BYJU'S Home Learning Program

Topic covered:

- **Electrostatics (Session - 2) - NEET**

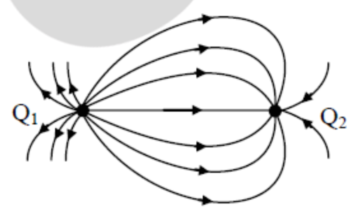
Worksheet

1. A cube of side 'b' has charge 'q' at each of its vertices. The electric field at the centre of the cube will be
   a. $\frac{q}{b^2}$
   b. $\frac{q}{2b^2}$
   c. $\frac{32q}{b^2}$
   d. Zero

2. An electric field can deflect
   a. X-rays
   b. Neutrons
   c. $\alpha - particles$
   d. $\gamma - rays$

3. The conventional direction of electric field is
   a. positive charge to negative charge
   b. negative charge to positive charge
   c. no specific direction
   d. direction cannot be determined

4. A few electric field lines for a system of 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

5. Two charges are placed a certain distance apart in air. If a glass slab is introduced between them, the net force on each charge will
   a. increase
   b. decrease
   c. remain the same
   d. become zero

6. An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The coulombic force F between the two is
   a. $K\frac{e^2}{r^3}\vec{r}$
   b. $K\frac{e^2}{r^2}\vec{r}$
   c. $-K\frac{e^2}{r^3}\vec{r}$
   d. $-K\frac{e^2}{r^2}\vec{r}$

7. What is the magnitude of a point charge which produces an electric field of 2 N C^{-1} at a distance of 60 cm? $\left(\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ Nm^2C^{-2}\right)$
   a. $8 \times 10^{-11}C$
   b. $2 \times 10^{-12}C$
   c. $3 \times 10^{-11}C$
   d. $6 \times 10^{-10}C$

8. A charge of $\sqrt{2}\ C$ is placed at the top of your school building and another equal charge at the top of your house. Take the separation between the two charges to be 2 km. How many kilo-newton of force is exerted by the charges on each other?
   a. 3.2 kN
   b. 4.5 kN
   c. 5 kN
   d. 6.2 kN

9. Determine the electric field vector at a distance of 0.50 m from a charge of −4 μC.
   a. $(-7.2 \times 10^4 NC^{-1})\hat{r}$
   b. $(-14.4 \times 10^4 NC^{-1})\hat{r}$
   c. $(-3.1 \times 10^4 NC^{-1})\hat{r}$
   d. $(-6.2 \times 10^4 NC^{-1})\hat{r}$

10. Two-point charges Q_1 and Q_2 are 3 m apart and their combined charges is 20 μC. If one repels other with force of 0.075 N. Calculate the two charges. (in μC)
    a. 15,5
    b. 10,10
    c. 35, -15
    d. 25, -5

11. From a lithium atom, all electrons are removed, then calculate the magnitude of electric field (in N/C) at a distance 1 m from centre of nucleus
    a. 43.2×10^{-10}
    b. 43.2×10^{-18}
    c. 43.2×10^{5}
    d. 43.2×10^{-6}

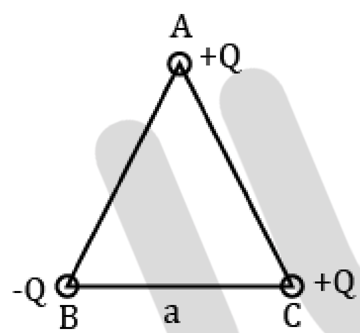
12. The magnitude of electric field required to balance a deuteron of mass 3.2 ×10^{-27} kg is (subjected to gravitational force)
    a. $2\ \times 10^{-7}NC^{-1}$
    b. $0.56\ \times 10^{-7}NC^{-1}$
    c. $2.56\ \times 10^{7}NC^{-1}$
    d. $3.12\ \times 10^{7}NC^{-1}$

13. What is the force between two small charges of $2 \times 10^{-7}\ C$ and $3 \times 10^{-7}\ C$ placed 30 cm apart in air?
    a. $3 \times 10^{-3}\ N$
    b. $9 \times 10^{-3}\ N$
    c. $6 \times 10^{-3}\ N$
    d. $1 \times 10^{-3}\ N$

14. Find out electric field intensity at point A$(0, 1\ m, 2\ m)$ due to a point charge $-80\ \mu C$ situated at point B$(\sqrt{2}\ \ m, 0, 1\ m)$
    a. $3 \times 10^4\left(-\sqrt{2}\hat{\imath} + \hat{\jmath} + \hat{k}\ \right)\frac{N}{C}$
    b. $-6 \times 10^4\left(-\sqrt{2}\hat{\imath} + \hat{\jmath} + 3\hat{k}\ \right)\frac{N}{C}$
    c. $6 \times 10^4\left(-\sqrt{2}\hat{\imath} + \hat{\jmath} + 3\hat{k}\ \right)\frac{N}{C}$
    d. $-9 \times 10^4\left(-\sqrt{2}\hat{\imath} + \hat{\jmath} + \hat{k}\ \right)\frac{N}{C}$

