilization formula
$\Phi_{erf} = \frac{E \times A \times 1.25}{\eta_B}$
DIN 5035 Construction drawing Constant / Utilization factor

Point illumination calculation method
$E = \frac{I}{h^2} \cos^3 \alpha$
α = Angle to the vertical h = Photometric height

Graphic design: Kerstin Schröder, Peter Zickermann, Bielefeld/D

Series (2): Photometric quantities in a space

The drawing shows a section of a building, four photometric quantities set out in a square, two curves and two calculation formulae.

In a space, the ground surface area (length x width) and the photometric height (the distance between the working plane and the light source) are key factors. The square with the four standard photometric quantities shows the mathematical relationship between the given quantities. The light source is positioned in the top left-hand corner of the square and is marked phi to indicate its full radiation power, luminous flux being measured in lumens (lm). The bottom left-hand corner of the square represents the working plane level.

The division of the radiation power of all luminaires installed in the space by the ground surface area of the space A, gives the illuminance level E in lux (lx). To apply this theory in practice, the result is increased by one quarter to increase the maintenance rate (factor 1.25) and to balance out light loss incurred through the shape of the space, reflectivity of the room surfaces and absorption of the luminaire (eta B). This utilization factor is provided in tabular form by manufacturers. This is the formula for the standard method of calculation (efficiency method) to find the average illuminance of a space, or the total required luminous flux, respectively. The next step is to find out of how light is distributed in the space. This depends on the radiation characteristics of the luminaire, which are determined in lighting laboratory tests. Sphere photometry helps us understand the photometric quantity known as luminous intensity I, which is measured in candela (cd), in the top right-hand corner of the square. Imagine a specific number of rays in the centre of the sphere photometer that do not have the same intensity in all directions. A section of the sphere – with a point in the centre and a circle on the surface of the sphere – is determined by the solid angle omega. In every section of this cone – irrespective of the size of the sphere – the number of rays remains the same.

That is to say, the direction of the rays generated by the light source remains constant. Using the same logics, this allows us to understand luminance L, measured in candela/m^2. Thus the four photometric quantities are correlated. Luminance incorporates the reflectivity of surfaces: the human eye actually only sees luminance. From the values calculated using the sphere photometer, cross section and longitudinal section values are as a rule given through the central vertical axis. This light distribution curve is the most important quality of the luminaire for the lighting designer. If the portion of radiation of a luminaire is known in every direction, the portion of light of every luminaire can be calculated on every point on the working plane. This is known as the point illumination calculation method, which works according to the law of inverse squares: inverse-square-law attenuation.

The radius of the sphere r – see square – has been converted into the distance between the working plane and the light source using the cosine. The results for every point calculated from individual light sources can be added to acquire the lux value for every point. Linking these values produces a lux curve.

A synopsis of mathematical and spatial references gives young lighting designers a basic understanding of lighting calculations. This lighting engineering approach to lighting is complementary to the more emotion-based design approach. The one cannot substitute or eliminate the other. Both approaches are part of a greater context. Every human activity takes place in the context of nature and culture, art and perception, or in the field of tension between community and individual.

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