PHYS-205B (Final Exam) 2022 Fall

Solutions

Problem 1

$$\vec{E} = \hat{r}\,\frac{kq}{r^2} = \hat{r}\,\frac{(9.0\times10^{9})(1.0\times10^{-9}\,C)}{(3.0\times10^{-2})^2}$$

$$= \hat{r}\;1.0\times10^{4}\ \frac{N}{C}$$

R = 1.0 cm

r = 3.0 cm

magnitude: $1.0\times10^{4}\ \frac{N}{C}$

direction: $\hat{r}$, away from the center of sphere.

Problem 2

Junction rule: net current at a junction is zero

Loop rule: Potential difference in the components of a loop add up to zero.

The loop rule is associated to conservation of energy.

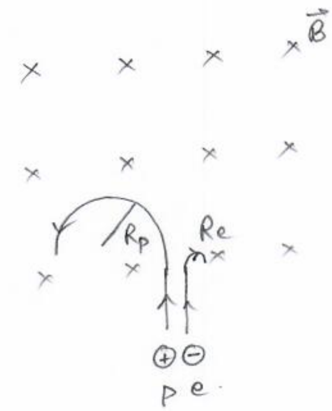
Problem 3

$$ma = qvB$$

$$m\frac{v^2}{R} = qvB$$

$$v = \frac{qB}{m}R$$

$$R = \frac{mv}{qB}$$



v, |q|, and B are same.

→ R_p is 2000 times larger than R_e.

→ They move in a circle with opposite sense.

Problem 4

$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2} \Rightarrow [\epsilon_0] = \frac{Q^2}{L^2[F]}$$

$$B = \frac{\mu_0}{4\pi}\frac{2I}{r} \Rightarrow [\mu_0] = \frac{[F]}{[I]^2}$$

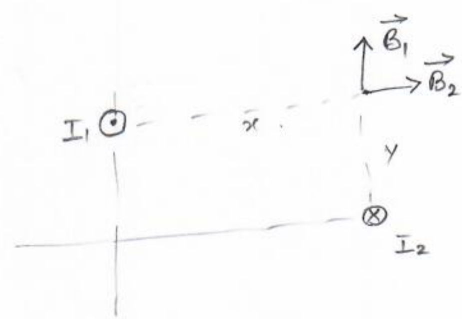
$$R = \frac{V}{I} \Rightarrow [R] = \frac{[F]L}{[I]^2 T}$$

$$\frac{1}{[R]}\sqrt{\frac{[\mu_0]}{[\epsilon_0]}} = \frac{[I]^2 T}{[F]L}\sqrt{\frac{[F]}{[I]^2}\frac{[F]L^2}{Q^2}}$$

$$= 1$$

dimensionless.

Problem 5



$$\vec{B}_1 = 0\,\hat{i} + \hat{j}\,\frac{\mu_0}{4\pi}\frac{2I_1}{x}.$$

$$\vec{B}_2 = \hat{i}\,\frac{\mu_0}{4\pi}\frac{2I_2}{y} + 0\,\hat{j}.$$

$$B_1 = \frac{\mu_0}{4\pi}\frac{2I_1}{x} = 10^{-7}\frac{2(1.0)}{12\times 10^{-2}}$$

$$= 1.7\times 10^{-6}\ \text{T}$$

$$B_2 = \frac{\mu_0}{4\pi}\frac{2I_2}{y} = 10^{-7}\frac{2(2.0)}{8.0\times 10^{-2}}$$

$$= 5.0\times 10^{-6}\ \text{T}$$

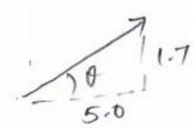
$$\vec{B}_1 = 0\,\hat{i} + \hat{j}\ 1.7\ \mu\text{T}$$

$$\vec{B}_2 = \hat{i}\ 5.0\,\mu\text{T} + 0\,\hat{j}$$

$$\vec{B}_{tot} = (5.0\,\hat{i} + 1.7\,\hat{j})\ \mu\text{T}.$$

$$|\vec{B}_{tot}| = \sqrt{5.0^2 + 1.7^2}$$

$$= 5.3\ \mu\text{T} \quad \text{(magnitude)}$$



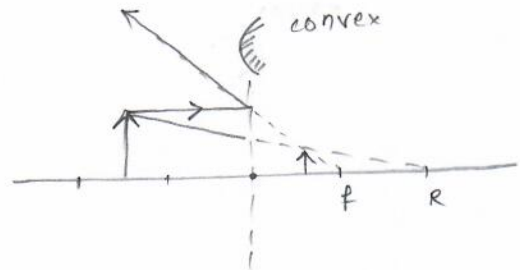
$$\theta = \tan^{-1}\left(\frac{1.7}{5.0}\right) = 19^\circ$$ counter clockwise w.r.t. $+\hat{i}$ (direction)

Problem 6

(a) $f = -10.0\text{cm}$, $R = -20.0\text{cm}$

diverging mirror.

(d)



(b) $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$\frac{1}{15.0} + \frac{1}{d_i} = \frac{1}{-10.0} \Rightarrow \frac{1}{d_i} = -\frac{1}{10.0} - \frac{1}{15.0} = -\frac{5.00}{30.0} \Rightarrow d_i = -6.00\text{cm}.$

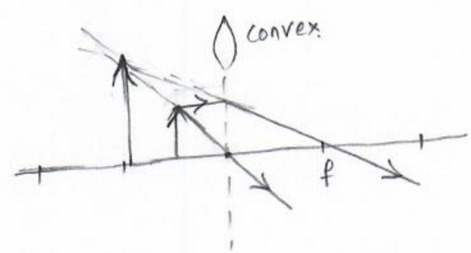
virtual image.

(c) $m = -\frac{d_i}{d_o} = -\frac{(-6.00\text{cm})}{15.0\text{cm}} = +0.400$ (diminished, upright)

$m = \frac{h_i}{h_o} \Rightarrow h_i = (+0.400)(1.00\text{m}) = +0.40\text{cm}.$

Problem 7

(a) converging lens, $f = +10.0\text{cm}$



(b) $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$\frac{1}{5.00} + \frac{1}{d_i} = \frac{1}{10.0} \Rightarrow \frac{1}{d_i} = \frac{1}{10.0} - \frac{1}{5.00} = -\frac{1}{10.0}$ $d_i = -10.0\text{cm}$

virtual image.

(c) $m = -\frac{d_i}{d_o} = -\frac{(-10.0\text{cm})}{(5.0\text{cm})} = +2.00$ (magnified, upright)

$m = \frac{h_i}{h_o} \Rightarrow h_i = (+2.00)(1.0\text{cm}) = +2.0\text{cm}.$