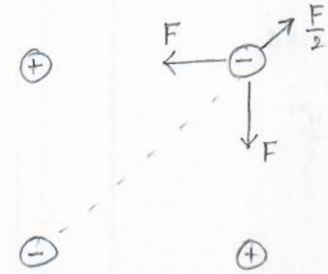
Solutions PHYS-205B (Midterm Exam 01) 2021 Fall

Problem 1

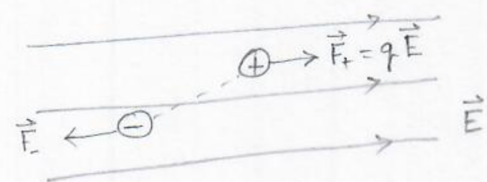


→ on each charge the two attractive forces result in a force of $\sqrt{2}\,F$ inward along the diagonal.

→ The repulsive force is $\frac{F}{2}$ along the diagonal.

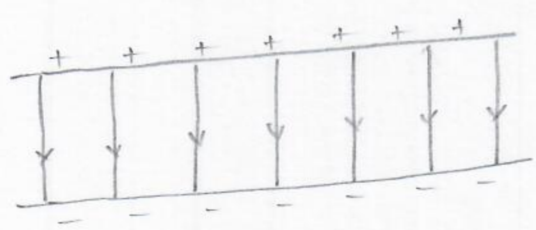
The resultant force on each charge is inward. Thus, the charges tend to implode.

Problem 2



$$\vec{F}_{tot} = +q\vec{E} - q\vec{E} = 0.$$

Problem 3



Problem 4

$$Q_A = Q \qquad Q_B = Q \qquad Q_C = Q$$

$$\frac{Q_A+Q_C}{2} = Q \qquad Q_B = Q \qquad \frac{Q_A+Q_C}{2} = Q$$

$$\frac{Q_A+Q_C}{2} = Q \qquad \frac{Q_B + \frac{Q_A+Q_C}{2}}{2} = Q \qquad \frac{Q_B + \frac{Q_A+Q_C}{2}}{2} = Q$$

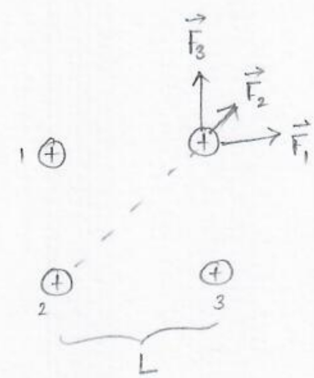
Answer: Q.

Problem 5

$$\Phi_E = \oint d\vec{a} \cdot \vec{E} = \frac{Q_{enclosed}}{\epsilon_0}$$

$$= \frac{+8.85 \times 10^{-12}\, C}{8.85 \times 10^{-12} \frac{C^2}{N m^2}} = +1.00 \frac{N m^2}{C}.$$

Problem 6



$$F = \frac{k q^2}{L^2}.$$

$$\vec{F}_1 = +F\,\hat{i} + 0\,\hat{j}$$

$$\vec{F}_2 = \frac{F}{2}\left[\cos 45\,\hat{i} + \sin 45\,\hat{j}\right]$$

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

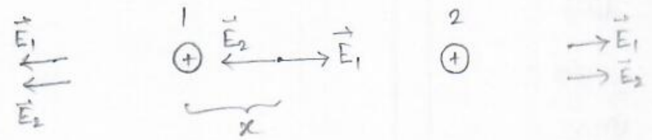
$$\vec{F}_{tot} = \left(F + \frac{F}{2\sqrt{2}}\right)\hat{i} + \left(F + \frac{F}{2\sqrt{2}}\right)\hat{j}$$

magnitude: $$|\vec{F}_{tot}| = \sqrt{2}\left(1 + \frac{1}{2\sqrt{2}}\right) F$$

$$= \left(\sqrt{2} + \frac{1}{2}\right) F$$

$$= \left(\sqrt{2} + \frac{1}{2}\right) \frac{1}{4\pi\epsilon_0} \frac{q^2}{L^2}$$

Problem 7



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

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

$$\frac{\sqrt{|q_1|}}{|x|} = \frac{\sqrt{|q_2|}}{|D-x|}$$

$$+1.00\,(D-x) = +2.00\,x$$

$$D = +3.00\,x$$

$$x = 0.333\,D$$

Problem 8

x-dir

$$\Delta x = +5.00\times10^{-2}\,m$$

$$\Delta t =$$

$$V_{ix} = 4.0\times10^{6}\,\frac{m}{s}$$

y-dir

$$\Delta y = ?$$

$$\Delta t =$$

$$V_{iy} = 0$$

$$V_{fy} =$$

$$a = -\frac{|q|}{m}E = -\frac{1.60\times10^{-19}}{9.11\times10^{-31}}\times2.0\times10^{3}$$

$$= -0.351\times10^{15}\,\frac{m}{s^2}$$

$$\Delta t = \frac{\Delta x}{V_{ix}}$$

$$= \frac{5.00\times10^{-2}}{4.0\times10^{6}}$$

$$= 1.25\times10^{-8}\,s$$

$$\Delta y = V_{iy}\,\Delta t + \frac{1}{2}a\,\Delta t^2$$

$$= 0 + \frac{1}{2}(-3.51\times10^{14})(1.25\times10^{-8})^2$$

$$= -2.74\times10^{-2}\,m$$

$$= -2.74\,cm$$

Problem 9

$$\phi_E = \oint d\vec{a} \cdot \vec{E} = \frac{Q_{enclosed}}{\epsilon_0}$$

$$= \frac{+5Q - 4Q}{\epsilon_0}$$

$$= \frac{+Q}{\epsilon_0} = \frac{+17.7 \times 10^{-12}\, C}{8.85 \times 10^{-12}\, \frac{C^2}{Nm^2}} = +2.00\ \frac{Nm^2}{C}$$

Problem 10

Since the charge distribution is spherical symmetric we have

$$\oint d\vec{a} \cdot \vec{E} = 4\pi r^2 E.$$

Thus, using Gauss's law,

$$\oint d\vec{a} \cdot \vec{E} = \frac{Q_{enclosed}}{\epsilon_0},$$

we have

$$4\pi r^2 E = \begin{cases} +\dfrac{Q}{\epsilon_0} & \text{for } r < R, \\[2ex] \dfrac{+Q + q_1}{\epsilon_0} & \text{for } R < r. \end{cases}$$

Thus,

$$\vec{E} = \begin{cases} \hat{r}\, \dfrac{1}{4\pi\epsilon_0} \dfrac{Q}{r^2} & \text{for } r < R, \\[2ex] \hat{r}\, \dfrac{1}{4\pi\epsilon_0} \dfrac{(Q + q_1)}{r^2} & \text{for } R < r. \end{cases}$$