Physics 10164 - Exam 3A

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. (20 pts) A 120-Watt light bulb emits light uniformly in all directions. At a distance of 5.4 meters from the bulb, determine (a) the intensity of the light, (b) the rms value of the electric field and (c) how much energy is absorbed by a detector of area 1.0 cm^2 in 15 minutes.

a) $I = \frac{120}{4\pi r^2} = \boxed{0.33\ W/m^2}$

b) $U_{tot} = I/c = 1.1 \times 10^{-9}\ J/m^3 = \epsilon_0 E_{rms}^2$

$E_{rms}^2 = \frac{1.1 \times 10^{-9}}{8.85 \times 10^{-12}} \Rightarrow \boxed{E_{rms} = 11\ N/C}$

c) $Power = I \cdot Area = (.33)(1.0 \times 10^{-4}\ m^2)$

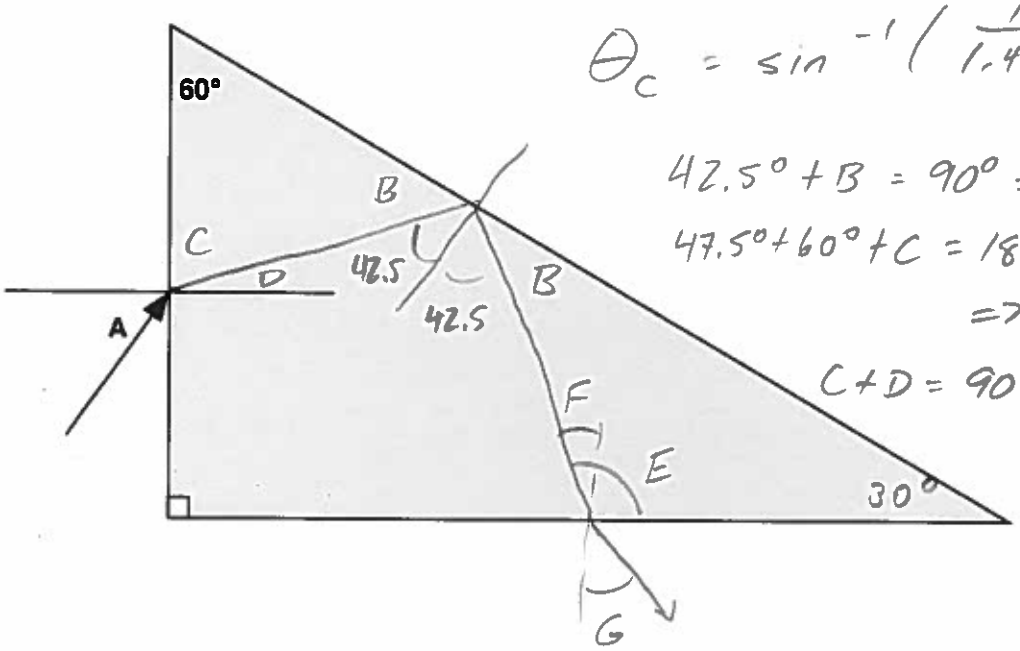
$= 3.3 \times 10^{-5}\ W$

$E = P \cdot t = (3.3 \times 10^{-5})(15\ min)\left(\frac{60\ sec}{min}\right)$

$= \boxed{0.029\ J}$

2. (25 pts) Light is incident on the 30-60-90 prism below at an angle A as shown. The prism has an index of refraction of 1.48 and is surrounded by air. Light reflects off the hypotenuse of the prism at the critical angle and exits out of the bottom surface.

Find the initial angle of incidence A and the final angle of refraction upon exiting the prism. Show all work and clearly label all calculated angles. Angle A is not necessarily drawn to scale (it could be anywhere from 1 to 89 degrees).



$\theta_c = \sin^{-1}\left(\frac{1}{1.48}\right) = 42.5°$

$42.5° + B = 90° \Rightarrow B = 47.5°$

$47.5° + 60° + C = 180°$

$\Rightarrow C = 72.5°$

$C + D = 90° \Rightarrow D = 17.5°$

$1.0 \sin A = 1.48 \sin 17.5° \Rightarrow \boxed{A = 26.4°}$

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b) $B + 30 + E = 180° \Rightarrow E = 102.5$

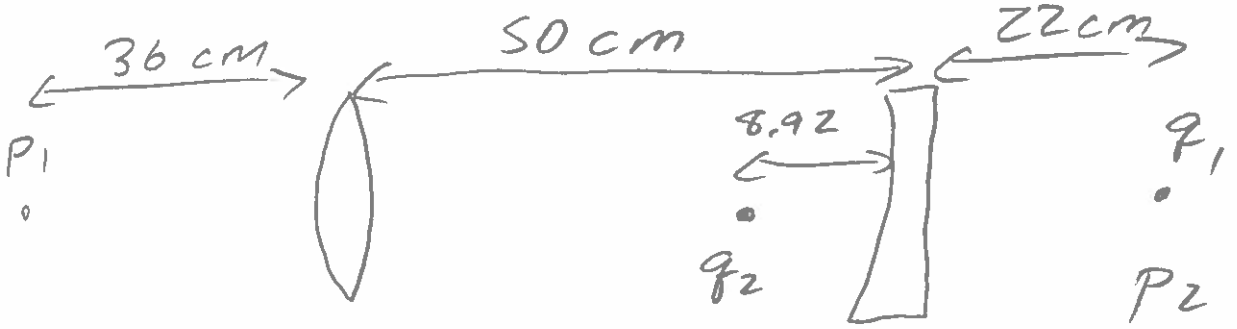
$E - 90 = F \Rightarrow F = 12.5°$

$1.48 \sin 12.5° = 1.0 \sin G$

$\boxed{G = 18.7°}$

#3. (25 pts) A converging lens with focal length +24.0 cm is located 50.0 cm in front of a concave mirror. An object located 36.0 cm in front of the converging lens causes the mirror to create a final image 8.92 cm in front of the mirror.

a) What is the focal length of the mirror?
b) What is the total magnification of the system?



a) $f_1 = +24.0\,cm$ $\quad f_2 = ?$

$$\frac{1}{36} + \frac{1}{q_1} = \frac{1}{24} \Rightarrow q_1 = 72\,cm$$

$$\frac{1}{-22} + \frac{1}{8.92} = \frac{1}{f_2} \Rightarrow \boxed{f_2 = 15.0\,cm}$$

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

$$= \left(-\frac{72}{36}\right) * \left(-\frac{8.92}{-22}\right) = \boxed{-0.811}$$

0.045

#4. (30 pts) Light of wavelength 550 nm is incident on two slits separated by [redacted] mm. The interference pattern from these slits shines on a 75.0 cm wide screen located 3.4 meters away from the slits. How many *complete* maxima can fit on the screen (don't forget to include the central maximum)?

$d \sin\theta = CI, DI$

If center of pattern is in center of screen, find out what is happening at edge, $y = 37.5$ cm.

$$\frac{dy}{L} = m\lambda \qquad m = \frac{dy}{L\lambda} = \frac{(.045 \times 10^{-3})(.375)}{(3.4)(550 \times 10^{-9})}$$

$$= 9.02$$

Since 9th max is at edge, only 8 complete maxima are present on either side of the central max, so $2 * 8 + 1$ (center) = **17**