	INDIAN SCHOOL AL WADI AL KABIR	
Class: XII	Department: SCIENCE 2024 – 25 SUBJECT: PHYSICS	Date: 15-04-2024
Worksheet No: 1 WITH ANSWERS	CHAPTER: 1; ELECTRIC CHARGES AND FIELDS	Note: A4 FILE FORMAT
NAME OF THE STUDENT	CLASS & SEC:	ROLL NO.

1. 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) $+\frac{Q}{4}$ (d) $+\frac{Q}{2}$

***Solution*:**

Let $2l$ = distance between the equal charges. For equilibrium of each outer charge,

$$\frac{Qq}{4\pi\varepsilon_0 l^2}+\frac{Q^2}{4\pi\varepsilon_0 (2l)^2}=0 \Rightarrow q+\frac{Q}{4}=0$$

$\Rightarrow \quad q = -\frac{Q}{4}$

$\therefore$ **(b)**

2. Three-point charges $4q$, Q and q are placed on a straight line of length l at points distant 0, $\frac{l}{2}$ and l respectively. The net force on charge q is zero. The value of Q is

(a) $-q$ (b) $-2q$ (c) $-\frac{1}{2}q$ (d) $4q$

***Solution*:**

Force between charges $4q$ and q = $\frac{1}{4\pi\varepsilon_0}\frac{4q^2}{l^2}$

Force between charges Q and q = $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Qq}{\left(\frac{l}{2}\right)^2}$

$$\therefore \quad \frac{1}{4\pi\varepsilon_0}\cdot\frac{4Qq}{l^2}=-\frac{1}{4\pi\varepsilon_0}\cdot\frac{4q^2}{l^2}$$

$Q = -q$

$\therefore$ **(a)**

3. A charge Q is placed at each of the two opposite corners of a square. A charge q is placed at each of the other two corners. If the resultant electric force on Q is zero, then Q is equal to

(a) $\frac{2\sqrt{2}}{q}$ (b) $\frac{-q}{2\sqrt{2}}$ (c) $-2\sqrt{2}q$ (d) $2\sqrt{2}q$

Solution:

Obviously, Q and q should be of opposite signs and the resultant intensity

$$\vec{E}_1+\vec{E}_2+\vec{E}_3=0$$

$$|\vec{E}_1|=|\vec{E}_2|=\frac{1}{4\pi\varepsilon_0}\cdot\frac{Qq}{a^2}$$

where 'a' is the side of the square.

$$|\vec{E}_3|=\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q^2}{(a\sqrt{2})^2}$$

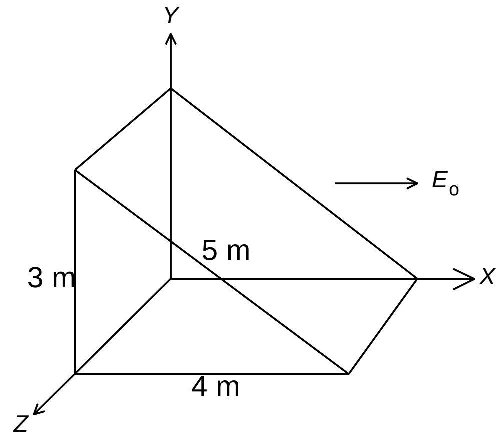
Now $|\vec{E}_1+\vec{E}_2|=E_1\sqrt{2}=|\vec{E}_3|$ which gives $Q = -2\sqrt{2}q$

∴ **(c)**

4. **The wedge-shaped surface in figure is in a region of uniform electric field *E*₀ along *x* axis. The net electric flux for the entire closed surface is**

(a)9 E_0 **(b) 15 E_0**

(c) 12 E_0 **(d) zero**



Solution:

Since field is uniform, the net flux for the closed surface is zero.

∴ **(d)**

5. A charge *Q* is placed at the centre of a cube. The flux of the electric field through the six surfaces of the cube is

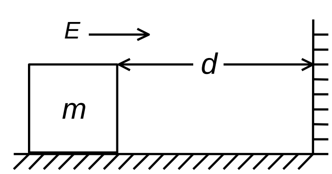
(a) $\frac{Q}{6\varepsilon_0}$ **(b)** $\frac{Q}{\varepsilon_0}$ **(c)** $\frac{Q}{6L^2}$ **(d)** $\frac{Q}{3L^2}$

Solution:

From Gauss's law $\phi_E=\frac{Q_{enc}}{\varepsilon_0}$

∴ **(b)**

***6.*A block of mass *m* carrying a positive charge *q* is placed on a smooth horizontal table, which ends in a vertical wall situated at a distance <u>*d*</u> from block. An electric field *E* is switched on towards right. Assuming elastic collisions, find the time period of resultant oscillation.**



