Rendering assignment three

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Introduction

This is my answers to the three handin in the Rendering course. The formulation of the exercises is given in italic.

Part 1

small 25W light bulb has an efficiency of 20%. How many photons are approximately emitted per second? Assume in the calculations that we only use average photons of wavelength 500 nm.

$$f = \frac{c}{\lambda} = \frac{3 * 10^8 \frac{m}{s}}{500m * 10^{-9}} = 6 * 10^14s^{-1}$$

$$q[500nm] = hf = 6.626 * 10^{-34}Js * 6 * 10^14s^{-1} = 3.976 * 10^{-19}J$$

$$N_{photon}[25W * 0.2] = \frac{25W * 0.2}{3.976 * 10^{-19}J/photon} = 1.258 * 10^{19}photon/s$$

Part 2

A light bulb (2.4 V and 0.7 A), which is approximately sphere-shaped with a diameter of 1 cm, emits light equally in all directions. Find the following entities (ideal conditions assumed)

Radiant flux

This is equal to the effect of the bulb. This can be obtained from the voltage and amperage:

$$W = A * V = 2.4V * 0.7A = 1.68J/s$$

Radiant intensity

Radian intensity is how much power is emitted per solid angle. Since we are to take the whole sphere of the lightbulb into consideration the solid angle is equal to four pi:

$$I = W/sr = \frac{1.68J/s}{4\pi sr} = 0.42\frac{J}{s * sr}$$

Radiant exitance

Radiant exitance is the power divided by the surface area. Since the bulb is a unit sphere the area of it is equal to 4 pi and the result is therefore the same as before but with different units:

$$M = W/m^2 = 0.42W/m^2$$

Emitted energy in 5 minutes

This is simply taking the flux effext of the bulb and multiply it with 5*60 seconds:

$$Q = W/s = 1.68J/s * 5 * 60s = 504J$$

Part 3

The light bulb from above is observed by an eye, which has an opening at the pupil of 6 mm and a distance of 1 m from the light bulb. Find the irradiance recieved in the eye
We use the inverse square law:

$$E = \frac{W}{4\pi r^2}$$

where E is irradiance, W is radiant flux and r is distance from light source. When we use the value of radiant flux calculated earlier and set r to 1m we get:

$$E = \frac{1.68J/s}{4\pi(1m)^2}$$

$$E = \frac{0.13J/s}{m^2}$$

Part 4

We start by calculating the flux of the bulb:

$$\Phi = P * \eta = 200W * 20$$

I assume the task is to calculate the irradiance at the closest point on the table. I can then use the inverse square law again:

$$E = \frac{W}{4\pi r^2}$$

$$E = \frac{40W}{4\pi(2m)^2}$$
$$E = \frac{40W}{4\pi 4m^2}$$

The irradiance is therefore:

$$E = 0.80\frac{W}{m^2}$$

To calculate the illuminance we use the relationship between radiometric and photometric quantities:

$$Photometric = radiometric * 685 * V(\lambda)$$

At 650 nm the luminous efficiency curve has the value 0.1. The illuminance at the table is therefore equal to:

$$Lux = E * 685 * V(\lambda)$$
$$Lux = 0.80\frac{W}{m^2} * 685 * 0.1L/W$$
$$Lux = 54.8L/m2$$

Part 5

We have the values:

$$I_{known} = 40\frac{lm}{sr}$$
$$r_{known} = 0.35m$$
$$r_{unknown} = 0.65m$$

If we asumme that the light sources are isotropic and spherical we can use the inverse square law:

$$E = \frac{I}{r^2}$$

So we have that:

$$E_{known} = \frac{I_{known}}{r^2_{known}}$$
$$E_{unknown} = \frac{I_{unknown}}{r^2_{unknown}}$$

since we know that:

$$E_{unknown} = E_{known}$$

We can derive the unkonwn irradiance:

$$\frac{I_{unknown}}{r^2_{unknown}} = \frac{I_{known}}{r^2_{known}}$$
$$I_{unknown} = I_{known}\frac{r^2_{unknown}}{r^2_{known}}$$
$$I_{unknown} = 40\frac{lm}{sr}\frac{0.65m^2}{0.35m^2}$$
$$I_{unknown} = 138\frac{lm}{sr}$$

Part 6

The relationship between flux and radiance and radiosity and radiance for a diffuse emitter is:

$$\Phi = LA\pi$$

$$B = L\pi$$

The flux is therefore equal to:

$$\Phi = 5000\frac{W}{m^2sr} * (0.1m)^2 * \pi = 157W$$

and the radiosity:

$$B = 5000\frac{W}{m^2sr}\pi = 1.570 * 10^4\frac{W}{m^2}$$

Part 7

The relationship between radiance and radiosity is equal to:

$$B = \int_\Omega Lcos\theta d\omega$$

We have that the projected solid angle is equal to:

$$\int_\Omega \cos\theta d\omega = \int_0^{2\pi}\int_0^{\pi} cos\theta sin\theta d\theta d\phi = \pi$$

The radiosity is therefore:

$$B = L\pi = 6000\pi\frac{W}{m^2}$$

To calculate the flux we use the relationship:

$$\Phi = B * A$$

$$\Phi = 6000\pi\frac{W}{m^2}(0.1m)^2 = 60\pi W$$