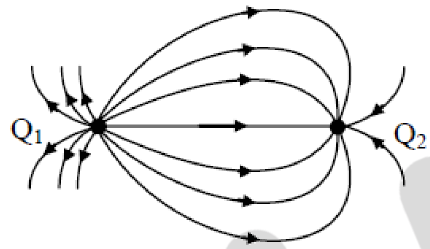
BYJU'S Home Learning Program

Topic covered:

- Electrostatics (Session - 2) - JEE

Daily Practice Problems

1. The electric field lines for two charges Q_1 and Q_2, fixed at two different points on the x-axis are shown in the figure. These lines suggest that

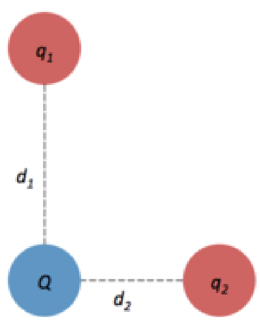


a. $|Q_1| > |Q_2|$
b. $|Q_1| < |Q_2|$
c. $|Q_1| = |Q_2|$
d. Can't say

2. A charge of 1 μC is divided into two parts such that their charges are in the ratio of 2: 3. These two charges are kept at a distance 1 m apart in vacuum. Then, the electric force between them (in N) is

a. 0.216
b. 0.00216
c. 0.0216
d. 2.16

3. Three point charges of strengths $q_1 = 4.0 \times 10^{-6}\, C$, $q_2 = 1.0 \times 10^{-6}\, C$ and $Q = -4.0 \times 10^{-6}\, C$ are fixed in a right triangle as shown blow. The distance between q_1 and Q is $d_1 = 4.0\, cm$ and the distance between q_2 and Q is $d_2 = 3.0\, cm$. What is the approximate electric field strength at location of charge Q due to the other two charges?



a. $2.5 \times 10^7 \frac{N}{C}$
b. $1.8 \times 10^7 \frac{N}{C}$
c. $1.2 \times 10^7 \frac{N}{C}$
d. $0.6 \times 10^7 \frac{N}{C}$

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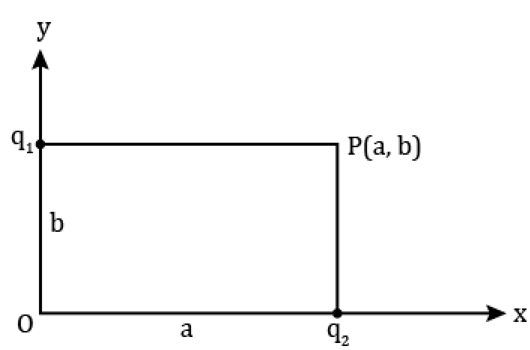
4. Two charges are placed on the x-axis such that a charge of $+ 3\ \mu C$ at $x = 0$ and a charge of $-5\ \mu C$ at $x = 0.40\ m$. Where must a third charge q be placed if the force it experiences is to be zero?
   a. 1.38 m to left of 3 μC
   b. 1.38 m to right of 3 μC
   c. 0.2 m to left of $-5\ \mu C$
   d. 0.2 m to right of $-5\ \mu C$

5. A charged oil drop is suspended in a uniform field of $3 \times 10^4\ V/m$ so that it neither falls nor rises. The charge on the drop will be
   (Take the mass of the charge $= 9.9 \times 10^{-15} kg\ and\ g = 10\ m/s^2$)
   a. $1.6 \times 10^{-18}\ C$
   b. $3.2 \times 10^{-18}\ C$
   c. $3.3 \times 10^{-18}\ C$
   d. $4.8 \times 10^{-18}\ C$

6. A pendulum bob of mass 40 milligram and carrying a charge of 2×10^{-8} C is at rest in a horizontal uniform electric field of 2×10^7 V m^{-1}. Calculate the tension in the thread of the pendulum and the angle it makes with the vertical.
   a. $\theta = 45^0,\ T = \sqrt{32} \times 10^{-1}\ N$
   b. $\theta = 45^0,\ T = \sqrt{8} \times 10^{-1}\ N$
   c. $\theta = 30^0,\ T = \sqrt{32} \times 10^{-1}\ N$
   d. $\theta = 30^0,\ T = \sqrt{8} \times 10^{-1}\ N$