(a) $\sqrt{\frac{2qEd}{m}}$ **(b)** $\sqrt{\frac{8md}{qE}}$

(c) $\sqrt{\dfrac{2md}{qE}}$ (d) $\sqrt{\dfrac{md}{qE}}$

***Solution*:**

Acceleration of the block $a = \dfrac{qE}{m}$

$d = \dfrac{1}{2}at^2$

Required time $= 2t = \sqrt{\dfrac{8md}{qE}}$

∴ **(b)**

***7.* An electric dipole is placed in an electric field generated by a point charge. Then**

(a) the net electric force on the dipole must be zero

(b) the net electric force on the dipole may be zero

(c) the torque on the dipole due to the field may be zero

(d) the torque on the dipole due to the field must be zero

***Solution*:**

The field is not uniform. However, the torque on the dipole can be zero if it is aligned along the line of force.

∴ **(c)**

Directions: Choose any one of the following four responses.

(a) Both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) Both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) Assertion is correct, Reason is incorrect
(d) Both Assertion and Reason are correct.

8. **Assertion:** A metallic shield in form of a hollow shell may be built to block an electric field.
Reason: In a hollow spherical shield, the electric field inside it is zero at every point.

Ans; a

9. **Assertion:** Electric lines of force never cross each other.
Reason: Electric field at a point superimpose to give one resultant electric field.

Ans; a

10. **Assertion:** The Coulomb force is the dominating force in the universe.
Reason: The Coulomb force is weaker than the gravitational force.

Ans; d

11. **Assertion:** When bodies are charged through friction, there is a transfer of electric charge from one body to another, but no creation or destruction of charge.
Reason: This follows from conservation of electric charges.
Ans; a

***12.* How many electrons must be removed from a piece of metal so as to leave it with a positive charge of 3.2×10^{-17} coulomb?**

Solution: From 'Quantization of charge' we know, $Q = ne$

$$\square\ n = \frac{Q}{e} = \frac{3.2\times10^{-17}C}{1.6\times10^{-19}C} = \mathbf{200}$$

13. **A copper penny has a mass of 32 g. Being electrically neutral, it contains equal amounts of positive and negative charges. What is the magnitude of these charges in □C. A copper atom has a positive nuclear charge of 3 □ 10$^{□26}$ C. Atomic weight of copper is 64g/mole and Avogadro's number is 6 □ 10 $^{-26}$ atoms/mole.**

Solution: 1 mole i.e., 64 g of copper has 6 □ 10^{23} atoms. Therefore, the number of atoms in copper penny of 32 g is

$$\frac{6\times10^{23}}{64}\times32\times10^{-3} = 3\times10^{20}$$

One atom of copper has each positive and negative charge of 3 □ 10$^{□26}$ C. So each charge on the penny is

(3 □ 10^{20}) □ (3 □ 10 $^{-26}$) = **9□C.**

14. **The electron and the proton in a hydrogen atom are 0.53 × 10^{-11} m apart. Compare the electrostatic and the gravitational forces between them in power of 10^{-41}.**

Solution: The magnitude of the electrostatic force is

$$F_E = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

$$= \frac{(9\times10^9\ \text{N}-\text{m}^2/\text{C}^2)\times(1.6\times10^{-19}\text{C})^2}{(5.3\times10^{-11}\text{m})^2}$$

$$= 8.2\times10^{-8}\ \text{N}$$

The magnitude of the gravitational force is

$$F_G = G\frac{m_e\, m_p}{r^2}$$

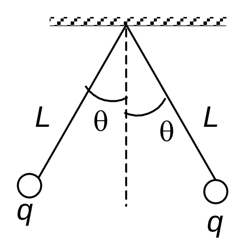
$$= \frac{(6.67\times10^{-11}\text{N}-\text{m}^2/\text{kg}^2)(9.11\times10^{-31}\text{kg})(1.67\times10^{-27}\text{kg})}{(5.3\times10^{-11}\text{m})^2}$$

$$= 3.6\times10^{-47}\ \text{N}$$

The ratio of the forces

$$\frac{F_G}{F_E} = \mathbf{44}$$

15. T**wo identical small charged spheres, each having a mass of 3.0 × 10^{-2} kg, hang in equilibrium as shown below. If the length of each string is $\sqrt{\frac{3}{2}}$ m and the angle □ = 45°, find the magnitude of the charge on each sphere in nC. (*g* = 10 m/s^2)**

