ILLUMINANCE

DEFINITION OF ILLUMINANCE

The quantity actually measured in photometry is illuminance, the amount of luminous flux incident per unit area. (Some texts refer to this quantity as illumination.) If, as shown in figure 1, flux F falls on an area A, the illuminance E is defined by

$$E = F/A.$$

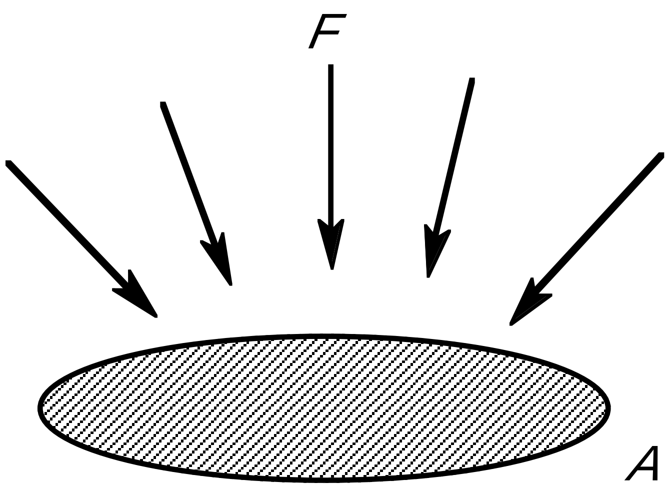

Figure 1. Illuminance is the total luminous flux incident on an area divided by the area.

It is the illuminance of the retina of the eye which initiates visual sensation, the illuminance of film which produces a photographic image, and the illuminance of a sensitive cell which activates a light meter.

Typical units of illuminance are lumens per square foot or lumens per square meter. From the conversion from feet to meters it is easy to show that

$$10.764 \ \mathrm{lm/m^2} = 1 \ \mathrm{lm/ft^2}.$$

ILLUMINANCE METERS

Most hand held light meters are, in fact, illuminance meters which measure the amount of luminous flux incident on a receiving plate. The components of a typical illuminance meter are:

(1) a diffusing plate;
(2) a filter;
(3) a sensitive cell;
(4) an electrical instrument.

The schematic arrangement of these components is shown in figure 2

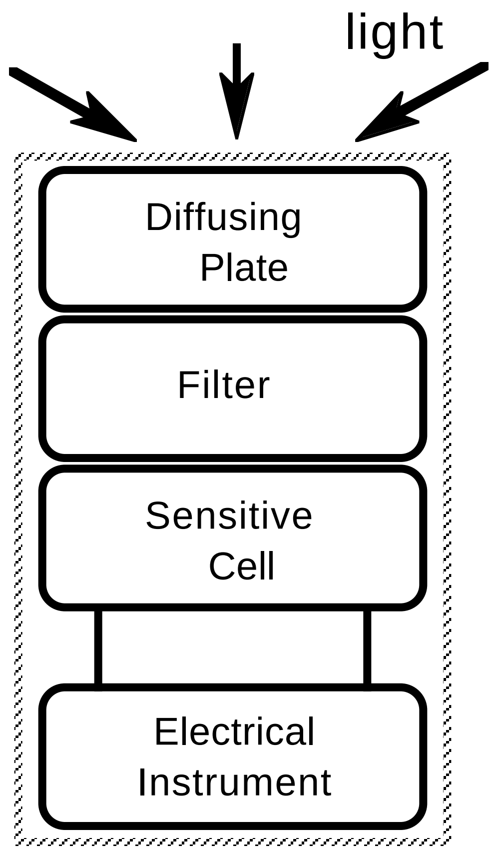

Figure 3. Schematic structure of an illuminance meter.

The purpose of the diffusing plate is to assure that the effect of obliquely incident light rays are included in the meter reading. Meters with such a diffusing plate are called <u>cosine corrected</u>.

The filter is chosen so that the meter will have a spectral sensitivity like that of the eye, the V_λ curve. The exact choice of filter depends on the spectral sensitivity of the sensitive cell. In some cases, e.g. photographic meters, the filter is omitted. This makes the meter somewhat more sensitive with no significant cost in accuracy for the intended application.

Sensitive cells convert light energy into a voltage or resistance. Three kinds of cells are in common use:

(1) Selenium (Se) cells.

The selenium cell is the oldest of light sensitive cells. Light incident on the cell produces a voltage which increases with the intensity of incident light. The selenium cell produces enough power that no batteries or other power source is needed. Selenium cells are rugged, long lived, and exhibit little hysteresis—that is, the meter reading is little affected by preceding exposure to light, especially bright light. Unfortunately, the sensitivity of the selenium cell is rather limited and meters using them lose accuracy below about 5 lm/ft^2.

