

# Final Exam Solutions, 2015 Spring

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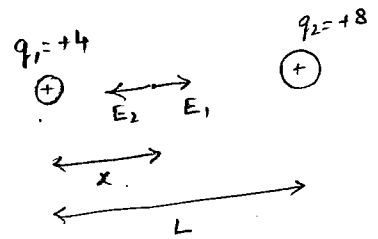
## Final Exam, prob. 1

$$|\vec{E}_1| = |\vec{E}_2|$$

$$\frac{kq_1}{x^2} = \frac{kq_2}{(L-x)^2}$$

$$L-x = \pm \sqrt{\frac{q_2}{q_1}} x$$

$$x = \frac{L}{\left(1 \pm \sqrt{\frac{q_2}{q_1}}\right)} = \frac{L}{1 + \sqrt{2}}$$



- solution not compatible with a being between the charges.

## Final Exam, prob. 2

$$\phi_E = \frac{1}{\epsilon_0} Q = \frac{53.4 \times 10^{-12} \text{ C}}{8.85 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}} = 6.03 \frac{\text{N}}{\text{C}} \text{ m}^2.$$

## Final Exam, prob. 3

$$V = \frac{k(q)}{y} + \frac{k(2q)}{\sqrt{a^2 + y^2}} = 0$$

$$\frac{k2q}{\sqrt{a^2 + y^2}} = \frac{kq}{y}$$

$$2y = \sqrt{a^2 + y^2}$$

$$4y^2 = a^2 + y^2$$

$$3y^2 = a^2$$

$$y = \pm \frac{a}{\sqrt{3}}$$

Final Exam, prob. 4

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

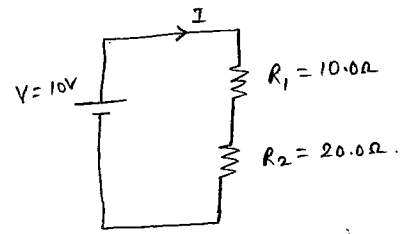
(b)  $I_1 = I_2 = \frac{V}{R_{eq}} = \frac{10}{30} = 0.33 \text{ A}$

(c)  $V_1 = I_1 R_1 = 3.3 \text{ V}$

$V_2 = I_2 R_2 = 6.7 \text{ V}$

(d)  $P_1 = I_1 V_1 = 1.1 \text{ W}$

$P_2 = I_2 V_2 = 2.2 \text{ W}$



Final Exam, prob 5

$$\vec{F} = q \vec{v} \times \vec{B}$$
$$= -1.6 \times 10^{-19} \times 3.96 \times 10^5 \text{ N}$$
$$= -6.336 \times 10^{-14} \text{ N}$$

$$\vec{v} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2.1 \times 10^6 & 2.7 \times 10^6 & 0 \\ 0.03 & -0.15 & 0 \end{vmatrix}$$
$$= \hat{k} (-2.1 \times 0.15 \times 10^6 - 0.03 \times 2.7 \times 10^6)$$
$$= -3.96 \times 10^5 \hat{k} \frac{\text{m}}{\text{s T}}$$

Final Exam, prob 6

$$\vec{B}_{tot} = \hat{k} \frac{\mu_0 I}{2\pi a} \frac{1}{2} + \hat{k} \frac{\mu_0 I}{2a} \frac{1}{2} - \hat{k} \frac{\mu_0 I}{2\pi a} \frac{1}{2}$$
$$= \hat{k} \frac{\mu_0 I}{4a}$$



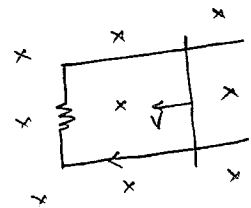
Final Exam, prob 7

(a) decreasing

(b) clockwise.

(c)  $I = \frac{BLV}{R} = \frac{0.8 \text{ T} \times (5 \times 10^{-2} \text{ m}) \times 2 \frac{\text{m}}{\text{s}}}{0.60 \Omega}$

$$= 0.13 \text{ A}$$

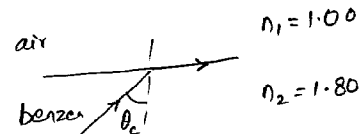


Final Exam, prob 8

$$n_2 \sin \theta_c = n_1 \sin 90$$

$$1.80 \sin \theta_c = 1.00$$

$$\theta_c = \sin^{-1} \left( \frac{1.00}{1.80} \right) = 33.7^\circ$$

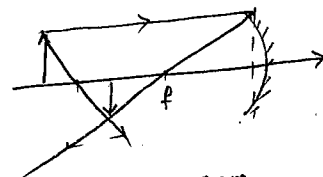


Final Exam, prob 9

$$f = \frac{R}{2} = \frac{10.0 \text{ cm}}{2} = 5.0 \text{ cm}$$

$$p = 12.0 \text{ cm}$$

$$h = 2.0 \text{ cm}$$



$$(a) \quad \frac{1}{12.0} + \frac{1}{q} = \frac{1}{5.0} \Rightarrow \frac{1}{q} = \frac{1 \times 12}{5.0 \times 12} - \frac{1 \times 5}{12.0 \times 5} = \frac{7}{60} \Rightarrow q = +8.57 \text{ cm}$$

$$(b) \quad m = -\frac{q}{p} = -\frac{8.57 \text{ cm}}{12.0 \text{ cm}} = -0.71$$

(c) real

(d) inverted

(e) see diagram.

Final Exam, prob. 10

(f) virtual, upright, smaller.

