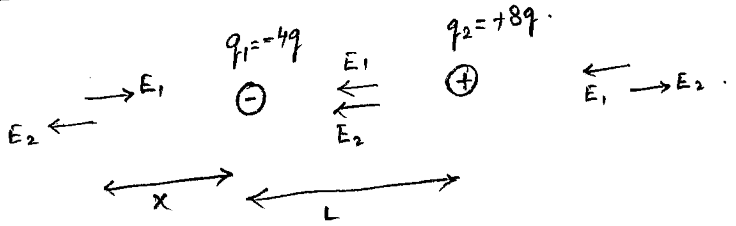
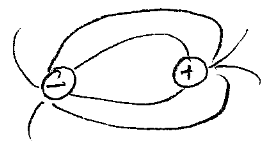
Solutions to Final Exam (Fall 2014, PHYS 205B)

Final Exam, prob. 1





Argue that it will be on the left of q_1.

$$E_1 = E_2$$

$$\frac{k|q_1|}{x^2} = \frac{k|q_2|}{(L+x)^2}$$

$$L + x = \sqrt{\frac{|q_2|}{|q_1|}}\, x$$

$$\sqrt{\frac{|q_2|}{|q_1|}} = \sqrt{\frac{8q}{4q}} = \sqrt{2}$$

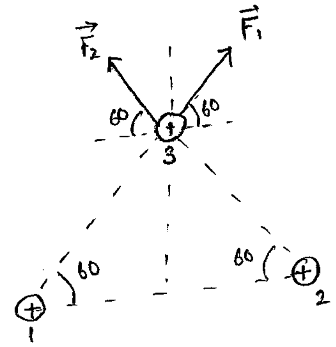
$$L + x = \pm\sqrt{2}\, x$$

$-\sqrt{2}$ leads to negative x.

$$x = \frac{L}{\sqrt{2}-1}$$

✓

Final Exam, prob. 2



$$F = |\vec{F}_1| = |\vec{F}_2| = \frac{kQ^2}{L^2}$$

$$\vec{F}_1 = F\cos 60\ \hat{i} + F\sin 60\ \hat{j}$$

$$\vec{F}_2 = -F\cos 60\ \hat{i} + F\sin 60\ \hat{j}$$

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

$$= 2F\sin 60\ \hat{j}$$

$$= \sqrt{3}\,\frac{kQ^2}{L^2}\ \hat{j}$$

$$2\sin 60 = 2\,\frac{\sqrt{3}}{2} = \sqrt{3}$$

Final Exam, prob. 3

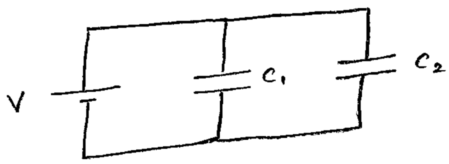
$\Phi_E = \vec{E} \cdot \vec{A}$

$= 20 \ \frac{Nm^2}{C}$

$\vec{E} = (137\ \hat{i} + 207\ \hat{j} + 10\ \hat{k}) \ \frac{N}{C}$

$\vec{A} = (0\ \hat{i} + 0\ \hat{j} + 2.0\ \hat{k}) \ m^2.$

Final Exam, prob. 4



(a) $C = C_1 + C_2$

$= 30.0\ \mu F$

(b) $Q_1 = C_1 V = 10.0 \times 10^{-6} \times 10 = 10^{-4}\ C$

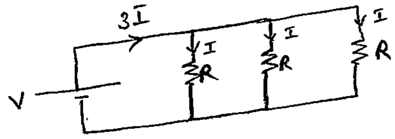
$Q_2 = C_2 V = 20.0 \times 10^{-6} \times 10 = 2 \times 10^{-4}\ C$

(c) $V_1 = V_2 = V = 10\ V$

(d) $U_1 = \frac{1}{2} C_1 V^2 = \frac{1}{2}\ 10.0 \times 10^{-6} \times 10^2 = 0.5 \times 10^{-3}\ J$

$U_2 = \frac{1}{2} C_2 V^2 = \frac{1}{2}\ 20.0 \times 10^{-6} \times 10^2 = 1.0 \times 10^{-3}\ J$

Final Exam, prob 5



(a) $\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}$

$\Rightarrow R_{eq} = \frac{R}{3} = 100.0\ \Omega$

(b) $V = 30.0\ V$ fall all three resistors.