7. 10 charges $q, 8q, 27q, \ldots. 1000q$ are separated at $r, 2r, 3r, \ldots \ldots, 10r$ then calculate the electric field intensity at origin.
   a. $55 \frac{kq}{r^2}$
   b. $110 \frac{kq}{r^2}$
   c. $220 \frac{kq}{r^2}$
   d. $440 \frac{kq}{r^2}$

8. Two-point charges $q_1 = 2$ μC and $q_2 = 1$ μC are placed at distances b = 1 cm and a = 2 cm from the origin on the y and x axes as shown in figure. The electric field vector at point P (a, b) will subtend an angle θ with the x-axis given by
   a. tan θ = 1
   b. tan θ = 2
   c. tan θ = 3
   d. tan θ = 4



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9. A particle of mass m and charge $+q$ is midway between two fixed charged particles, each having a charge $+q$ and at a distance $2L$ apart. The middle charge is displaced slightly along the line joining the fixed charges and released. The time period of oscillation is proportional to

   a. $L^{1/2}$
   b. L
   c. $L^{3/2}$
   d. L^2

10. Two charges 4q and q are placed at a distance ℓ apart. An another charged particle Q is placed in between them (at mid-point). If resultant force on q is zero then the value of Q is

   a. +q
   b. -q
   c. 2q
   d. -2q

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Answer Key

Question Number	1	2	3	4	5	6
Answer Key	(a)	(b)	(a)	(a)	(c)	(a)

Question Number	7	8	9	10
Answer Key	(a)	(b)	(c)	(b)

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Solutions

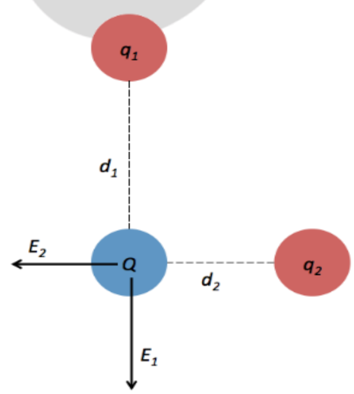
1. (a)
Number of Electric field lines emerging from Q_1 are more than the number of lines terminating at Q_2. So, Q_1 is a positive charge of higher magnitude and Q_2 is a negative charge of smaller magnitude.

2. (b)
Ratio of charges=2: 3
Therefor, $q_1 = \frac{2}{5}\ \mu C$ and $q_2 = \frac{3}{5}\ \mu C$
Electrostatic force between the two charges

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$$

$$= \frac{(9\times10^9)(2\times10^{-6})(3\times10^{-6})}{5\times5\times1^2}$$
$$= 2.16\times10^{-3}\ N$$
$$=0.00216\ N$$

3. (a)
Electric field at point charge Q is the vector sum of the electric field at Q due to q_1 $(i.e\ E_1)$ and the electric field at Q due to q_2 $(i.e\ E_2)$
Because of superposition of electric field on the point charge Q can be divided into two part



$$E_1 = \frac{kq_1}{d_1^2} = \frac{(9\times10^9)(4\times10^{-6})}{(4\times10^{-2})^2} = 2.25\times10^7\ \frac{N}{C}$$
$$E_2 = \frac{kq_2}{d_2^2} = \frac{(9\times10^9)(1\times10^{-6})}{(3\times10^{-2})^2} = 1\times10^7\ \frac{N}{C}$$

Since, electric field E_1 and E_2 are at right angle to each other, the magnitude of the electric field on point charge Q is

