PHYS 2C

Discussion Section – 3/11

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- This will be the last discussion for the course
- Due to preventive measures for Coronavirus, this material is being circulated via email
- Attempt all problems by yourself, before looking at solution
- Please Email the TA to setup 1-on-1 remote office hours if necessary.

3 problems, covering:

- Lens Equation
- Lens-makers Equation
- Eye – corrective lenses

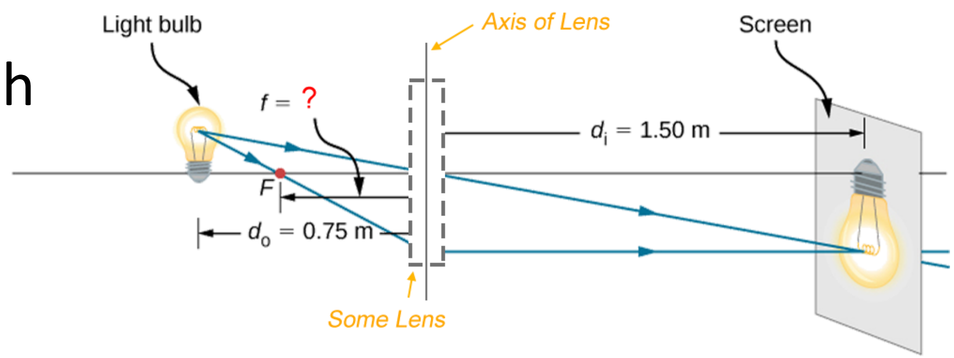
Note:

These problems are you to practice and may not be representative of the types or difficulty of problems that may be asked on the final exam.

Discussion Problem 1

Choosing Type of Lens and focal distance

To project an image of a light bulb on a screen 1.50 m away,
1) You need to choose what type of lens to use (converging or diverging) and its focal length (*see figure*). The distance between the lens and the light bulb is fixed at 0.75 m.



2) What is the magnification and orientation of the image?

Problem modified from LibreTexts.org

Discussion Problem 2

Designing your lens
(Are you perhaps *a lens maker?*)

You are tasked with designing a lens that looks like one in the figure shown. The lens must operate in air and must be made of glass with refractive index 1.55. The lens is expected to have a focal distance of 200mm.

1. Is the lens diverging or converging? What type of lens is this? (*give specific name*)
2. Assuming that the lens is symmetrically ground on both sides, what is the radius of curvature of the lens?

Discussion Problem 3

Correcting Farsightedness

a) What optical power (in D) of eyeglass lens is needed to allow a farsighted person, whose near point is 1.00 m, to see an object clearly that is 25.0 cm from the eye?

b) Is the lens converging or diverging?

Assume the corrective lens is fixed 1.5 cm from the eye.

SOLUTIONS FOLLOW

Please make sure to attempt the problems before looking at solutions.

Unlike previous discussion session slides, these contain the full discussion needed to solve the problems

Discussion Problem 1 - Solution

Discussion:

- When projecting an image, the resulting image must be *Real*
- We note that the image is formed on the other side of the lens

We can conclude we need a *converging* lens

The focal length can be found by using the thin-lens equation and solving for the focal length.

- The object distance is $d_o = 0.75m$ and the image distance is $d_i = 1.5m$.
- $\frac{1}{d_o} + \frac{1}{d_f} = \frac{1}{f} \Rightarrow f = \left(\frac{1}{d_o} + \frac{1}{d_i}\right)^{-1} = \left(\frac{1}{0.75} + \frac{1}{1.5}\right)^{-1} \Rightarrow f = 0.5m$

- The Magnification is: $m = -\frac{d_i}{d_o} = -\frac{1.5}{0.75} = -2.0$

Note:

- The minus sign for the magnification means that the image is inverted
- The focal length is positive, as expected for a converging lens.

Discussion Problem 2 - Solution

- Observing the lens, we see that it is narrow in the middle and wider at the top => it is a Diverging Lens
- We see that the glass lens has a *concave* shape from either side => It is specifically a Bi-Concave lens
- To calculate the focal distance of the lens, we will use the *lensmakers equation:* $\frac{1}{f} = (\frac{n_2}{n_1} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$
- We note that $R_1 < 0$ and $R_2 > 0$. Since the lens is symmetric, $|R_1| = |R_2|$ = R
- Using this fact, our lens makers equation becomes: $\frac{1}{f} = (\frac{n_2}{n_1} - 1)(\frac{-2}{R})$, where R is the required radius of curvature.
- Making R the subject of the equation and substituting $n_1 = 1.00$and $n_2 = 1.55$, we get:

$$R = -2f\left(\frac{n_2}{n_1} - 1\right) = -2(-20\text{cm})\left(\frac{1.55}{1.00} - 1\right) \Rightarrow R = 22\text{cm}$$

- Note we have used a negative value for $f$since this a diverging lens and the image formed is virtual

Discussion Problem 3 - Solution

- When an object is 25.0 cm from the person's eyes, the eyeglass lens must produce an image 1.00 m away (the near point), so that the person can see it clearly.
- An image 1.00 m from the eye will be $100cm - 1.5cm = 98.5cm$ from the eyeglass lens because the eyeglass lens is 1.5 cm from the eye.
- This suggests $d_i = -98.5cm$, where the minus indicates that the images is formed as the same side as the object
- Calculating the object distance: $d_o = 25.0cm - 1.5cm = 23.5cm$
- Now that we have the d_i and d_o, we can calculate the optical power of the lens that is required:

$$P = \frac{1}{f_{eff}} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{23.5cm} + \frac{1}{-98.5cm} = +3.24D$$

Note:

- The positive optical power indicates a converging (convex) lens, as expected
- While calculating the P in the last step, make sure to convert the distances to SI units before using it in the formula, to get the answer in Diopters