LUMINOUS EXITANCE

DEFINITION OF LUMINOUS EXITANCE

The luminous exitance or luminous emittance of a radiator is the total flux emitted in all directions from a unit area of the radiator. Luminous exitance is symbolized by M and has units of lumens per square meter, just like illuminance. In symbols

$$M = F / S \tag{1}$$

where a total flux dF comes from a source of area dS (figure 1).

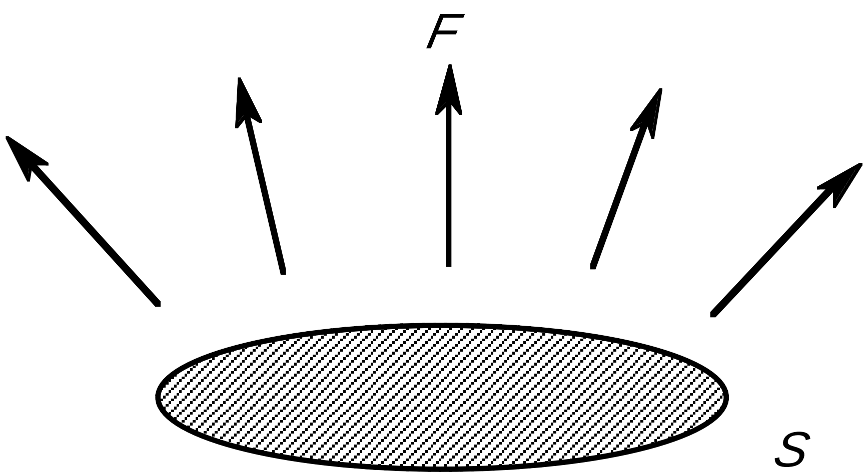

Figure 1. Luminous exitance is the total luminous flux radiated by an area divided by the area.

Both luminance and luminous exitance pertain to radiating sources of finite area, but luminance quantifies the flux radiated in a particular direction while luminous exitance pertains to the total flux emitted. Exitance is a much easier concept to grasp but, unfortunately, not as useful as luminance.

LUMINOUS EXITANCE OF A LUMINOUS SOURCE

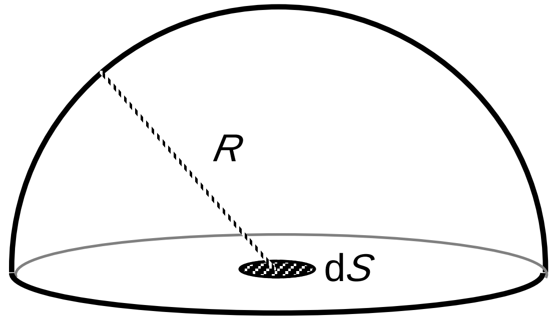

Figure 2. To find the luminous exitance of a source, first find the total luminous flux from a surface element d*S* through a hemisphere of radius R centered on d*S*.

To calculate the luminous exitance from an element of area d*S*, we must first find the total flux emitted by the area. Do this by constructing a hemisphere of radius *R* centered on d*S*, as shown in figure 2 and finding all the flux through the hemisphere, which is all the flux leaving the source. The total flux leaving d*S* and passing through an area d*A* of the hemisphere is

$$\mathrm{d}F = L\cos\theta\cos\phi\,\mathrm{d}A\,\mathrm{d}S/r^2$$

and combining this with (1) gives for luminous exitance

$$M = \frac{\mathrm{d}F}{\mathrm{d}S} = \int_{hemisphere} \frac{L\cos\theta\cos\phi}{r^2}\mathrm{d}A.$$

Over the surface of the hemisphere the radius of the hemisphere is *R* and $\phi=0$, $\cos\phi=1$, all constants as well. This allows us to simplify the integral to

$$M = \frac{\mathrm{d}F}{\mathrm{d}S} = \frac{1}{R^2}\int_{hemisphere} L\cos\theta\,\mathrm{d}A.$$

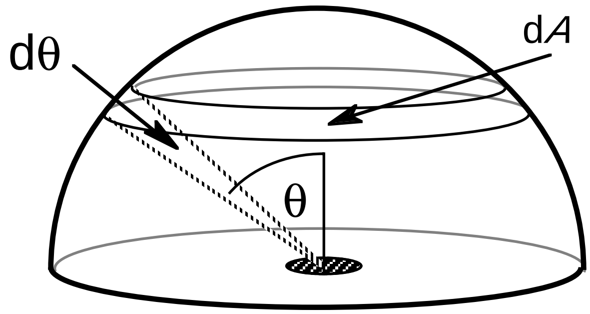

Figure 3. To integrate over the hemisphere of figure 1, break the area up into infinitesimal ring shaped areas which subtend angle dθ.

We need to find the area dA as a function of angle θ. Let the area of the hemisphere be broken into circular rings on the surface of the hemisphere as shown in figure 3. The width of a ring is Rdθ and its circumference is 2πRsinθ, so its area is

$$dA = 2\pi R^2 \sin\theta \, d\theta.$$

The luminous exitance becomes

$$M = \frac{dF}{dS} = 2\pi \int_{0^\circ}^{90^\circ} L \cos\theta \sin\theta \, d\theta. \tag{2}$$

In general L will depend on orientation through the angle θ, and this must be taken into account in integrating (2). In the case of a Lambert radiator, however, L is independent of direction and evaluating the integral gives

$$M = 2\pi L \int_{0^\circ}^{90^\circ} \sin\theta \, d(\sin\theta) = \left[\pi L (\sin\theta)^2\right]_{0^\circ}^{90^\circ}.$$

Taking the limits, then, the luminous exitance of a Lambert radiator is given by

$$M = \pi L \quad \text{...for Lambert radiators.} \tag{3}$$

If we rewrite (3) in Lambert units,

$$\pi L(\text{cd/area}) \Rightarrow L(\text{Lambert units})$$

and

$$M(\text{lm/m}^2) = \pi L(\text{cd/m}^2) = L(\text{asb}),$$

$$M(\text{lm/ft}^2) = \pi L(\text{cd/ft}^2) = L(\text{ft-L}).$$