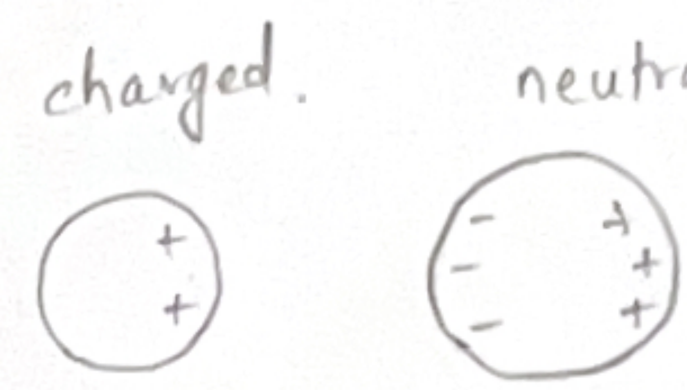
Solutions

Midterm Exam 01 (PHYS-205B-001) Spring 2023

Problem 1



→ neutral sphere is polarized

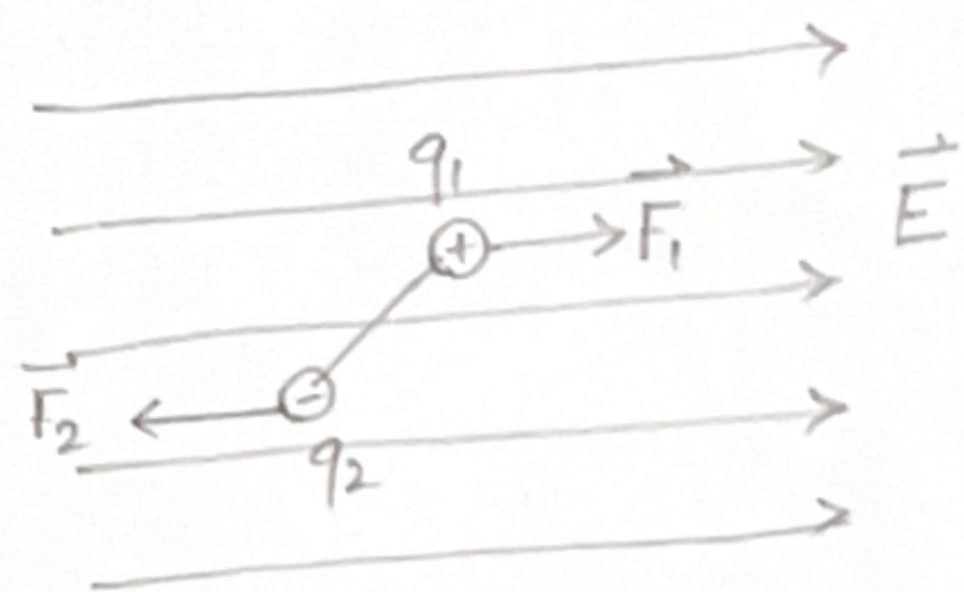
→ repulsion from + charges is weaker than attraction from −.

Answer: Force is not zero. It is attractive.

Problem 2

$q_1 = +q$

$q_2 = -q$



$$\vec{F}_1 = +q\vec{E}$$

$$\vec{F}_2 = -q\vec{E}$$

$$\vec{F}_{tot} = \vec{F}_1 + \vec{F}_2 = 0.$$

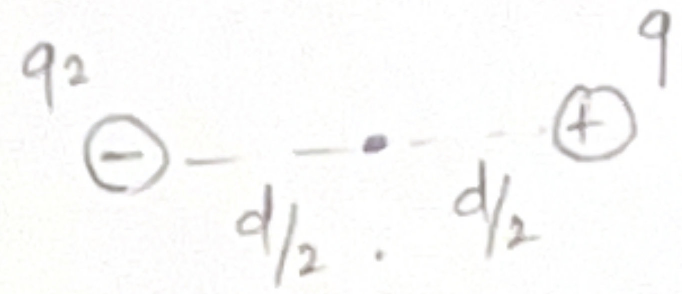
Total electric force on an electric dipole is zero.

