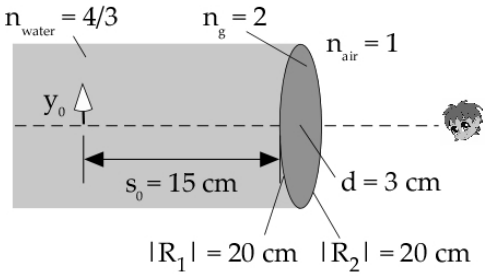
Physics 108 Midterm Exam (Spring of 2017)

1. ***Aquarium viewing lens***

An aquarium viewing lens is a *thick* bi-convex lens (center-thick) with radii of curvature $R_1 = - R_2 = + 20$ cm. It is made of glass with refractive index $n_g = 2$. The curved surfaces are separated by d = 3 cm. The viewing side of the lens is in air with $n_{air} = 1$. The other side of the lens is in water with $n_{water} = 4/3$. An object $y_0 = 1$ cm in the water is 15 cm away from the lens surface as shown below.

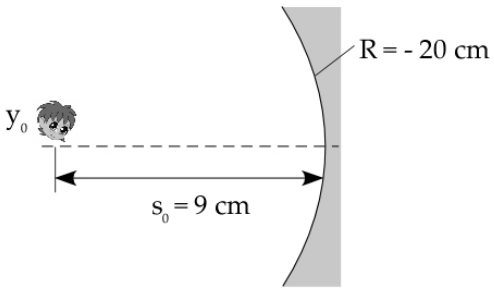
(a) (**20 points**) Find the location of the image for an observer on the air side.
(b) (**10 points**) Find the linear size and the orientation of the image.
(c) (**10 points**) If you put your eyes close to the lens to view the object in the water, what is the angular size of the image?
(d) (**Extra 10 points**) If you look into the flat water surface at the object directly without the lens, what is the angular size of the image at the nearest distance of distinct vision?



2. ***Vanity mirror and flat mirror***

A vanity mirror is a concave mirror with a radius of curvature R < 0. A flat mirror has a radius of curvature infinitely large.

(a) (**20 points**) When you look into a vanity mirror with R = - 20 cm standing at a distance 9 cm away (as shown below), where is the image of your pupil?
(b) (**10 points**) When you look into a flat mirror, what is the closest distance to the mirror less than which you can no longer see yourself clearly?
(c) (**10 points**) Assume that your pupil is 4 mm in diameter. What is its angular size when you look into the flat mirror at it from 13 cm away from the mirror?
(d) (**Extra 10 points**) Find the angular size of the image of your pupil when viewing from where you stand in Part (a) (i.e., 9 cm away from the mirror).



3. **Wedge-shaped air gap**

(**10 pints**) A pair of glass slides are pressed together and illuminated with an orange-colored light at λ = 0.6 μm. When the reflected light from the air gap between the slides is viewed at an angle of $\theta = 60^{o}$ in the air, one sees 50 fringes over a distance of 1 cm along the slides. Find the wedge angle formed by the slides.

4. ***Michelson interferometer***

In the following Michelson interferometer that consists of a 50%-50% beam splitter and a pair of mirrors, M_1 and M_2. The arm length for M_1 is fixed at x_1 = 20 cm. M_2 is moving at a constant speed v = 1 cm/sec so that the arm length for M_2 is x_2 = 20 cm + v t. The refractive index of the air can be taken to unity. The interferometer is illuminated with a monochromatic beam I_{inc} at wavelength λ = 0.5 μm

(a) (**10 points**) Show that the intensity at the detector $I_d(t)$ is a sinusoidal function of time t as a result of the movement of M_2.

(b) (**Extra 5 points**) Find the time period for $I_d(t)$ due to the movement of M_2.