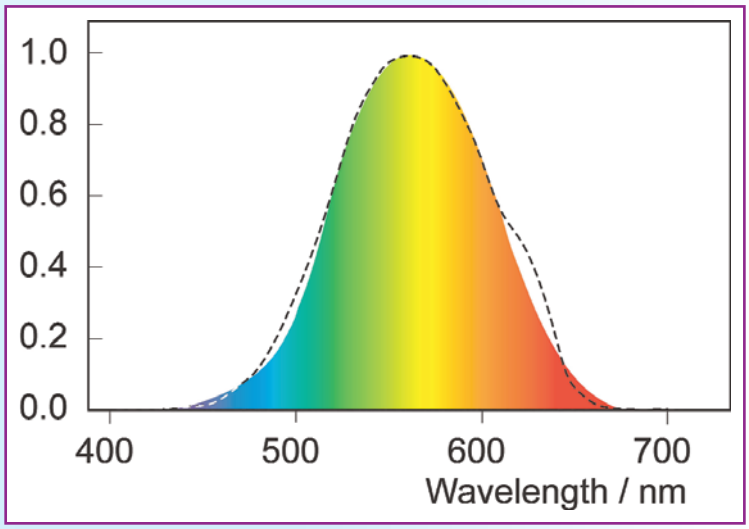
measurement matters

Making light work

Light meters (more correctly illuminance meters or luxmeters) are typically used to measure interior light levels of a few hundred lux. The human eye has a very wide dynamic range; one can see objects illuminated with 0.005 lux, at which level outlines can just be perceived, through to the 100,000 lux of direct sunlight. Light meters are commonly used over the range from 1 lux, the nuisance level from street lighting, to the 10,000 lux required in some surgical situations. Specific requirements are frequently imposed by legislation, regulations, or contracts; for example 750 lux is required for the inspection of exported meat.

Illuminance meters measure the intensity of visible light on a surface. This is not simply a sum of all electromagnetic radiation from blue to red falling on the surface, but rather a weighted sum of this radiation: the meter responds to different colours or wavelengths in the same way as does the human eye, with maximum response in the green and low responses in the blue and red (see figure). This response is achieved by matching a coloured glass filter to the spectral response of the light detecting element to mimic the human eye's response — the "photopic" response.

This combination of filter and light sensor is a photometer. Combined with some form of diffuser to ensure appropriate response to light incident at all angles it forms an illuminance meter. Alternatively, combined with focussing optics set up to view a distant object and measure the light emitted per unit area and solid angle, it forms a luminance meter.



The relative response of the eye to different colours — the photopic response curve. The dashed line shows the actual response of one good quality meter.

Light meters can vary widely in their accuracy. Nowadays, for as little as $250 one can buy instruments with an attractive digital display and a variety of data handling tools. Do not allow such features to distract attention from the core requirements:

- **Calibration.** Demonstrating that regulatory or contractual requirements are being met (or not met) requires a meter that has been recalibrated regularly by an accredited laboratory.
- **Angular response.** In normal use the illuminance being measured results from light arriving from all directions. For example, the illumination on an inspection bench will come not only from an overhead light but also from reflection off surrounding walls. But meters are usually calibrated with a lamp some distance from the meter; in consequence the calibration is strictly valid only for light incident at right angles to the plane of the meter. To measure correctly, the meter's response to off-axis light should be proportional to the cosine of the incident light direction; how well this requirement is met should be ascertained at purchase and checked periodically.
- **Accuracy of photopic response.** The meter will read incorrectly unless it matches the eye's colour response; this should be checked at purchase and every third or fourth calibration. This characteristic is described by a parameter denoted f_1' for which a value of less than six percent is medium quality and less than three percent is very good. When using a light meter remember that it is calibrated for white light; even a good meter can vary by 25 percent or more from the photopic response over small wavelength ranges in the red or blue (see figure), and thus using illuminance meters to measure a red vehicle light or a blue LED is prone to severe error.

In conclusion, calibration alone will not guarantee accuracy; the correctness of both angular and colour response are essential.

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