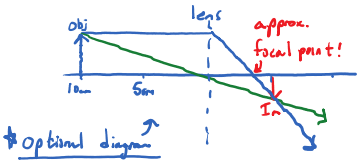
Week 4 Quiz

Monday, April 19, 2021 2:21 PM

In their annual riddle contest, Bernice asks Benny a question: when an object is placed 10 cm from a thin lens, an image is created 5 cm from the lens, how can this be?

(a) Find one lens which will satisfy Bernice's riddle. Give the lens type (converging or diverging) and the lens focal length. Show, using relevant physics, that the lens will indeed create an image 5 cm from the lens.



$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{f} = \frac{1}{10\,cm} + \frac{1}{5\,cm} = \frac{3}{10\,cm}$

$\Rightarrow f = \frac{10}{3}\,cm = 3.33\,cm$

matches!

focal length is + $\Rightarrow$ converging lens

I drew green ray first, then horizontal blue ray. Since image is at 5cm, blue ray must intersect green at red image. I will use this for sense making.

(b) For the above system, would the lens create a clear image on a screen held at the image location? Explain.

yes, image is a real image ($d_i > 0$, rays converge / no tracing rays back)

(c) For the above system, what is the magnification of the image?

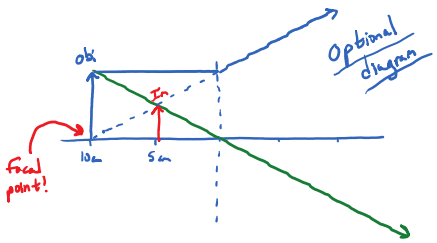
$d_i = +5\,cm$

$d_o = +10\,cm$

$\Rightarrow m = -\frac{5\,cm}{10\,cm} = -\frac{1}{2}$

(d) Find all other lenses which will also satisfy Bernice's riddle. For each of these lenses, list the lens type, lens focal length, whether or not it will create a clear image on a screen held at the image location, and the magnification of the image. Make sure to show your work and explain your answers. Use the table to keep track of your answer(s). There may be more rows than necessary.

Lens type	Focal length	Clear image on screen?	Image magnification
diverging	-10 cm	No	$+\frac{1}{2}$



$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{f} = \frac{1}{+10cm} + \frac{1}{-5cm} = -\frac{1}{10\,cm} \Rightarrow f = -10\,cm$

$m = -\frac{d_i}{d_o} = -\frac{-5\,cm}{+10\,cm} = +\frac{1}{2}$

- focal length is $< 0 \Rightarrow$ diverging lens
- trace rays back / $d_i < 0 \Rightarrow$ virtual image $\Rightarrow$ No image on a screen

Rubric

Part (a)
1 pt - Thin lens equation
2 pts - Analysis with math or ray model to solve the riddle (either answer is accepted)
1 pt - Correct lens type & focal length

Part (b)
1 pt - Correct answer
1 pt - Correct explanation

Part (c)
0.5 pts - Magnification equation
0.5 pts - Correct answer

Part (d)
2 pts - Analysis to find alternate solution to the riddle
1 pt - Correct answer