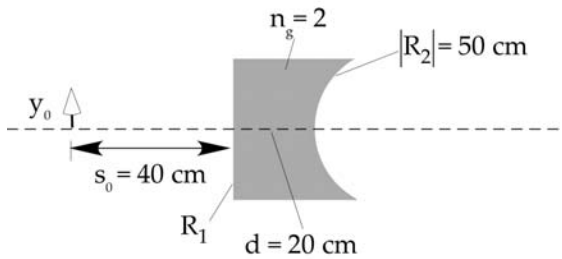
Physics 108 Midterm Exam (Spring of 2015)

1. <u>*Plano-concave lens*</u>

   A *thick* plano-concave lens in air is used to image an object placed at a distance s_0 = 40 cm in front of the lens. $R_1 = +\infty$.



(1) (20 points) Using the refraction equation $n_1/s_o + n_2/s_i = (n_2 - n_1)/R$ and treating the lens as two spherical refractive surfaces separated by 20 cm, find the location and the linear magnification of the image after the second surface;

(2) (20 points) Find the ABCD matrix for this lens;

(3) (10 points) Using the ABCD matrix, find the image location after the second surface;

(4) (**extra 5 points**) If the separation between the two surfaces *d* is made much smaller than 50 cm so that we have a thin plano-concave lens, what is the focal length of this thin lens?

2. <u>*Curved mirror*</u>

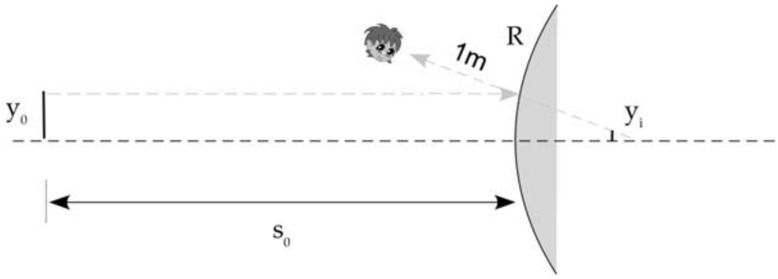
   By intuition, we judge the distance of a known object from us by the angular size of the object. For example, when we directly look along a straight highway, the distance of a familiar car from us is inversely proportional to the angular size (thus the size of the image formed on the retina) of the car.

(1) (10 points) You are 1 m from a FLAT mirror and see the reflection of a 2-m tall van (y_0 = 2 m) at a distance s_0 = 40 m from the mirror. Find the image size y_i of the van and its angular size α from your vantage point.

(2) (15 points) If the mirror is CURVED with R = + 80 m, you are 1 m in front of the mirror and look at the reflection of the same van. Find the linear size and its angular size α of the van as you see it now.

(3) (**extra 5 points**) From the curved rear mirror, how far away does the van appear to you?

(Now you know why there is a warning sign printed on the front face of the right-side mirror on a car).



3. *Interference*

(1) (10 points) In a Young's double-slit interference set-up, if the separation between the two slits is reduced by a factor of 10 from *d* to *d/10* while everything else the same is kept the same (i.e., normal-incidence illumination, the slit size, and the screen position), what happens to the maximum intensity I_{max}, the minimum intensity I_{min}, and the fringe spacing near the center of the screen?

(2) (15 points) During the class, you were given a pair of glass slides that were pressed together for observing interference fringes due to reflections at the air gap between the slides. The slides are 25 mm wide. If you see 10 bright fringes across the width of the slides at an angle 60° from the surface normal, how much does the air gap change across the slide assuming that the wavelength of the visible light is 0.5 μm?

(3) (**extra 5 points**) A beam of white light with wavelengths λ_0 ranging from 0.35 μm to 0.75 μm is normally incident on a soap bubble of thickness d = 0.5 μm and refractive index n = 4/3. In the reflected light, which wavelengths have the minimum intensity?

(This is the foundation of a successful start-up company based in San Francisco that was later bought out by a large British company).