Problem 3

$$\phi_B = \int \vec{E}\cdot d\vec{a} = \vec{E}\cdot\vec{A} = E\,\underbrace{\hat{i}\cdot\hat{k}}_{=0}\,A = 0$$

$\vec{E} = E\,\hat{i}$ and $\vec{A} = A\,\hat{k}$

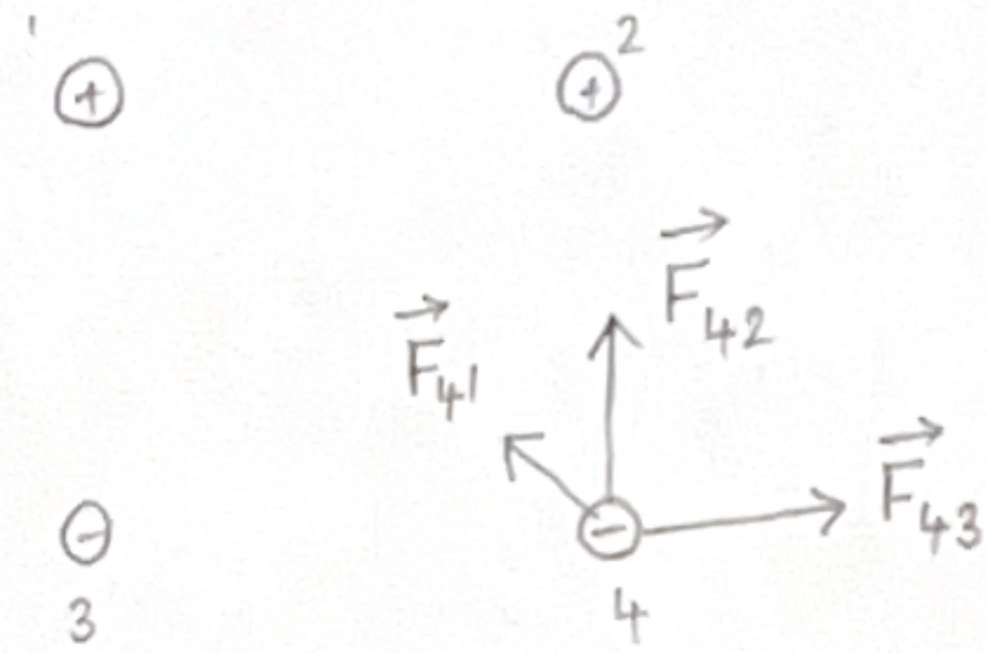
Problem 4



$$V = V_1 + V_2$$

$$= \frac{kq_1}{d/2} + \frac{kq_2}{d/2} = +\frac{kq}{d/2} - \frac{kq}{d/2} = 0.$$

Problem 5



$$\vec{F}_{41} = \frac{kq^2}{(\sqrt{2}L)^2}\left[-\cos 45\,\hat{i} + \sin 45\,\hat{j}\right]$$

$$= \frac{kq^2}{2L^2}\left[-\frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}\right]$$

$$\vec{F}_{42} = \frac{kq^2}{L^2}\left[0\,\hat{i} + \hat{j}\right]$$

$$\vec{F}_{43} = \frac{kq^2}{L^2}\left[\hat{i} + 0\,\hat{j}\right]$$

$$\vec{F}_{tot} = \frac{kq^2}{L^2}\left[\left(1-\frac{1}{2\sqrt{2}}\right)\hat{i} + \left(1+\frac{1}{2\sqrt{2}}\right)\hat{j}\right]$$

$$|\vec{F}_{tot}| = \frac{kq^2}{L^2}\sqrt{\left(1-\frac{1}{2\sqrt{2}}\right)^2 + \left(1+\frac{1}{2\sqrt{2}}\right)^2} \longrightarrow \text{magnitude.}$$

