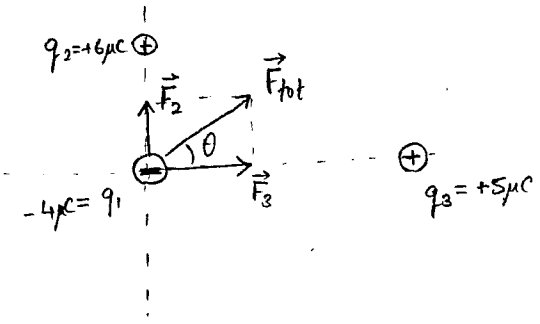
Solutions to Final Exam (PHYS-203A, Summer 2015)

prob. 1

$$|\vec{F}_2| = \frac{k q_1 q_2}{r_{12}^2} = \frac{9\times10^9 \times 6\times10^{-6} \times 4\times10^{-6}}{(4\times10^{-2}\,m)^2} = 135\ N$$

$$|\vec{F}_3| = \frac{k q_1 q_3}{r_{13}^2} = \frac{9\times10^9 \times 5\times10^{-6} \times 4\times10^{-6}}{(6\times10^{-2}\,m)^2} = 50\ N$$



$$\vec{F}_2 = 0\,\hat{i} + 135\,\hat{j}\ N$$

$$\vec{F}_3 = 50\,\hat{i}\ N + 0\,\hat{j}$$

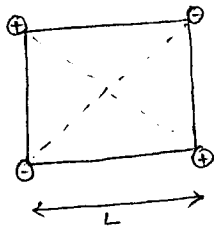
$$\vec{F}_{tot} = 50\,\hat{i} + 135\,\hat{j}$$

$$\vec{F}_{tot} = \vec{F}_1 + \vec{F}_2$$

$$|\vec{F}_{tot}| = \sqrt{50^2 + 135^2} = 144\ N$$

$$\theta = \tan^{-1}\left(\frac{135}{50}\right) = 69.7^\circ \quad \text{w.r.t positive } x\text{-axis.}$$

prob. 2



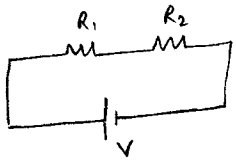
(a) $$V_{center} = +\frac{ke}{\sqrt{2}L} - \frac{ke}{\sqrt{2}L} + \frac{ke}{\sqrt{2}L} - \frac{ke}{\sqrt{2}L} = 0$$

(b) $$V_{side} = +\frac{ke}{L/2} - \frac{ke}{L/2} + \frac{ke}{\sqrt{L^2+\frac{L^2}{4}}} - \frac{ke}{\sqrt{L^2+\frac{L^2}{4}}} = 0$$

(c) $$\Delta U = +e\,(V_{center} - V_\infty) = 0$$

(d) $$\Delta U = +e\,(V_{side} - V_{center}) = 0.$$

prob. 3



(a) $$R_{eq} = R_1 + R_2 = 30.0\,\Omega$$

(b) $$I_1 = I_2 = I = \frac{V}{R_{eq}} = \frac{10.0}{30.0} = 0.333\ A$$

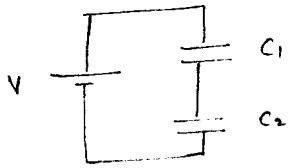
(c) $$V_1 = I_1 R_1 = 3.33\ V$$

$$V_2 = I_2 R_2 = 6.67\ V$$

(d) $$P_1 = I_1^2 R_1 = (0.333)^2\,10.0 = 1.11\ W$$

$$P_2 = I_2^2 R_2 = (0.333)^2\,20.0 = 2.22\ W$$

prob. 4



(a) $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{10.0\mu F} + \frac{1}{20.0\mu F}$

$\Rightarrow C_{eq} = 6.67\mu F$

(b) $Q_1 = Q_2 = V C_{eq} = 66.7\,\mu C$

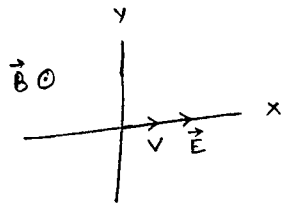
(c) $V_1 = \frac{Q_1}{C_1} = \frac{66.7\,\mu C}{10.0\,\mu F} = 6.67\ V$

$V_2 = \frac{Q_2}{C_2} = \frac{66.7\,\mu C}{20.0\,\mu F} = 3.33\ V$

(d) $U_1 = \frac{Q_1^2}{2C_1} = \frac{(66.7\,\mu C)^2}{2 \times 10\,\mu F} = 222\,\mu J$

$U_2 = \frac{Q_2^2}{2C_2} = \frac{(66.7\,\mu C)^2}{2 \times 20\,\mu F} = 111\,\mu J$

prob. 5

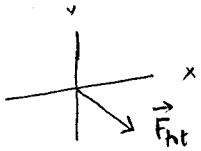


$\vec{F}_E = q E \hat{i}$

$= 1.80\,\mu C \times 4.50 \times 10^3 \frac{N}{C} \hat{i} = 8.1 \times 10^{-3}\ N\ \hat{i}$

$\vec{F}_B = q v B (-\hat{j})$ → using right hand rule.

