Physics

Question 2.1:

Two charges 5×10^{-8} C and -3×10^{-8} C are located 16 cm apart. At what point(s) on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero.

Answer 2.1:

There are two charges,

$$q_1 = 5 \times 10^{-8} \text{ C}$$
$$q_2 = -3 \times 10^{-8} \text{ C}$$

Distance between the two charges,

d = 16 cm = 0.16 m

Consider a point P on the line joining the two charges, as shown in the given figure.

r = Distance of point P from charge q_1

Let the electric potential (V) at point P be zero.

Potential at point P is the sum of potentials caused by charges q_1 and q_2 respectively.

$$\therefore V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{r} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{(d-r)} \quad \ldots (1)$$

Where,

ε_0 = Permittivity of free space

For V = 0, equation (i) reduces to

$$0 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{r} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{(d-r)} \implies \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{r} = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{(d-r)}$$

$$\implies \frac{q_1}{r} = -\frac{q_2}{(d-r)} \implies \frac{5 \times 10^{-8}}{r} = -\frac{(-3 \times 10^{-8})}{(0.16-r)} \implies 5(0.16 - r) = 3r$$

$$\implies 0.8 = 8r \implies r = 0.1 \text{ m} = 10 \text{ cm}$$

Therefore, the potential is zero at a distance of 10 cm from the positive charge between the charges.

Suppose point P is outside the system of two charges at a distance s from the negative charge, where potential is zero, as shown in the following figure.

For this arrangement, potential is given by,

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{s} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{(s-d)} \cdots \cdots \cdots \cdots \cdots (2)$$

Where,

ε_0 = Permittivity of free space

For V = 0, equation (2) reduces to

$$0 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{s} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{(s-d)} \implies \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{s} = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{(s-d)} \implies \frac{q_1}{s} = -\frac{q_2}{(s-d)}$$

$$\implies \frac{5 \times 10^{-8}}{s} = -\frac{(-3 \times 10^{-8})}{(s-0.16)} \implies 5(s - 0.16) = 3s$$

$$\implies 0.8 = 2s \implies s = 0.4 \text{ m} = 40 \text{ cm}$$

Therefore, the potential is zero at a distance of 40 cm from the positive charge outside the system of charges.

Ap Physics Chapter 2

RS Peters

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