15. A charge q is placed at the centre of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to
    a. $-\frac{Q}{2}$ b. $-\frac{Q}{4}$
    c. $+\frac{Q}{2}$ d. $+\frac{Q}{4}$

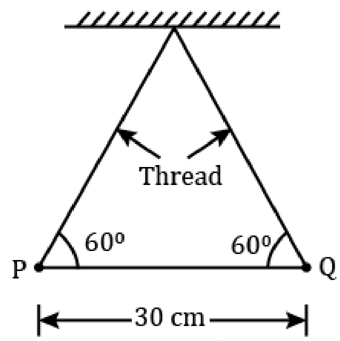
16. Three charges are placed at the vertices of an equilateral triangle of side 'a' as shown in figure. The force experienced by the charge placed at the vertex A in a direction normal to BC is:
    a. $Q^2/(4\pi \in_0 a^2)$ b. $-Q^2/(4\pi \in_0 a^2)$
    c. Zero d. $Q^2/(2\pi \in_0 a^2)$



17. Two small similar spheres A and B having charges 4q and -4q, when placed at a certain distance apart, exert an electric force F on each other. When another identical uncharged sphere C, first touched with A then with B and then removed to infinity, the force of interaction between A and B for the same separation will be
    a. $F/2$ b. $F/8$
    c. $F/16$ d. $F/3$

18. 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

19. Two small identical balls P and Q, each of mass $\sqrt{3}/10$ gram, carry identical charges and are suspended by threads of equal lengths. At equilibrium, they position themselves as shown in figure. What is the charge on each ball. Given $\frac{1}{4\pi\varepsilon_0}$=$9 \times 10^9$ Nm^2C^{-2} and take g = 10 ms^{-2}.



a. 10^{-3} C
b. 10^{-5} C
c. 10^{-7} C
d. 10^{-9} C

20. An infinite number of charges, each q coulomb, are placed along x-axis at x = 1 m, 3 m, 9 m,… Calculate the electric field at the point x = 0 due to these charges, if all the charges are of the same sign.

a. $\frac{1}{4\pi\varepsilon_0}\frac{9q}{8}NC^{-1}$
b. $\frac{1}{4\pi\varepsilon_0}\frac{9q}{10}NC^{-1}$
c. $\frac{1}{4\pi\varepsilon_0}\frac{9q}{7}NC^{-1}$
d. $\frac{1}{4\pi\varepsilon_0}\frac{9q}{5}NC^{-1}$

Answer Key

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

Question Number	7	8	9	10	11	12
Answer Key	(a)	(b)	(b)	(a)	(a)	(a)

Question Number	13	14	15	16	17	18	19	20
Answer Key	(c)	(d)	(b)	(c)	(b)	(c)	(c)	(a)

Solutions

1. (d)
   Electric field intensity at the centre due to all the eight charges is zero, because the fields due to individual charges cancel in pairs.

2. (c)
   An electric field can deflect only charged particles.

3. (a)
   The conventional direction of field lines is from positive to negative. The field lines originate at the positive charge and terminate at the negative charge

4. (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.

5. (b)
   In air, the force between charges is $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$
   When the glass slab is introduced between them, the permittivity becomes $\epsilon = K\epsilon_0$
   where $K =$ dielectric constant of glass.
   Thus, force becomes, $F' = \frac{1}{4\pi K\epsilon_0}\frac{q_1 q_2}{r^2}$
   Hence, $F' < F$

6. (c)
   Using Coulomb's law, the force between two charges is given by,
   $F = \frac{kq_1 q_2}{r^3}\vec{r}$,
   where r= distance between charges.
   Here, $q_1 = -e$, charge of an electron; $q_2 = Ze = e$, charge of the nucleus and $r =$ radius of hydrogen atom.
   (note: for a hydrogen atom, atomic number $= Z = 1$)
   Thus, the force between electron and nucleus will be, $F = \frac{k(-e)e}{r^3}\vec{r} = -k\frac{e^2}{r^3}\vec{r}$

7. (a)
   As, $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$
   $2 = \frac{9\times10^9\times q}{(0.6\times0.6)}$
   $\Rightarrow q = 8\times10^{-11}\ C$

8. (b)

$$q_1 = q_2 = \sqrt{2}\,C, r = 2\times 10^3 m, F = ?$$
$$F = 9\times 10^9\ \frac{\sqrt{2}\times\sqrt{2}}{(2\times 10^3)^2} N$$
$$= 4.5\times 10^3 N = 4.5\ kN$$