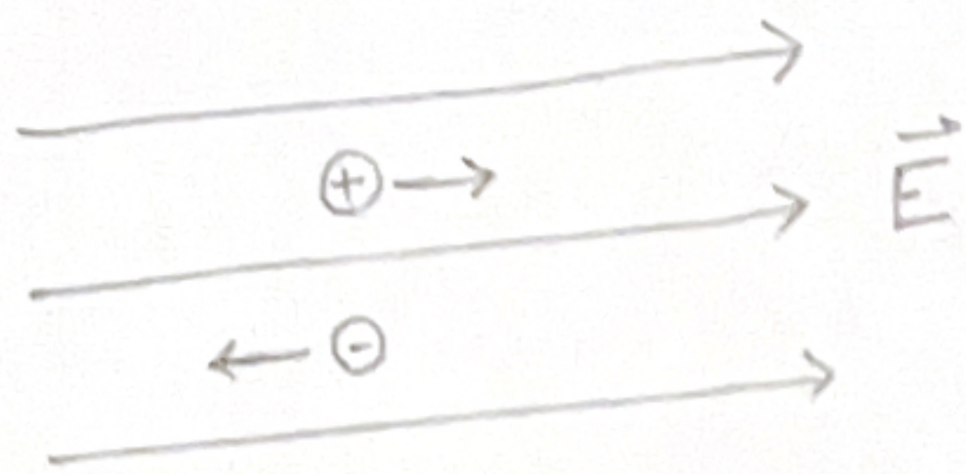
$$= \frac{kq^2}{L^2}\sqrt{2\left(1+\frac{1}{8}\right)} = \frac{3}{2}\,\frac{kq^2}{L^2}$$

$$\theta = \tan^{-1}\left(\frac{1+\frac{1}{2\sqrt{2}}}{1-\frac{1}{2\sqrt{2}}}\right) = \tan^{-1}\left(\frac{2\sqrt{2}+1}{2\sqrt{2}-1}\right) = 65^\circ \text{ counterclockwise w.r.t. } \hat{i}.$$

Problem 6

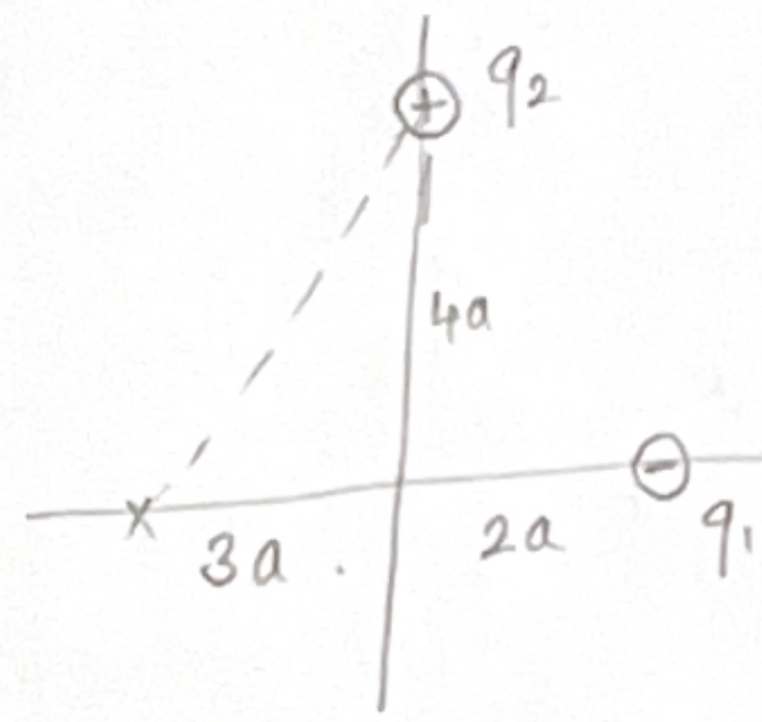
$$x_p = \frac{1}{2} a_p \Delta t^2 \qquad a_p = \frac{q_p E}{m_p}$$

$$x_e = \frac{1}{2} a_e \Delta t^2. \qquad a_e = \frac{q_e E}{m_e}$$



$$\frac{x_e}{x_p} = \frac{a_e}{a_p} = \frac{\left(\frac{q_e E}{m_e}\right)}{\left(\frac{q_p E}{m_p}\right)} = \frac{m_p}{m_e} = 1836.$$

Problem 7



$$V_1 = \frac{kq_1}{5a}.$$

$$V_2 = \frac{kq_2}{\sqrt{(3a)^2+(4a)^2}} = \frac{kq_2}{5a}.$$

$$V_1 + V_2 = \frac{kq_1}{5a} + \frac{kq_2}{5a}$$

$$= \frac{k(q_1+q_2)}{5a} = \frac{(9.0\times10^9)(-1.0+2.0)\times10^{-9}}{5(1.8\times10^{-2})} = +1.0\times10^2 \text{ Volt}$$