PHY431, Homework 2 DUE: Jan 26, 2017

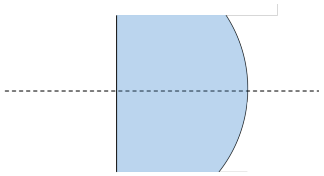
Spherical interfaces, GRIND lenses (Fermat, Huygens), ray tracing

1. (2 pts) A small goldfish is viewed through a spherical glass fishbowl 10 cm in diameter. For water, n=4/3. The glass is thin so the effect of refraction through the glass can be neglected. Determine the apparent position and magnification of the fish when its actual position is:

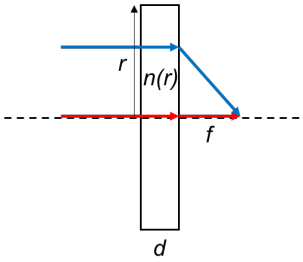
   (a) at the center of the bowl and

   (b) nearer to the viewer, halfway from center to glass along the line of sight.

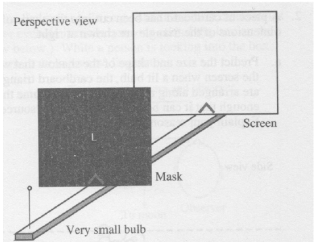
2. (2 pts) See the image below: A glass optic consists of a flat surface (on the left) and a curved surface (on the right). The distance between the surfaces is 10 mm (at the center, dashed line). The radius of curvature is 100 mm. An object in air sits 10 mm to the left of the optic. What is the location of the final image created by this optic? Hint: this is NOT a thin lens.



3. (3 pts) GRIND lens: The index of refraction of glass can be increased by diffusing in impurities. It is then possible to make a lens of constant thickness by varying the index of refraction of the glass vs the distance r from the center. Given a disk of radius a and thickness d, find the radial variation of the index of refraction $n(r)$ which will produce a converging lens with focal length f. You may assume ($d \ll a$). Hints: Thinking about the Huygens picture will reveal why the light bends even though it strikes a flat surface head on. Fermat's theorum still applies. You may need to do a Taylor expansion of your expression to make the approximation.

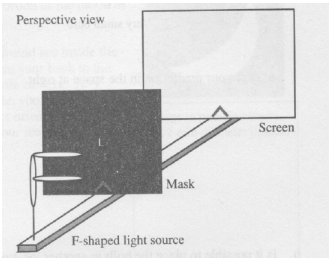


4. (3 pts) A mask containing a hole in the shape of the letter L is placed between a screen and a very small bulb as shown in Fig. 1



   (a) Sketch what what you would see on the screen when the bulb is turned on.

   The small bulb is replaced by three long filament light bulbs that are arranged in the shape of the letter F as shown in Fig. 2



(b) Sketch what what you would see on the screen when the bulbs are turned on. The scale of your sketch should be consistent with your answer to part (a). *Explain how you determined your answer*. Hint: if the hole in the screen was just a simple hole (not having a shape), what would the 'F' look like on the screen? And if you start to give it a shape…?