02562 Rendering - Introduction DTU Compute

Worksheet 5

The purpose of this exercise is to get acquainted with radiometric and photometric concepts.

Learning Objectives

- Use radiometric concepts to describe how light energy is emitted and received.
- Explain the different radiometric quantities.
- Use solid angles in radiometric calculations.
- Convert between radiometric and photometric units.

Part 1

A small 25 W 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.

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
- Radiant intensity
- Radiant exitance
- Emitted energy in 5 minutes

Use W for Watt, J for Joule, m for meter, s for second and sr for steradian.

Part 3

The light bulb from above is observed by an eye, which has an opening of the pupil of 6 mm and a distance of 1 m from the light bulb. Find the irradiance received in the eye.

Part 4

A 200 W spherically shaped light bulb (20% efficiency) emits red light of wavelength 650 nm equally in all directions. The light bulb is placed 2 m above a table. Calculate the irradiance at the table.

Photometric quantities can be calculated from radiometric ones based on the equation

$$\text{Photometric} = \text{Radiometric} \cdot 685 \cdot V(\lambda)$$

in which $V(\lambda)$ is the luminous efficiency curve.
At 650 nm, the luminous efficiency curve has a value of 0.1. Calculate the illuminance.

Part 5

In a simple arrangement the luminous intensity of an unknown light source is determined from a known light source. The light sources are placed 1 m from each other and illuminate a double sided screen placed between the light sources. The screen is moved until both sides are equally illuminated as observed by a photometer. At the position of match, the screen is 35 cm from the known source with luminous intensity $I_s = 40\ \text{lm/sr} = 40$ cd and 65 cm from the unknown light source. What is the luminous intensity I_x of the unknown source?

Part 6

The radiance L from a diffuse light source (emitter) of 10×10 cm is 5000 W/(sr m^2). Calculate the radiosity (radiant exitance). How much energy is emitted from the light source?

Part 7

The radiance $L = 6000 \cos\theta$ W/(m^2 sr) for a non-diffuse emitter of area 10 by 10 cm. Find the radiant exitance. Also, find the power of the entire light source.

Part 8 (optional)

The Earth and Mars receive energy from the Sun. Is the radiance from the Sun identical on the two planets? Explain your answer. Why is it warmest on the Earth? Reconsider your answers after the next calculations.

Assume the Sun is a diffuse emitter of total power $3.91 \cdot 10^{26}$ W and the surface area is $6.07 \cdot 10^{18}$ m^2. Calculate the radiance from the Sun on the two planets. Assume the Sun is in zenith and the distance from the Sun to the Earth and Mars is $1.5 \cdot 10^{11}$ m and $2.28 \cdot 10^{11}$ m, respectively.
Find the solid angle the Sun is observed under at the Earth and Mars.

How much energy is received on a 1×1 m^2 surface on the Earth and Mars, respectively?

Part 9 (optional)

A horizontal plate is illuminated on a cloudy day. The sky has a uniform radiance of 1000 W/(m^2 sr). Calculate the irradiance at the center of the plate.
Find the result if the sky is blocked so only a conical section (half angle 30°) of the sky can be seen from the center of the plate.

Worksheet 5 Deliverables

Solutions for Parts 1–7 and, optionally, Parts 8–9. Optional parts give extra credit. Please insert everything into your lab journal.

Reading Material

The curriculum for Worksheet 5 is (8 pages)

B Sections 14.1 and 14.6. *Photons* and *Radiometry*.

Supplementary reading material (available on DTU Learn):

- Hanrahan, P. Rendering Concepts. In *Radiosity and Realistic Image Synthesis*, Chapter 2, pp. 13–40. Academic Press, 1995.

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