Physics 10164 - Spring 2019 Exam 3B

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (25 pts) A 3.5 cm^2 detector is placed 4.0 meters away from a 75 Watt light bulb that shines uniformly in all directions.

(a) What is the rms value of the electric field of the light that is incident on the detector?
(b) How much time does it take for the detector to collect 5.0 Joules of energy?

$$S = \frac{75\ W}{4\pi(4)^2} = 0.373\ W/m^2$$

a) $0.373 = c * u_{tot}$

$$\Rightarrow u_{tot} = 1.24 \times 10^{-9}\ J/m^3 = \epsilon_0 E_{rms}^2$$

$$\Rightarrow \boxed{E_{rms} = 12\ N/C}$$

b) $P = (0.373\ \frac{W}{m^2})(3.5 \times 10^{-4}\ m^2)$

$$= 1.3 \times 10^{-4}\ W$$

$$t = \text{Energy}/\text{Power} = 5.0/1.3 \times 10^{-4} = \boxed{38{,}000\ s}$$

2. (25 pts) A mirror has a focal length of +35 cm.

a) At what <u>object distance</u> does the resulting image have a magnification of +1.8?

b) If we move the object to a new location, the resulting image has a magnification of -0.35. What is the new <u>image distance</u>?

a) $+1.8 = -\frac{q}{p} \Rightarrow q = -1.8p$

$\frac{1}{p} - \frac{1}{1.8p} = \frac{1}{35}$

$\frac{1.8}{1.8p} - \frac{1}{1.8p} = \frac{1}{35}$

$\frac{0.8}{1.8p} = \frac{1}{35}$

$28 = 1.8p$

$\Rightarrow \boxed{p = 16 \text{ cm}}$

b) $-0.35 = -\frac{q}{p} \Rightarrow q = 0.35p$

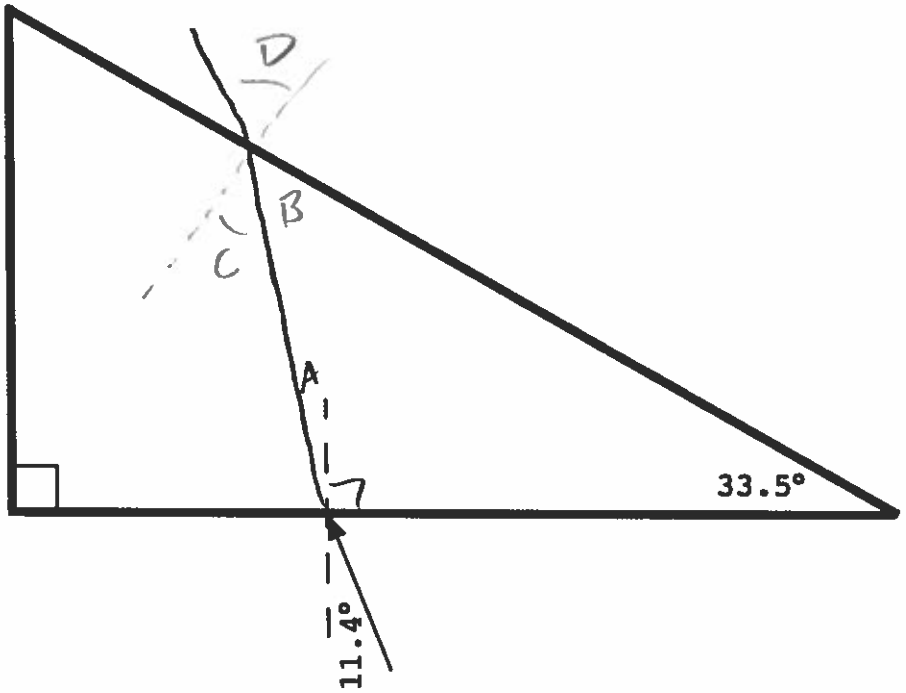
or $p = \frac{q}{0.35}$

$\frac{1}{p} + \frac{1}{q} = \frac{1}{35}$

$\frac{0.35}{q} + \frac{1}{q} = \frac{1}{35}$

$\frac{1.35}{q} = \frac{1}{35} \Rightarrow \boxed{q = 47 \text{ cm}}$

3. (25 pts) The prism below has an index of refraction of 1.44 and is surrounded by air. Light is incident on the bottom face of the prism as shown. Through what face of the prism does the light exit, and what is the final angle of refraction?



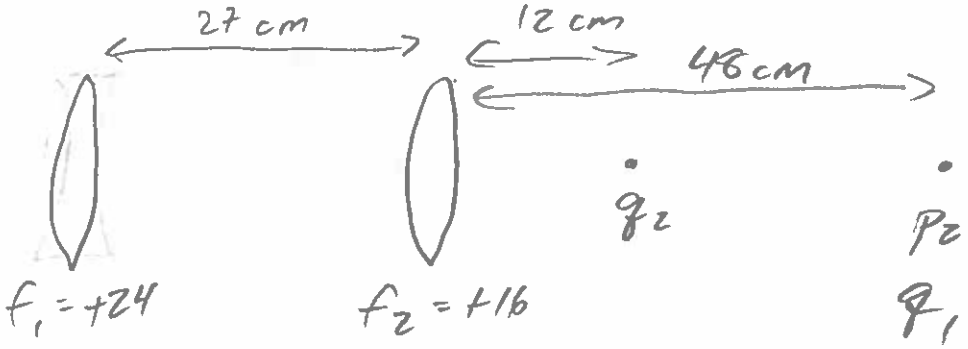
$1.0 \sin 11.4 = 1.44 \sin A \Rightarrow A = 7.9°$

$A + 90° + 33.5° + B = 180° \Rightarrow B = 48.6°$

$B + C = 90° \Rightarrow C = 41.4°$

$1.44 \sin C = 1.0 \sin D \Rightarrow \boxed{D = 72.2°}$

4. (25 pts) Two lenses are separated by 27 cm. The lens in front has a focal length of +24 cm. The lens behind has a focal length of +16 cm. If the final image of this two lens system is located 12 cm behind the 2nd lens, (a) where is the object with respect to the 1st lens and (b) what is the total magnification of the system?



$$\frac{1}{p_2} = \frac{1}{f_2} - \frac{1}{q_2} = \frac{1}{16} - \frac{1}{12}$$

$$\Rightarrow p_2 = -48\text{ cm}$$

$$\Rightarrow q_1 = 48 + 27 = 75\text{ cm}, +$$

$$\frac{1}{p_1} = \frac{1}{f_1} - \frac{1}{q_1} = \frac{1}{+24} - \frac{1}{75}$$

$$p_1 = +35.3\text{ cm}$$

so p_1 is 35 cm in front of lens 1

b) $M_{TOT} = \left(-\frac{q_1}{p_1}\right) * \left(-\frac{q_2}{p_2}\right)$

$$= \left(-\frac{75}{35.3}\right) * \left(-\frac{12}{-48}\right) = -0.53$$