Homework 1.

This semester we will study optics. Optics is the science discipline which describes propagation and properties of light. Using formal definition, we can say that the light is visible part of electromagnetic radiation – the electromagnetic field which changes periodically in space and time.

Using simple observations we can establish a number of properties of light without going deep into the "microscopic" nature of this phenomenon:

- Light transfers the energy. A considerable part of the energy we use in our everyday life came from the Sun.
- Light can propagate in vacuum, since there is vacuum in between the Earth and the Sun.
- The energy from a light source propagates along a direct line which we will call *the ray of light*. We can make this conclusion by observation of the shadows.

We have discussed two major ways to change the direction of a light ray. These are reflection and refraction.

There are surfaces (which we will call "mirrors") which are able to reflect light (see the Figure 1 below).

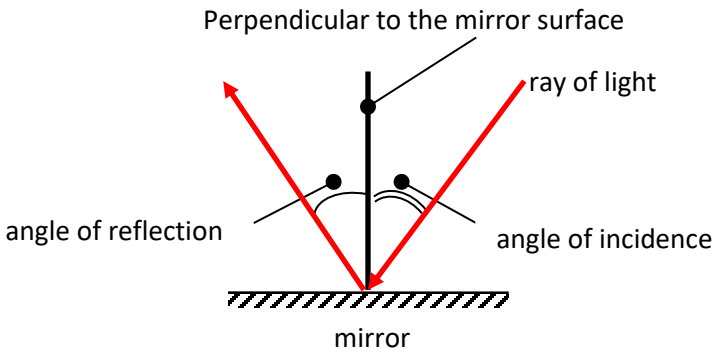


Figure 1.

As the light is reflected from the surface, the angle of incidence (or incident angle) is always equal to the reflection angle.

Similar to the reflection, the refraction can change the direction of light propagation. We learned that in any material light propagates slower than in vacuum. The number which shows how many times the speed of light in a material less than in vacuum is called *index of refraction*, or *refractive index*. For example, the index of refraction of diamond is ~2.4. It means that light propagates in diamond 2.4 times slower than in vacuum.

The direction of a light beam changes as the light enters into one media from another media, say, from air to water. This phenomenon is called *refraction*.

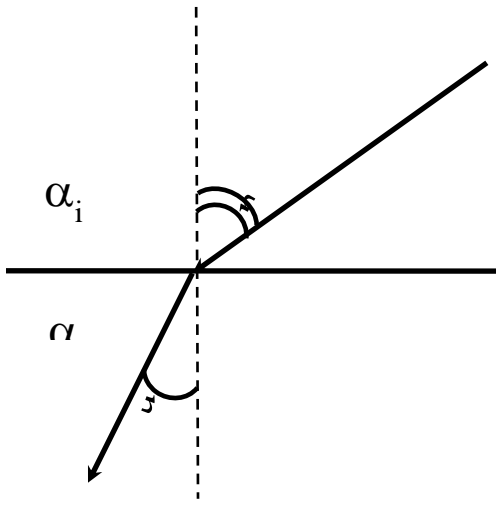


Figure 2.

Let us imagine that the light enters into the media characterized by the refractive index $\mathbf{n_r}$ from the media characterized by the refractive index $\mathbf{n_i}$ (Figure 2). The angle $\boldsymbol{\alpha_I}$ is the angle of incidence; $\boldsymbol{\alpha_r}$ is the *angle of refraction*. There is an important expression which connects these angles. It is called "Snell's law":

$$\frac{sin\alpha_i}{sin\alpha_r} = \frac{n_r}{n_i} \qquad (1)$$

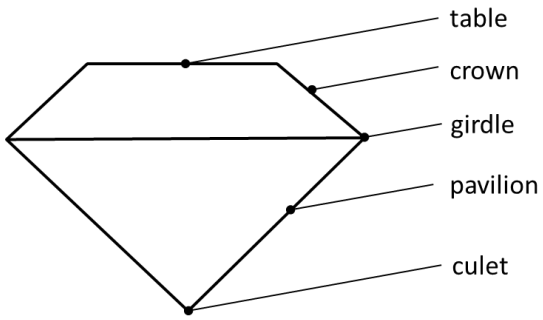
It is easy to obtain the expression for the $\sin\boldsymbol{\alpha_r}$:

$$sin\alpha_r = \frac{n_i}{n_r} sin\alpha_i$$

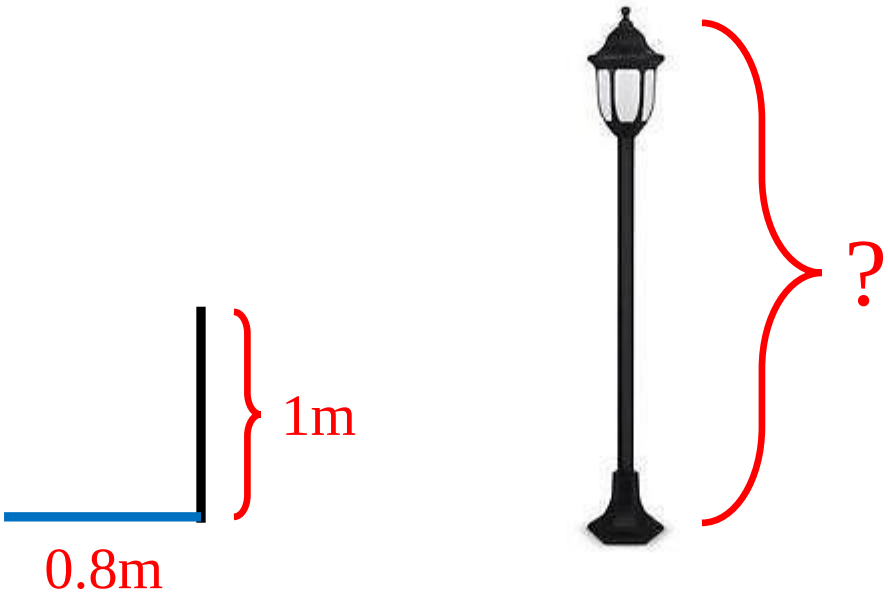
If you know the angle of incidence you can easily calculate the angle of refraction.

Problems:

1. A classical diamond cut design suggested in 1919 by Marcel Tolkowsky is shown schematically in Figure 3 below. Could you qualitatively explain why this particular shape is used?



2. A vertical stick 1m high, placed near a street lamp makes a 0.8m shadow. If we increase the distance between the stick and the street lamp (in the same plane) by 1m, the shadow of the stick will be 1.25m. Find the height of the street lamp.



3. A transparent glass plate is placed between the eye of the observer and a point source of light. Using pencil and ruler plot the position of the light source as it is seen by the observer.