Problem Set 1

niceguy

January 9, 2023

1. Two small charged bodies are placed at two vertices of a square in free space (Figure 1). The electric force between the charges is stronger for

Solution:

$$F = k\frac{Q_1 Q_2}{r^2}$$

Substituting, the forces are $k\frac{Q^2}{a^2}$ and $-k\frac{2Q^2}{a^2}$. The force is stronger in the second case.

2. Three point charges of unequal magnitudes and polarities are placed at vertices of an equilateral triangle (Figure 2). The electric force $\vec{F}_e$ on the lower right charge is

Solution: Using vectors,

$$\begin{aligned}\vec{F}_e &= k\frac{2Q^2}{a^2}\hat{i} + k\frac{Q^2}{a^2}\left(-0.5\hat{i} + \frac{\sqrt{3}}{2}\hat{j}\right)\\ &= \frac{kQ^2}{a^2}\left(1.5\hat{i} + \frac{4+\sqrt{3}}{2}\hat{j}\right)\end{aligned}$$

Therefore, it is as in figure c.

3. Three point charges $Q = -1\text{nC}$ are placed at three vertices $(a, 0, 0), (0, a, 0)$ and $(0, 0, a)$ of a cube with $a = 1\text{m}$. Find the electric field intensity vector at (a) the coordinate origin $(0, 0, 0)$ and (b) the point on the z-axis $(0, 0, 100\text{m})$.

Solution: At the origin,

$$\vec{E} = -k\frac{Q}{a^2}(\hat{i} + \hat{j} + \hat{k}) = 8.99\hat{i} + 8.99\hat{j} + 8.99\hat{k}$$

On the z-axis,

$$\begin{aligned}\vec{E} &= -k\frac{Q}{10001}\left(\frac{1}{\sqrt{10001}}\hat{i} - \frac{100}{\sqrt{10001}}\hat{k} + \frac{1}{\sqrt{10001}}\hat{j} - \frac{100}{\sqrt{10001}}\hat{k}\right) + k\frac{Q}{9801}\hat{k}\\ &= 8.99 \times 10^{-6}\hat{i} + 8.99 \times 10^{-6}\hat{j} - 2.71 \times 10^{-3}\hat{k}\end{aligned}$$

This can also be done by approximating the point charges as 1 point charge $Q = -3\text{nC}$ at $(0, 0, 0)$, which gives a similar result.

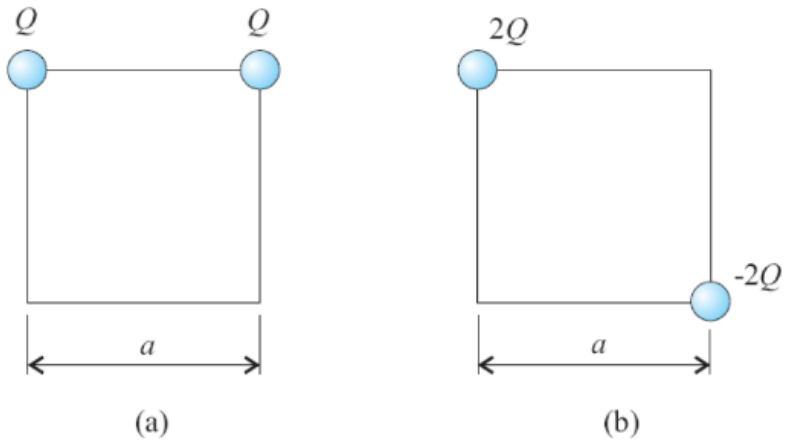

Figure 1: Two small charged bodies

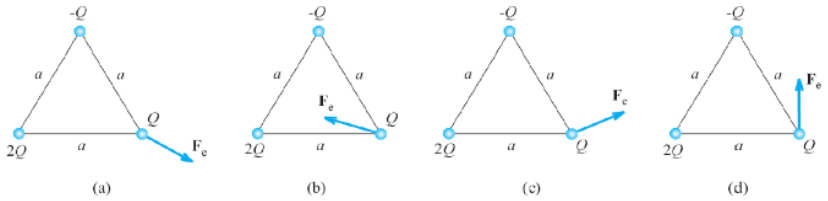

Figure 2: Three point charges