Homework 11.

Radiometry and Photometry

We start a new topic which I would call ”Radiometry and Photometry”. Here we will consider the energy transferred by light. In the beginning I would like to discuss the concept of a solid angle.

Solid angle **Ω** is a two-dimensional “relative” of a regular angle. As you remember, a measure for a regular angle can be introduced as the ratio of the length of the arc swiped by the angle (we can say “the angle, subtended by an arc”) on a circle to the radius of the circle. This ratio does not depend on the circle’s radius. Similarly, we can introduce the measure of a solid angle as the ratio of the area of the sphere subtended by the solid angle (spherical cap) to the square of the sphere’s radius.

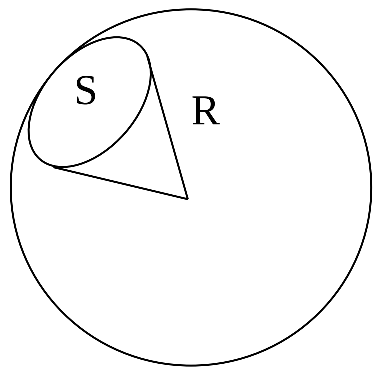

Figure 1.

$$\Omega = \frac{S}{R^2} \qquad (1)$$

The solid angle of a cone with the apex angle Θ can be calculated as:

$$\Omega = 2\pi\left(1 - \cos\left(\frac{\Theta}{2}\right)\right) \qquad (2)$$

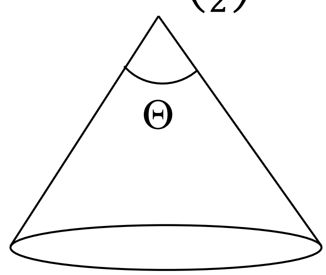

Figure 2.

Radiometry.

The science of measurement of electromagnetic radiation is called *radiometry*.

Being absorbed, the electromagnetic waves deliver energy to the absorbing object. An object which emits the light loses energy. The scope of radiometry is quantitative description of the processes of emission and absorption of electromagnetic energy. Below are given some of the most important radiometric quantities:

1. **Radiant energy** (measured in Jouls, J) – total energy, emitted by the object.

2. **Radiant flux** (J/s=Watt, W) - total energy, emitted by the object per unit time. Since energy or work per unit time is called power, we can say that radiant flux is the total optical power, emitted by the object.

3. **Radiant exitance** (W/m^2) – optical power, emitted by a unit area of an emitting object's surface.

4. **Irradiance** (W/m^2) – optical power, *incident* to a unit area of the *absorbing* object's surface.

5. **Radiant intensity** (W/sr) –optical power, emitted into a unit solid angle.

6. **Brightness** ($W/sr\ m^2$)- optical power, emitted by a unit area of an emitting object's surface into a unit solid angle.

Problems:

1. Estimate solid angle at which we see the Sun.
2. A firefly emits total 10^{-5}W of optical power in all directions. Find radiant intensity of the firefly.

3. How will the irradiance of an object change if we increase the distance from the light source to the object 2 times?

4. The diameter of the telescope objective is 60cm; the diameter of the eye pupil is about 6mm. How many times does the telescope increase apparent brightness of a star?

5. A screen is placed at a distance of 1.5m from a point light source. The irradiance of the screen in the point closest to the source is $0.5W/m^2$. We put a mirror parallel to the screen at the other side of the point source at the distance of 1.5m, so some extra light reflected from the mirror reaches the screen. How will the irradiance of the screen change? Make a picture. (*Hint: construct the image of the point source, produced by the mirror*).