

Answers for Tutorial 1

The marks to be awarded for each question are indicated in square brackets.

Problem 1 [10]

a. The force is attractive as one ball has a positive charge (has lost electrons) and the other has a negative charge (has gained electrons). [2]

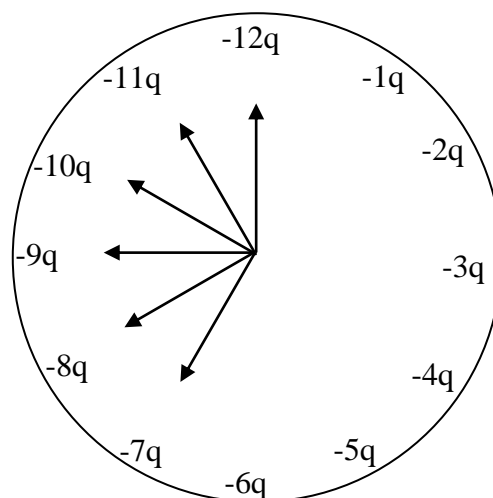
$$b. \quad F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} = \left| \frac{-q^2}{4\pi\epsilon_0 r^2} \right| \text{ (as } q_1 = -q_2 \equiv q\text{)}. [2]$$

$$q = \sqrt{4\pi\epsilon_0 Fr} = \sqrt{\frac{1}{8.99 \times 10^9} \times 9 \times 0.04} = 1.27 \mu\text{C}. [3]$$

$$c. \quad q = ne \Rightarrow n = \frac{q}{e} = \frac{1.27 \times 10^{-6}}{1.6 \times 10^{-19}} = 7.91 \times 10^{12} \text{ electrons}. [3]$$

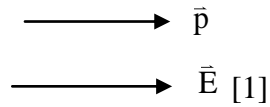
Problem 2 [10]

Consider e.g. field due to charges $-12q$ and $-6q$ (at 12 and 6 o'clock, respectively). Get field in direction 12 o'clock of strength 6 units [4 for understanding this]. Field due to charges $-q$ and $-7q$ is also of strength 6 units, but directed towards 7 o'clock. A similar argument applies for the fields due to charges $-2q$ and $-8q$, $-3q$ and $-9q$, $-4q$ and $-10q$, and $-5q$ and $-11q$. We thus have six contributions to the electric field of equal strength pointing in the 7, 8, 9, 10, 11 and 12 o'clock directions (see diagram) [4 if manage to understand this/draw diagram]. Adding these gives a field pointing towards the "mean" position, i.e. the hour hand is pointing towards 9:30 [2 if get time correct].

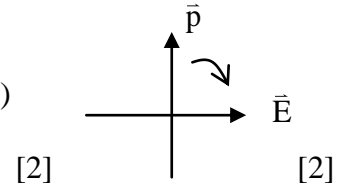


Problem 3 [10]

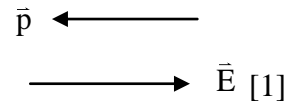
a. $\tau = |\vec{p} \times \vec{E}| = pE \sin \theta = pE \sin(0) = 0.$ [2]



b. $\tau = |\vec{p} \times \vec{E}| = pE \sin \theta = pE \sin(90) = pE = (2e \times d) \times (E)$
 $= (2 \times 1.6 \times 10^{-19} \times 0.78 \times 10^{-9}) \times (3.4 \times 10^6)$
 $= (2.5 \times 10^{-28}) \times (3.4 \times 10^6)$
 $= 8.5 \times 10^{-22} \text{ Nm}.$



c. $\tau = |\vec{p} \times \vec{E}| = pE \sin \theta = pE \sin(180) = 0.$ [2]



You could discuss the difference between situation a. (stable equilibrium) and c. (unstable).

The maximum total mark for this Tutorial is 30.