SIMG-215-02-20061 **Solutions to Quiz #2** — 5 October 2006

1. If the object distance is +400 mm, locate the image created by a lens with focal length f = +200mm and find the magnification of that image.

$$\frac{1}{z_1}+\frac{1}{z_2}=\frac{1}{f}\Rightarrow\frac{1}{400mm}+\frac{1}{z_2}=\frac{1}{200mm}$$

$$\Rightarrow\frac{1}{z_2}=\frac{1}{200mm}-\frac{1}{400mm}=\frac{2}{400mm}-\frac{1}{400mm}$$

$$\Rightarrow\frac{1}{z_2}=\frac{1}{400mm}\Rightarrow z_2=400mm$$

$$M_t=-\frac{z_2}{z_1}-=\frac{400mm}{400mm}=-1$$

2. You are trying to create an image of a luminous object (e.g., the light bulb you used in the laboratory). The distance from the **object** to the **image** is fixed at 5 m = 5000 mm. Note that this is NOT the distance from the object to the lens that we usually use. You have a lens with focal length f = 1 m = 1000 mm. Find the distance z_1 from the object to the lens that produces an image at the image plane and find the magnification of the resulting image.

The problem says that the SUM of the distances is 5 m:

$$z_1+z_2=5000mm\Rightarrow z_2=5000mm-z_1$$

Plug into the equation:

$$\frac{1}{z_1}+\frac{1}{z_2}=\frac{1}{f}=\frac{1}{1000mm}$$

$$\Rightarrow\frac{1}{1000mm}=\frac{1}{z_1}+\frac{1}{5000mm-z_1}$$: This answer is sufficient

$$M_t=-\frac{z_2}{z_1}=-\frac{5000mm-z_1}{z_1}$$

but yoiu can solve it to find a solution $z_2 \cong 3618mm$

$M_t = -2.62$

3. Describe characteristics of the two "types" of image that can be generated by an optical imaging system.

real image = image formed in space where it can be shown on a piece of paper or put on a sensor

virtual image = image formed "behind" the lens where it may be seen with the eye but not displayed on a piece of paper

4. Assume that the speed of light in vacuum is c = 3 × 108 meters per second. Calculate the speed of light in a diamond, for which the index of refraction n = 2.4.

$$n = \frac{c}{v} \Rightarrow v = \frac{c}{n} = \frac{3 \times 10^8 \frac{m}{s}}{2.4} = \frac{3}{2.4} \frac{m}{s}$$
$$= \frac{5 \times 0.6}{4 \times 0.6} \times 10^8 \frac{m}{s} = \frac{5}{4} \times 10^8 \frac{m}{s} = 1.25 \times 10^8 \frac{m}{s}$$

5. We have looked at imaging with a pinhole camera and with lenses in the laboratory. Write down and defend one feature of each system that is advantageous for some imaging application. In other words, under what conditions is a pinhole camera preferred over imaging with lenses, and vice versa..

The lens "collects" more light and thus forms a "brighter" image, but only works for light with wavelengths for which the index of refraction is not one. In other words, if you can't refract the light, you can't make a lens This is the case for X rays. You can also "magnify" or "demagnify" ("minify") the image with a lens

The pinhole works for any wavelength that may be absorbed (including X rays). The pinhole camera forms images that are "dim" because little light reaches the sensor, but the images are "in focus" at any distance.