(c) $V = I_{eq} R_{eq} = (\cancel{3}I) \frac{R}{\cancel{3}} \Rightarrow I = \frac{V}{R} = \frac{30.0}{300.0} = 0.10\ A.$ → same for each resistor

(d) $P = \frac{V^2}{R} = \frac{30 \times 3\cancel{0}}{3\cancel{0}\cancel{0}} = 3.00\ W.$ ⟶ same for each resistor.

Final Exam, prob. 6

$$\vec{F} = q\, \vec{v} \times \vec{B}$$

$$4.24\times10^{-17}\,N\,\hat{i} + 1.6\times10^{-17}\,N\,\hat{j} + 0\,\hat{k} = 1.6\times10^{-19}\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ V_x & V_y & 2000 \\ 0 & 0 & 10\times10^{-3} \end{vmatrix}$$

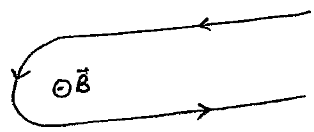
$$= 1.6\times10^{-19}\left[V_y\, 10^{-2}\,\hat{i} - V_x\, 10^{-2}\,\hat{j} + 0\,\hat{k} \right]$$

Comparing x-component

$$4.24\times10^{-17} = 1.6\times10^{-19} \times V_y\, 10^{-2}$$

$$V_y = \frac{4.24\times10^{-17}}{1.6\times10^{-21}} = 2.65\times10^{4}\ \frac{m}{s}.$$

Final Exam, prob. 7



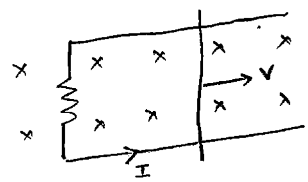
$\odot \hat{z}$

$$\vec{B} = \frac{\mu_0 I}{2\pi R}\,\frac{1}{2}\,\hat{z} + \frac{\mu_0 I}{2\pi R}\,\frac{1}{2}\,\hat{z} + \frac{\mu_0 I}{2R}\,\frac{1}{2}\,\hat{z}$$

$$= \frac{\mu_0 I}{4R}\left(\frac{1}{\pi} + \frac{1}{\pi} + 1\right)\hat{z}$$

$$= \frac{\mu_0 I}{4R}\left(\frac{2}{\pi} + 1\right)\hat{z}.$$

Final Exam, prob. 8



(a) Increasing

(b) Anticlockwise.

(c) $$I = \frac{1}{R}\frac{d\phi_B}{dt} = \frac{BLV}{R}$$

$$= \frac{1.2\times10\times10^{-2}\times5}{0.4} = 1.5\ A$$

Final Exam, prob. 9

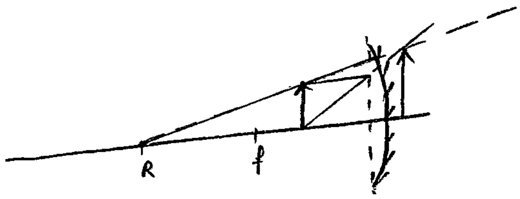
RC circuit : $\tau = RC$

LR circuit : $\tau = \frac{L}{R}$

(a) $RC = \frac{L}{R} \Rightarrow R = \sqrt{\frac{L}{C}} = \sqrt{\frac{9.00}{4.00 \times 10^{-6}}} = 1.50 \times 10^{3}\ \Omega$

(b) $\tau = RC = 1.50 \times 10^{3} \times 4.00 \times 10^{-6} = 6.00 \times 10^{-3}$ sec.

Final Exam, prob. 10



(e) virtual, upright, larger.