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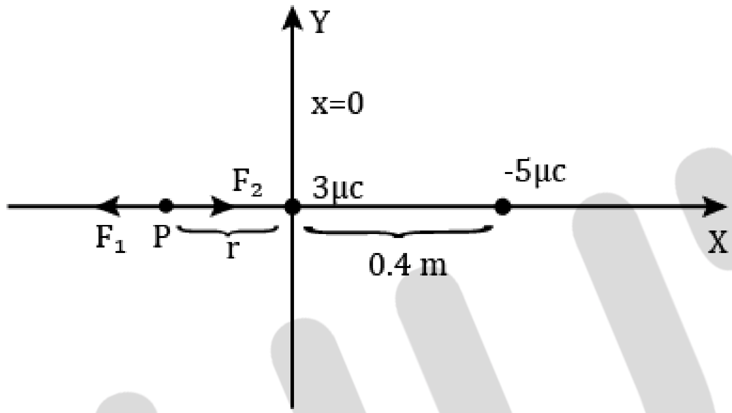
$$E = \sqrt{E_1^2 + E_2^2} = \sqrt{(2.25 \times 10^7)^2 + (1 \times 10^7)^2}$$

$$E = 2.5 \times 10^7 \ \frac{N}{C}$$

4. (a)



From the figure, force can only be zero in the region where point P is located (left of 3μC)

$F_1 = F_2$ for the charge to have net zero force,

$\Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{3 \times 10^{-6} \times q}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{5 \times 10^{-6} \times q}{(r+0.4)^2}$

$\Rightarrow \frac{3}{r^2} = \frac{5}{(r+0.4)^2}$

$\Rightarrow \frac{(r+0.4)}{r} = \pm\sqrt{\frac{5}{3}}$

$\Rightarrow \frac{(r+0.4)}{r} = \pm 1.288$

Since, r has to be positive, therefore

$\frac{(r+0.4)}{r} = +1.288$

Solving, we get r = 1.38 m

Therefore, we need to keep q 1.38 m to the left of 3μC so that it can experience zero net Force.

5. (c)

The charge drop can only remain in equilibrium, if electrostatic force balance weight. Therefore,

$$qE = mg$$

$$\Rightarrow q = \frac{mg}{E} = \frac{9.9 \times 10^{-15} \times 10}{3 \times 10^4} = 3.3 \times 10^{-18} C$$

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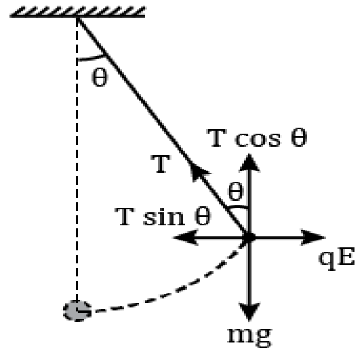
6. (a)



For equilibrium,

$$T\ sin\theta\ =\ qE\ ...(i)$$
$$T\ cos\theta\ =\ mg\ ...(ii)$$

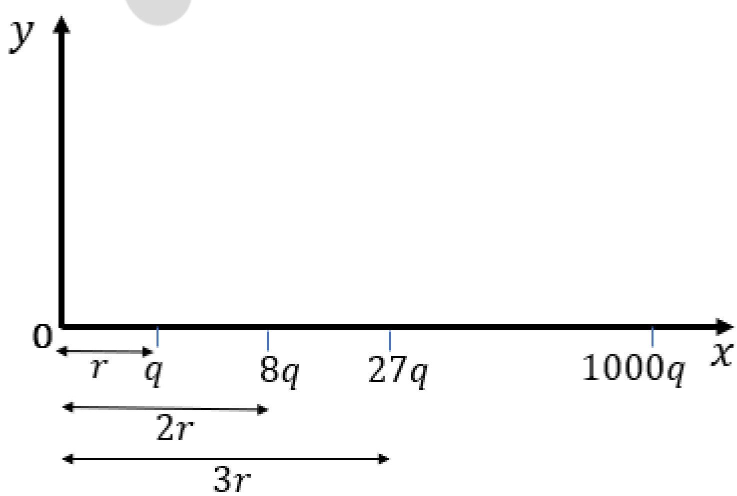
On dividing equation (i) by (ii) we get,

$$\tan\theta = \frac{qE}{mg} = \frac{(2\times10^{-8})(2\times10^{7})}{40\times10^{-3}\times10} = 1$$
$$\theta\ =\ 45°$$

by using equation (i)

$$T\ =\ \frac{qE}{sin\,\theta} = \frac{(2\times10^{-8})(2\times10^{7})}{\sin 45^0} =\ 0.4\sqrt{2}\ \ N = \sqrt{32}\times10^{-1}\ N$$