9. (b)

$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q\hat{r}}{r^2} = \frac{9\times10^9\times[-4\times10^{-6}]}{(0.5)^2} = [-14.4\times 10^4\ NC^{-1}]\hat{r}$

10. (a)

Since combined charge of Q_1 and Q_2 is
$Q_1 + Q_2 = 20\ \mu C$ ....(1)
The force is repulsive, so according to Coulomb's Law
$0.075 = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2} = 9\times 10^9\left[\frac{Q_1Q_2}{(3)^2}\right]$
$\Rightarrow\ Q_1Q_2 = 75\times 10^{-6}\ C = 75\ \mu C$
Substituting value of Q_2 from (1)
$Q_1(20 - Q_1) = 75$
$\Rightarrow\ Q_1^2 - 20Q_1 + 75 = 0$
$\Rightarrow\ Q_1 = 15, 5$
So, $Q's$ are 5 μC and 15 μC

11. (a)

$$q = 3\times 1.6\times 10^{-19}\ C$$

Electric field (E)= $\frac{kq}{r^2}$

$$E = \frac{9\times 10^9\ \times 3\times 1.6\times 10^{-19}}{1} = 43.2\times 10^{-10}$$

12. (a)

Deuteron is made of a proton and a neutron.
For force balance, $qE\ =\ mg$
$\Rightarrow E = \frac{mg}{q} = \frac{3.2\times10^{-27}\times10}{1.6\times10^{-19}} = 2\ \times 10^{-7}NC^{-1}$

13. (c)

$$F = \frac{1}{4\pi\ \epsilon_0}\frac{q_1q_2}{r^2}$$
$$F = 9\times 10^9\times\frac{(2\times 10^{-7})(3\times 10^{-7})}{(0.3)^2}$$
$$F = 6\times 10^{-3}\ N$$

14. (d)

Here, $\vec{r_A} = 0\hat{\imath} + 1\hat{\jmath} + 2\hat{k}$ and $\vec{r_B} = \sqrt{2}\hat{\imath} + 0\hat{\jmath} + 1\hat{k}$

$\Rightarrow \vec{r_A} - \vec{r_B} = -\sqrt{2}\hat{\imath} + 1\hat{\jmath} + 1\hat{k}$

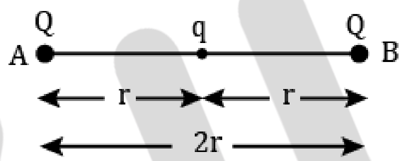
$\Rightarrow |\vec{r_A} - \vec{r_B}| = \sqrt{\left(-\sqrt{2}\right)^2 + (1)^2 + (1)^2} = 2 \text{ m}$

Since $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{|\vec{r_A}-\vec{r_B}|^3}(\vec{r_A} - \vec{r_B})$

$$\vec{E} = \frac{(-80 \times 10^{-6}) \times 9 \times 10^9}{(2)^3}(-\sqrt{2}\hat{\imath} + \hat{\jmath} + \hat{k})$$

$$\vec{E} = -9 \times 10^4\left(-\sqrt{2}\hat{\imath} + \hat{\jmath} + \hat{k}\right) N/C$$

15. (b)



The three charges will be in equilibrium, if no net force acts on each charge, q is in equilibrium because the forces exerted on q by charge Q at A and charge Q at B are equal and opposite, i.e. if

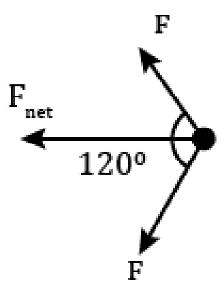
$\frac{qQ}{4\pi\varepsilon_0 r^2} = \frac{Q \times Q}{4\pi\varepsilon_0 (2r)^2}$

or $q = -\frac{Q}{4}$

Similarly, charge Q at B will be in equilibrium if q $= -\frac{Q}{4}$. Hence the correct choice is (b)

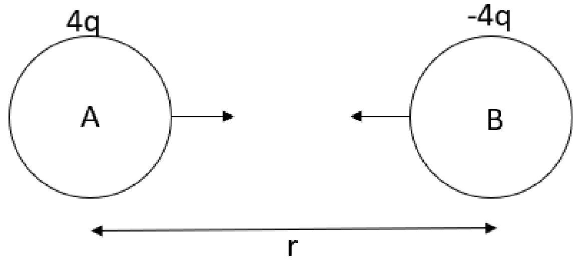
16. (c)

Forces on charge at A



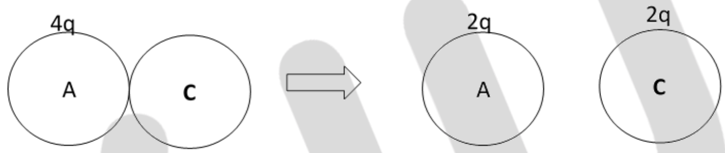
The net force F_{net} is as shown, so, there is no component of net force normal to BC.