(2) Cadmium sulfide (CdS) cells.

The cadmium sulfide cell has succeeded the selenium cell in many applications. The CdS cell acts as a variable resister, its resistance decreasing with increasing illuminance. A battery in series with the CdS cell is used to generate a measurable electrical current. The CdS cell offers increased sensitivity over the older selenium cell at a cost of increased fragility and hysteresis.

(3) Silicon (Si) cells.

The silicon cell is the most recently developed of the sensitive cells discussed here and provides more sensitivity than a CdS cell with reduced hysteresis. Light incident on the cell influences its no-load voltage, but, unlike the selenium cell, no power may be drawn from the silicon cell. Battery driven circuitry rather more elaborate than that required with other cells is necessary to extract a light-dependent current from the silicon cell.

The end product of the circuitry associated with each cell is an electrical current which depends on light intensity. There are two common ways of converting this current to a usable reading. The older method is to pass the current through a coil wrapped around a spring loaded needle. The coil moves in the field of a permanent magnet and the meter is deflected as a consequence of the interaction between current and magnetic field. The greater the current, the more force the needle exerts against the spring and the greater the deflection. The reading is taken from a scale beneath the needle. More recently developed meters have converted the current to a digital LED display.

A typical light meter is shown in figure 3.

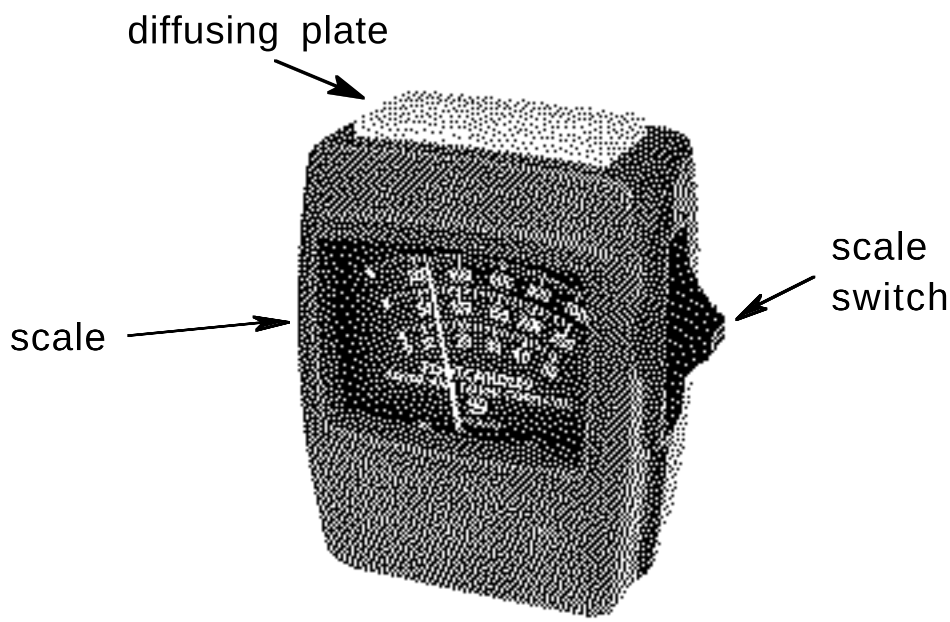

Figure 3. A typical light meter. The illuminance of the diffusing plate is read from one of the three scales on the front of the meter according to the position of the scale switch.

Illuminated Surface	Illuminance
Ground in bright sunshine	5000 $lm/ft^2 \cong 50,000\ lm/m^2$
Ground on overcast day	1000 $lm/ft^2 \cong 10,000\ lm/m^2$
Work surface in well lit room	20 $lm/ft^2 \cong 200\ lm/m^2$
	to 50 $lm/ft^2 \cong 500\ lm/m^2$
Optometrist's acuity chart	20 $lm/ft^2 \cong 200\ lm/m^2$ or more

Table 1. Typical illuminance magnitudes.

No matter what the details of the operation of the illuminance meter, however, all ultimately measure the same thing—the light flux per unit area of the sensitive cell, its illuminance. Illuminance is the working quantity in photometry. All other photometric entities we'll define must ultimately be measured indirectly through an illuminance reading of some sort.

It is useful to have a feeling for illuminance magnitudes. Table 1 gives illuminances which might be measured in typical lighting situations.

Incidentally, the scales of illuminance meters often give readings in foot-candelas or lux (abbreviated ft-cd and lx). These two units are numerically the same as lumens per square foot or lumens per square meter, respectively, as will be explained later.