7. (a)



$$E_0 = E_1 + E_2 + E_3 + \cdots + E_{10}$$
$$E_0 = \frac{kq}{r^2} + \frac{k8q}{(2r)^2} + \frac{k27q}{(3r)^2} + \cdots + \frac{k1000q}{(10r)^2}$$

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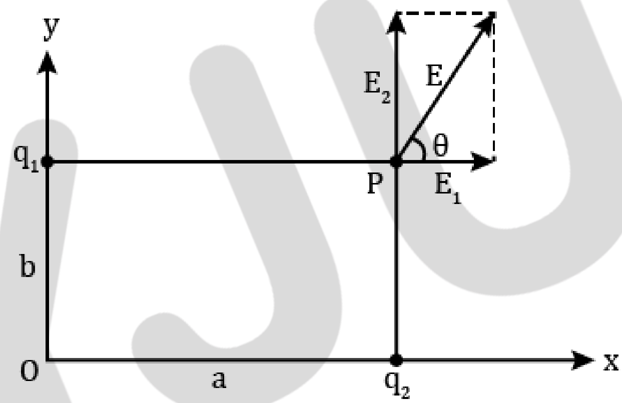
$$E_0 = \frac{kq}{r^2}\left[1 + \frac{8}{4} + \frac{27}{9} + \cdots + \frac{1000}{100}\right]$$
$$\Rightarrow E_0 = \frac{kq}{r^2}[1 + 2 + 3 + \cdots + 10]$$

Sum of 1st n number is given by formula $\frac{n(n+1)}{2}$, therefore

$$E_0 = \frac{kq}{r^2}\left(\frac{n(n+1)}{2}\right)$$
$$\Rightarrow E_0 = \frac{kq}{r^2}\left(\frac{10(10+1)}{2}\right)$$
$$\Rightarrow E_0 = 55\frac{kq}{r^2}$$

8. (b)



Let, Electric field due to charge q_1 be E_1, and electric field due to charge q_2 be E_2.
The electric field E_1 at (P) has a magnitude

$$E_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{a^2}$$

and is directed along $+x$-axis.
The electric field E_2 at (P) due to q_2 has a magnitude.

$$E_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2}{b^2}$$

and is directed along $+y$-axis.
The angle θ subtended by the resultant field E with the x-axis is given by

$$\tan\theta = \frac{E_2}{E_1} = \frac{q_2}{q_1} \cdot \frac{a^2}{b^2} = \frac{1}{2} \times \left(\frac{2}{1}\right)^2 = 2$$

Hence the correct choice is (b).

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9. (c)

If the middle charge is displaced by a distance x, the net force acting it. When it is released, is

$$F = \frac{1}{4\pi\varepsilon_0}\times\frac{q^2}{(L+x)^2} - \frac{1}{4\pi\varepsilon_0}\times\frac{q^2}{(L-x)^2}$$

$$= -\frac{1}{4\pi\varepsilon_0} \times \frac{4q^2Lx}{(L^2-x^2)^2}$$

For $x \ll L$, $F = -\frac{q^2x}{\pi\varepsilon_0 L^3} = -kx$

Where, $k = \frac{q^2}{\pi\varepsilon_0 L^3}$

Now, $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m\pi\varepsilon_0 L^3}{q^2}}$

$\Rightarrow T \propto L^{\frac{3}{2}}$

So, the correct choice is (c)

10. (b)

The force due to $+4q$ on $+q$ is given as,

$F_1 = \frac{1}{4\pi\varepsilon_0} \times \frac{4q\times q}{l^2}$

The force due to Q on +q is given as,

$F_2 = \frac{1}{4\pi\varepsilon_0} \times \frac{Q\times q}{(l/2)^2}$

If the resultant force is zero, then the force due to Q should be opposite to the force due to $+4q$.

Therefore, the charge Q should be negative.

The magnitudes of the two forces should be the same and it can be written as,

$\frac{1}{4\pi\varepsilon_0} \times \frac{4q\times q}{l^2} = -\frac{1}{4\pi\varepsilon_0} \times \frac{Q\times q}{\left(\frac{l}{2}\right)^2}$

$\Rightarrow Q = q$

Thus, the value of Q is −q.

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