17. (b)



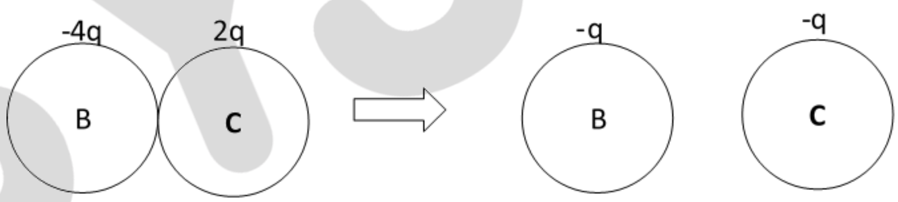
$$F = k\frac{(4q)(-4q)}{r^2}$$

Case:1 When C is touched with A, then charge on A & C each = 2q

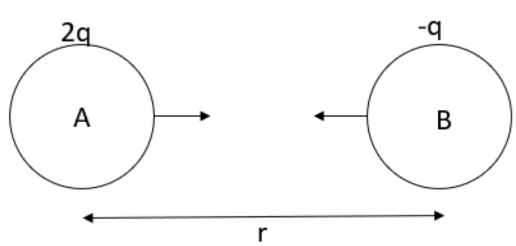


Case:2 After that C is touched with B, charge on

$$B = \frac{2q + (-4q)}{2} = -q$$



Case:3



Now, force $F' = \frac{1}{4\pi\varepsilon_0}\frac{(2q)(-q)}{r^2} \Rightarrow F' = \frac{F}{8}$

18. (c)

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

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

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

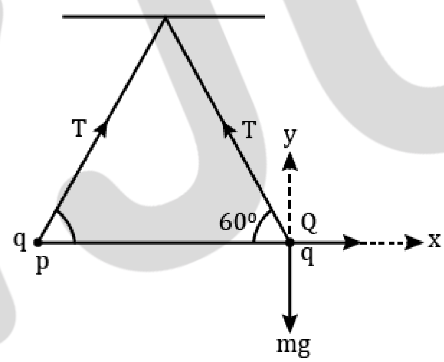
For $x \ll L$, $F = -\frac{q^2x}{\pi\varepsilon_0 L^3} = -kx$

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

Now, $T = 2\pi\sqrt{\frac{m}{k}}$

So, the correct choice is (c)

19. (c)



Let us consider forces on a ball, say, Q. Three forces act on it: (i) tension T in the thread, (ii) force mg to gravity and (iii) force F due to Coulomb repulsion along +ve x-direction. For equilibrium, the sum of the x and y components of these forces must be zero.

i.e. $T\cos 60° - F = 0 \ldots (i)$

and, $T\sin 60° - mg = 0 \ldots (ii)$

From second equation $T = \frac{mg}{\sin 60}$

Replacing this T in equation (i) we get,

$$\frac{mg}{\sin 60} \times \cos 60 = F$$

$$mg\cot 60 = F$$

These equations give mg cot 60° = $\frac{\sqrt{3}}{10} \times 10^{-3} \times 10 \times \frac{1}{\sqrt{3}} = 10^{-3}$ N.

Now,

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

Putting $F = 10^{-3}$N, r = 0.3 m and $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$,

$$10^{-3} = \frac{(9 \times 10^9)(q^2)}{0.3^2}$$
$$\frac{10^{-3}}{10^{11}} = q^2$$
$$q = 10^{-7}$$

We get q = 10^{-7} coulomb.

20. (a)

$$E_0 = E_1 + E_2 + E_3 + \cdots$$
$$E_0 = \frac{kq}{1^2} + \frac{kq}{3^2} + \frac{kq}{9^2} + \cdots$$
$$E_0 = kq\left[\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{9^2} + \ldots..\right]$$
$$E_0 = \frac{q}{4\pi \in_0}\left[1 + \frac{1}{9} + \frac{1}{81} + \cdots\right]$$

As we know that $S_\infty = \frac{a}{(1-r)}$

Where a is the first term and $r = \frac{b}{a} = \frac{\frac{1}{9}}{1} = \frac{1}{9}$

$$E_0 = \frac{q}{4\pi \in_0}\left[\frac{a}{(1-r)}\right] = \frac{q}{4\pi \in_0}\left[\frac{1}{(1-\frac{1}{9})}\right]$$
$$E_0 = \frac{9}{8}\frac{q}{4\pi \in_0}$$