PHYS 205B (2017 Spring) Midterm Exam 1

Prob. 1

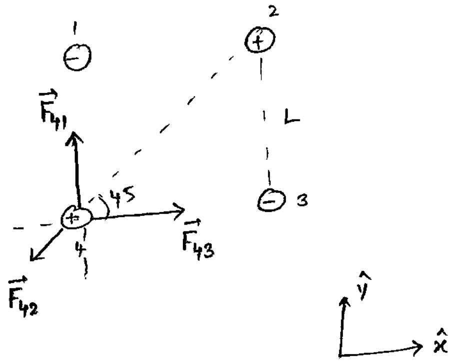
$$\frac{F_e}{F_g} = \frac{\left(\frac{k e^2}{\cancel{r^2}}\right)}{\left(\frac{G m_e m_p}{\cancel{r^2}}\right)} = \frac{k e^2}{G m_e m_p}$$

$$= \frac{(8.99\times 10^{9})\,(1.60\times 10^{-19})^2}{(6.67\times 10^{-11})\,(9.1\times 10^{-31})\,(1.67\times 10^{-27})}$$

$$= 2.3\times 10^{39}$$

Prob. 2

$$F = \frac{kQ^2}{L^2}$$



$$\vec{F}_{41} = 0\,\hat{i} + F\,\hat{j}$$

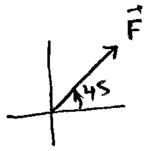
$$\vec{F}_{42} = -\frac{F}{2}\cos 45\,\hat{i} - \frac{F}{2}\sin 45\,\hat{j}$$

$$\vec{F}_{43} = F\,\hat{i} + 0\,\hat{j}$$

$$\vec{F} = \left(F - \frac{F}{2\sqrt{2}}\right)\hat{i} + \left(F - \frac{F}{2\sqrt{2}}\right)\hat{j}$$

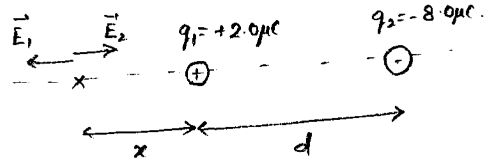
magnitude: $F\left(1 - \frac{1}{2\sqrt{2}}\right)\sqrt{2} = \frac{kQ^2}{L^2}\left(\sqrt{2} - \frac{1}{2}\right)$

direction:



45° counterclockwise w.r.t. $\hat{x}$

Prob. 3



Argue that the cancellation happens on the left of q_1.

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

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

$$\frac{2.0}{x^2} = \frac{8.0}{(d+x)^2}$$

$$\pm \frac{1.0}{x} = \frac{2.0}{d+x}.$$

$$d + x = \pm 2x$$

$+$: $x = d = +10\,cm$ ✓

$-$: $x = -\frac{d}{3} = -3.3\,cm$

we argued that negative x is not possible.

Answer: 10 cm to the left of q_1.

Prob. 4

$$V_f = \overset{=0}{\cancel{\vec{V}_i}} + a\,t$$

$$V_e = a_e\,t = \left(\frac{e}{m_e} E\right) t$$

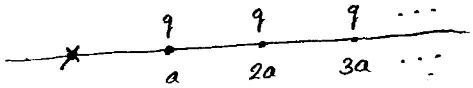
$$V_p = a_p\,t = \left(\frac{e}{m_p} E\right) t$$

$$\frac{V_e}{V_p} = \frac{\frac{\cancel{e}}{m_e} \cancel{E}\,\cancel{t}}{\frac{\cancel{e}}{m_p} \cancel{E}\,\cancel{t}} = \frac{m_p}{m_e} = \frac{1.67\times 10^{-27}\,kg}{9.1\times 10^{-31}\,kg}$$

$$= 1835$$

$$= 1800 \quad \text{(two significant digits.)}$$

Prob. 5



$$\vec{E} = -\hat{i}\left[\frac{kq}{a^2} + \frac{kq}{(2a)^2} + \frac{kq}{(3a)^2} + \cdots\right]$$

$$= -\hat{i}\,\frac{kq}{a^2}\left[1 + \frac{1}{2^2} + \frac{1}{3^2} + \cdots\right]$$

$$= -\hat{i}\,\frac{kq}{a^2}\,\frac{\pi^2}{6}$$

Prob. 6

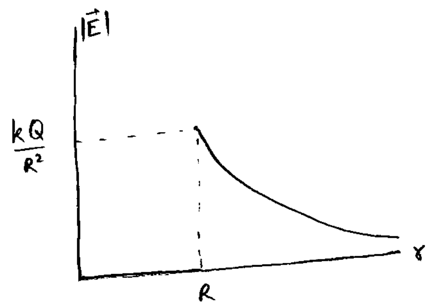
$$\vec{E} = \left(14\,\hat{i} + 20\,\hat{j} + 16\,\hat{k}\right)\ \frac{N}{C}$$

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

$$\phi_E = \vec{E}\cdot\vec{A} = 32\ \frac{Nm^2}{C}.$$

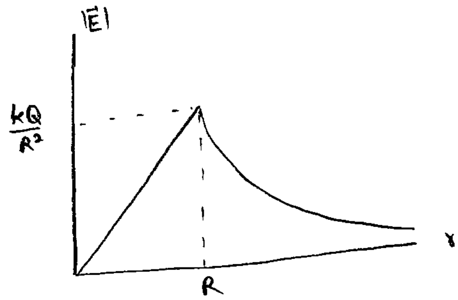
Prob. 7

conducting sphere



$$\vec{E} = \begin{cases} 0, & r < R, \\ \frac{kQ}{r^2}, & R < r. \end{cases}$$

nonconducting solid sphere

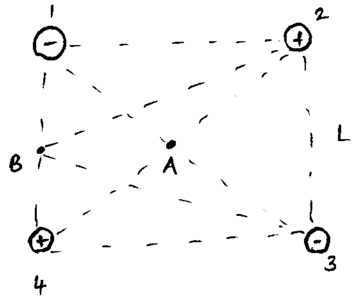


$$\vec{E} = \begin{cases} \frac{kQr}{R^3}, & r < R, \\ \frac{kQ}{r^2}, & R < r. \end{cases}$$

Prob. 8

$$V_A = -\frac{kq}{\sqrt{\left(\frac{L}{2}\right)^2+\left(\frac{L}{2}\right)^2}} + \frac{kq}{\sqrt{\left(\frac{L}{2}\right)^2+\left(\frac{L}{2}\right)^2}} - \frac{kq}{\sqrt{\left(\frac{L}{2}\right)^2+\left(\frac{L}{2}\right)^2}} + \frac{kq}{\sqrt{\left(\frac{L}{2}\right)^2+\left(\frac{L}{2}\right)^2}}$$

$$= 0$$



$q_1 = q_3 = -q$

$q_2 = q_4 = +q$

$$V_B = -\frac{kq}{L/2} + \frac{kq}{\sqrt{L^2+\left(\frac{L}{2}\right)^2}} - \frac{kq}{\sqrt{L^2+\left(\frac{L}{2}\right)^2}} + \frac{kq}{L/2}$$

$$= 0$$

$$V_A - V_B = 0$$