Physics 10164 - Spring 2019 Exam 3D

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) The intensity of moonlight during a full moon is approximately 0.024 Watts/m^2 when the moon is high in the sky.

a) What is the rms value of the magnetic field associated with this light?

b) How much energy in the form of moonlight is contained within the volume of an open football stadium of 350,000 m^3 volume?

c) If the playing field has an area of 5100 m^2, how much time would it take to collect enough energy from moonlight to boil a pot of water? Assume 820,000 Joules of energy is needed.

a) $0.024 = c * u_{tot} \Rightarrow u_{tot} = 8.0 \times 10^{-11}\ J/m^3$

$$8.0 \times 10^{-11} = \frac{B_{rms}^2}{\mu_0} \Rightarrow \boxed{B_{rms} = 1.0 \times 10^{-8}\ T}$$

b) $E = u_{tot} * Volume = \left(8.0 \times 10^{-11}\ \frac{J}{m^3}\right)(350{,}000\ m^3)$

$$= \boxed{2.8 \times 10^{-5}\ J}$$

c) $Power = \left(0.024\ \frac{W}{m^2}\right)(5100\ m^2) = 12.24\ W$

$$time = \frac{Energy}{Power} = \frac{820{,}000}{12.24} = \boxed{6700\ s}$$

2. (25 pts) Two-part question for a single mirror:

a) For a mirror with a focal length of -15 cm, what **object** distance results in an image with a magnification of +0.44?

b) For a mirror with a focal length of +15 cm, what is the **image** distance for which the image has a resulting magnification of +0.44?

a) $0.44 = -\frac{q}{p} \Rightarrow q = -0.44p$

$\frac{1}{p} - \frac{1}{0.44p} = \frac{1}{-15}$

$\frac{0.44}{0.44p} - \frac{1}{0.44p} = \frac{1}{-15}$

$-\frac{0.56}{0.44p} = -\frac{1}{15}$

$8.4 = 0.44p$

$\boxed{p = 19\,cm}$

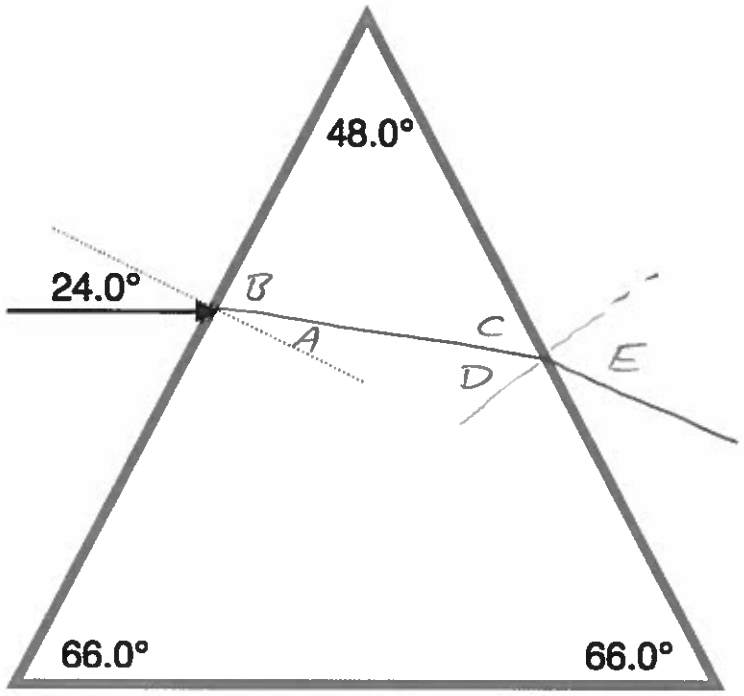
b) $-\frac{0.56}{0.44p} = +\frac{1}{15}$

$-8.4 = 0.44p$

$p = -19\,cm$

$q = -0.44p = \boxed{8.4\,cm}$

3. (25 pts) The prism below has an index of refraction of 1.48 for blue light and 1.43 for red light, and the prism is surrounded by air. Light is incident on the left face of the prism as shown. What is the angular separation (2 SF) between the red and blue light that emerges from the right side of the prism?



Blue

$1.0 \sin 24° = 1.48 \sin A$

$\Rightarrow A = 15.95°$

$A + B = 90 \Rightarrow B = 74.05°$

$B + 48 + C = 180 \Rightarrow C = 57.95°$

$C + D = 90 \Rightarrow D = 32.05°$

$1.48 \sin 32.05° = 1.0 \sin E$

$E = 51.75°$

Red

$1.0 \sin 24° = 1.43 \sin A$

$A = 16.52°$

$B = 73.48°$

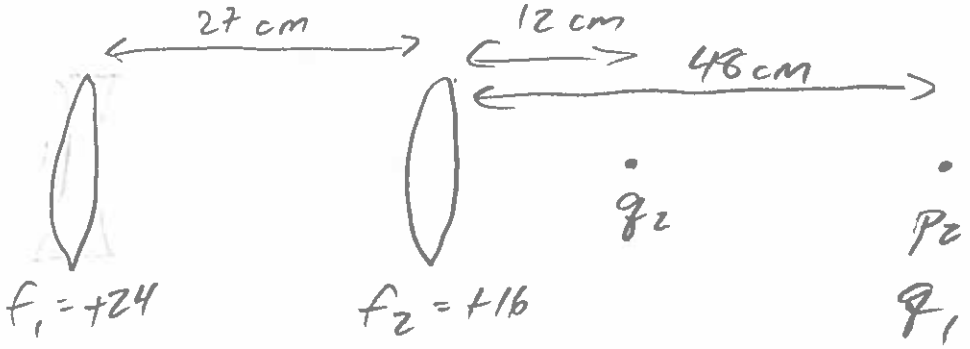
$C = 58.52°$

$D = 31.48°$

$E = 48.30$

$\boxed{\Delta\theta = 3.4°}$

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?



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

$$\Rightarrow p_2 = -48\,cm$$

$$\Rightarrow q_1 = 48 + 27 = 75\,cm, +$$

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

$$p_1 = +35.3\,cm$$

so p_1 is 35 cm in front of lens 1

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

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