Physics 108 Midterm Exam (Spring of 2014)

1. *Thin lens*

A *thin* meniscus lens is made of glass with refractive index $n_g = 1.50$. The front surface has a radius of curvature $r_1 = +5$ cm and the back surface has a radius of curvature $r_2 = +10$ cm. The separation between the two surfaces can be neglected. The lens is used in air ($n_{air} = 1.00$) to image an object placed at a distance $s_0 = 30$ cm in front of the lens.

(1) (**15 points**) *Using the refraction equation* $n/s_o + n'/s_i = (n' - n)/r$ and treating the lens as two spherical refraction surfaces separated by zero distance, find the location and the linear magnification of the image after the second surface;

(2) (**10 points**) Find the focal length of this lens in air and use this information to determine the location of the image after refraction at the second surface.

2. *Lens combination and thick lens*

Two thin lenses, one with $f^{(1)} = +30$ cm and the other with $f^{(2)} = +60$ cm placed in air, are initially pressed together so that the distance between them can be neglected.

(1) (**10 points**) Find the focal length of this lens combination.

(2) (**15 points**) Now separate the two lenses in air by a distance of d = 40 cm and find the ABCD matrix for this new lens combination;

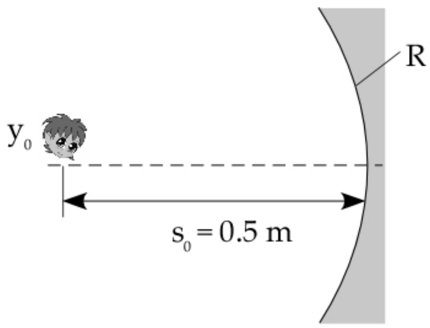
(3) (**5 points**) Using the ABCD matrix, find the image location of an object placed at $s_0 = 30$ cm in front of the first lens.

3. *Spherical mirror*

A spherical mirror with a radius of curvature R is used to form an image of a *real* object of height y_0 placed at s_0.

(1) (**10 points**) Find linear magnification $m = y_i/y_0$ in terms of R and s_0.

(2) (**10 points**) If you stand in front of such a mirror at $s_0 = 0.5$ m away, find the value and sign of R such that you will look twice as large as your real size y_0 in front of it.



4. *Interference*

Young's interference fringes are produced by illuminating a pair of identical, parallel silts that are oriented along the x-axis and separated by a distance of d along y-axis. A screen, parallel to x-y plane, is placed at a distance z away from the double slits. Let the illuminating light beam with λ_0 normally incident on the slits (from left side) so that amplitudes and initial phases of the electric fields at the slits are the same.

(1) (**10 points**) Write the total intensity $I_{total}(y,z)$ on the screen in terms of the intensity $I_{single\ beam}$ when one of the slits is blocked and other given parameters when $z >> d$;

(2) (**5 points**) If an extra phase $\delta\phi_2$ is added to the second slit ($slit_2$), what is the total intensity $I_{total}(y,z)$ now?

(3) (**5 points**) When $\delta\phi_2$ increases from zero, *explain* how the fringes will move (up or down and how much in terms of $\delta\phi_2$).

(This is how one can use to move fringes or detect $\delta\phi_2$).