$= 1.80\,\mu C \times 3.00 \times 10^6 \frac{m}{s} \times 1.50 \times 10^{-3}\ T\ (-\hat{j}) = -8.1 \times 10^{-3}\ N\ \hat{j}$

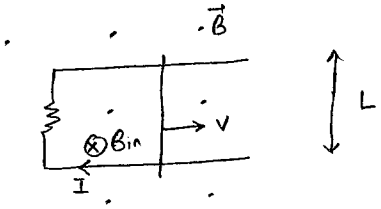


$\vec{F}_{tot} = \vec{F}_E + \vec{F}_B$

$= 8.1 \times 10^{-3}\ N\ \hat{i} - 8.1 \times 10^{-3}\ N\ \hat{j}$

$|\vec{F}_{tot}| = \sqrt{(8.1 \times 10^{-3})^2 + (-8.1 \times 10^{-3})^2} = 1.15 \times 10^{-2}\ N$

prob. 6



(a) increasing

(b) clockwise

(c) $I = \frac{BLv}{R} = \frac{1.20 \times 5.00\times10^{-2} \times 4.00}{400.0}$

$= 6.00 \times 10^{-4}$ A

prob. 7

$d = ct = 2.99\times10^{8}\frac{m}{s} \; 1 \times 365 \times 24 \times 60 \times 60 \text{ sec}$

$= 9.4 \times 10^{15}$ m

prob. 8

(a) $f' = f\left(1 \pm \frac{v}{c}\right)$

$v = c\left(\frac{f'}{f} - 1\right) = 2.99\times10^{8}\left(\frac{510.0\,nm}{540.0\,nm} - 1\right) = -1.66\times10^{7}\frac{m}{s}$

(b) Receding. Because, the observed frequency is lower than the emitted frequency.

prob. 9

(a) $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $\quad \frac{1}{d_i} = \frac{1}{-10.0} - \frac{1}{+12.0} = -\frac{22}{120}$

$\Rightarrow d_i = -\frac{120}{22}\text{ cm} = -5.46\text{ cm}$

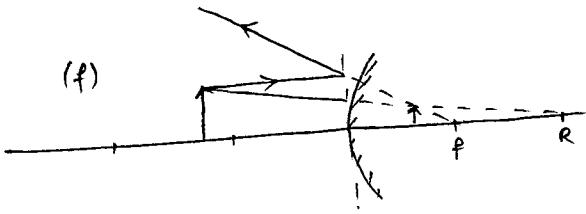
(b) $m = -\frac{d_i}{d_o} = -\frac{(-5.46\text{cm})}{(+12.0\text{cm})} = +0.455$

(c) Virtual

(d) Upright.

(e) $h_i = m\,h_o = +0.455 \times 2.00\text{ cm} = 0.910\text{ cm}$

(f)



$f = -10.0$ cm

$d_o = +12.0$ cm

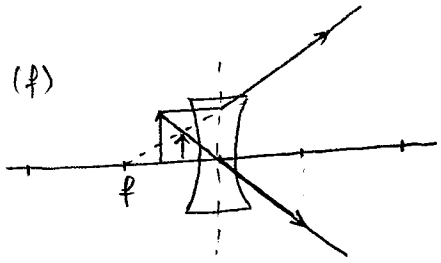
prob. 10

(a) $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $\qquad \frac{1}{d_i} = \frac{1}{(-6)} - \frac{1}{(+4)} = -\frac{5}{12}$

$\Rightarrow \quad d_i = -\frac{12}{5}\,cm = -2.40\,cm$

(b) $m = -\frac{d_i}{d_o} = -\frac{(-2.40\,cm)}{(+4.00\,cm)} = +0.600$

(f)



$f = -6.00\,cm$

$d_o = +4.00\,cm$

(c) Virtual

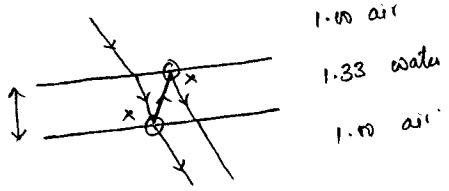
(d) Upright

(e) $h_i = m\,h_o = +0.600 \times 2.00\,cm = +1.20\,cm$

prob. 11

$\frac{d \sin\theta}{\lambda} = m \qquad \lambda = \frac{d \sin\theta}{m} = \frac{0.300 \times 10^{-3}\,m \times \sin(0.500^\circ)}{5} = 524\,nm$

prob. 12



$n\frac{x_2 - x_1}{\lambda} + m'\frac{1}{2} = \begin{cases} m & \text{maxima} \\ m + \frac{1}{2} & \text{minima.} \end{cases}$

$x_2 - x_1 = 2d \qquad m = 1$ (smallest)

$m' = 0$

$n\frac{2d}{\lambda} = m$

$d = \frac{m\lambda}{2n} = \frac{1 \times 665\,nm}{2 \times 1.33} = 250\,nm.$