Example

Find the luminance of the moon.
The sun directly points to the moon. Treat the sun and moon as flat discs.

$L_{sun} = 1600 \times 10^6 \frac{cd}{m^2}$

B. $d_{sun} = 10^6$ Km

A $S_o = \pi (5 \times 10^5)^2$
$S_o = 7.85 \times 10^{11}$ Km^2

$R = 147 \times 10^6$ Km

$d_{sun} \ll R$
$10^6 \ll 147 \times 10^6$

$\theta = \phi = 0$

$$E_{moon} = \frac{(1600 \times 10^6)(7.85 \times 10^{11})}{(147 \times 10^6)^2}$$

$$E_{moon} = 58 \times 10^3 \frac{lm}{m^2} = 58 \text{ Klux}$$

The light that hits the moon scatters of as a Lambertian source.

If we incorrectly assume that the moon does not absorb any light

$$L_{moon} = \frac{E_{moon}}{2\pi} = \frac{58 \times 10^3}{2\pi}$$

Full hemisphere

$L_{moon} = 9.2 \times 10^3$ cd/m^2

L_{moon} is actually 2.5×10^3 cd/m^2

So reflectivity of moon is $\eta = \frac{2.5 \times 10^3}{9.2 \times 10^3} = 0.27$

Find illuminance in full sun using

$L = 1600 \times 10^6 \ cd/m^2$ for sun

$r_{sun} = \frac{1.392 \times 10^6}{2} \ Km$ $R = 1.496 \times 10^8 \ Km$

$r_{sun} \ll R$

$$E = \frac{L \cos\theta \cos\varphi \, S_0}{R^2}$$

$$= \frac{(1600 \times 10^6)(\pi)\left(\frac{1.392 \times 10^6}{2}\right)^2}{(1.496 \times 10^8)^2}$$

$E = 10^5$ lux Just like on Table 5.3

Example

From table 5.3 Normal illuminance for a room is

$$100 < E < 2000 \text{ lux}$$

We want $E = 250$ lx
Using LUXEON CoB 205 with a color Temperature of 2200K.

Find LED space on the ceiling. Use a distance of 2.5m between ceiling and floor.

From spec sheet: $\Phi = 567$ lm

$$I = I_0 \cos\theta$$

Emission is circular with diameter of 6.5mm

Approximate with a uniform Luminance with a fixed beam angle

compute solid angle

$$\Omega = \int_0^{2\pi} d\phi \int_0^{\pi/2} \cos\theta \sin\theta \, d\theta$$

$$= 2\pi \left(-\frac{1}{2} \cos^2\theta \Big|_0^{\pi/2} \right)$$

$$= 2\pi \left(-\frac{1}{2}\right)\left(\cos^2 0 - \cos^2 \pi/2 \right)$$

$$= \pi$$

Using uniform I

$$\Omega = 2\pi (1 - \cos\alpha)$$

$$\pi = 2\pi (1 - \cos\alpha)$$

$$\alpha = 60^\circ$$

Calculate Luminance

$$L = \frac{567}{(\pi)(\pi)(3.25 \times 10^{-3})^2} = 5.4 \times 10^6 \text{ cd/m}^2$$

Use the point source approximation

$$r_{LED} << \text{ceiling height}$$

$$3.25 \times 10^{-3} << 2.5$$

On the floor; Find the illuminance produced by a single LED

$$E = \frac{L \cos\theta \cos\psi \; S_o}{R^2}$$

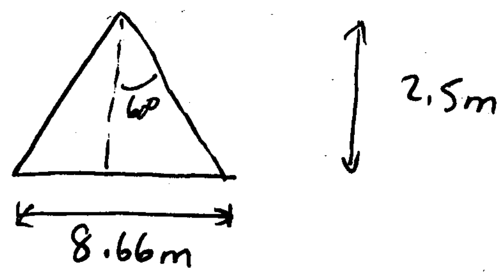
$$= \frac{(5.4\times10^6)(1)(1)(\pi)(3.25\times10^{-3})^2}{(2.5)^2}$$

$E = 28.9$ lux

$E < 250$ lux so we need overlapping LED illumination patterns

Single LED pattern

$\tan 60° = \frac{\Delta x}{2.5}$



We want $\frac{250}{28.9}$

9 overlapping beams
Separate by $\frac{8.66}{9} = 0.96$ m