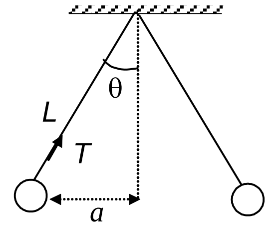


Solution: From the right angled triangle, we have $\sin\theta = \frac{a}{L}$

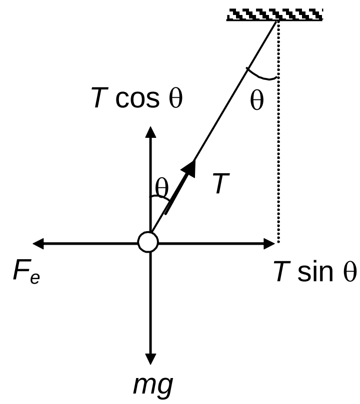
or, $a = L\sin\theta$ = (15 m) sin 5° = 0.013 m

Hence, the separation of the spheres is

$2a$ = 0.026 m



F.B.D. of one of the spheres:-



Since the sphere is in equilibrium, the resultants of the forces in the horizontal and vertical directions must separately add up to zero. thus

$T\sin\theta - F_e = 0$

∴ $T\sin\theta = F_e$ … (i)

and $T\cos\theta - mg = 0$

∴ $T\cos\theta = mg$ … (ii)

Dividing equation (i) by equation (ii) , we get

$$\tan\theta = \frac{F_e}{mg} \quad \text{or,} \quad F_e = mg\tan\theta$$

$= (3 \times 10^{-2}\text{ kg}) \times (10\text{ m/s}^2)(\tan 45°)$

$= 0.3$ N

Let q be charge on each sphere.

According to Coulomb's law

$$F_e = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{|q||q|}{r^2}$$

∴ q = **15 μC**

16. **An electron ($q = -e$) is placed near a charged body experiences a force in the positive y direction of magnitude 3.60×10^{-8} N.**

(a) The electric field at that location is $x \times 10^{-9,}$ find x. (where x is in N)

(b) What would be the force exerted by the same charged body on an alpha particle ($q = +2e$) placed at the location initially occupied by the electron?

Solution: Using equation (7), we have

$$E_y = \frac{|F_y|}{|q_0|} = \frac{3.60 \times 10^{-8}\text{N}}{1.60 \times 10^{-19}\text{C}} = \mathbf{225}$$

The electric field is in the negative y direction.

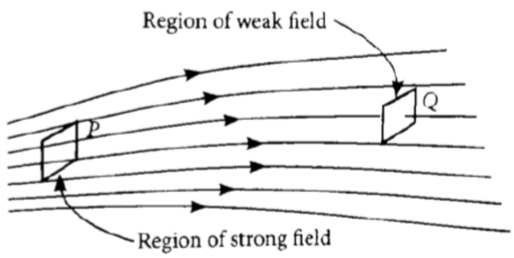
(b) The force on the alpha particle is given by

$F_y = q_0 E_y = 2(+1.60 \times 10^{-19}\text{ C})(2.25 \times 10^{11}\text{ N/C})$ = **72**

The force is in the negative *y* direction, the same direction as the electric field.

Case Study Questions

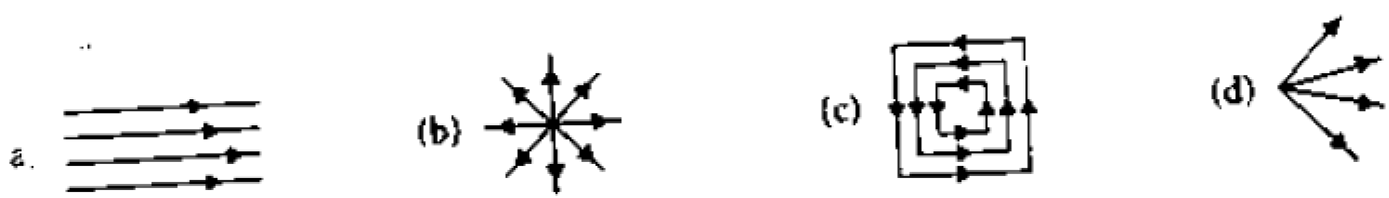
1.Electric field strength is proportional to the density of lines of force i.e., electric field strength at a point is proportional to the number of lines of force cutting a unit area element placed normal to the field at that point. As illustrated in given figure, the electric field at P is stronger than at Q.



(i) Electric lines of force about a positive point charge are
(a) radially outwards (b) circular clockwise
(c) radially inwards (d) parallel straight lines

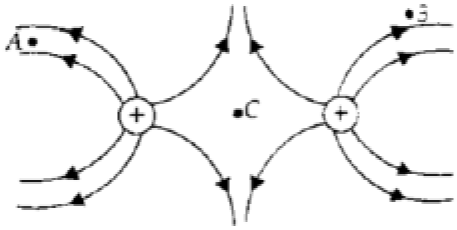
(ii) Which of the following is false for electric lines of force?
(a) They always start from positive charge and terminate on negative charges.
(b) They are always perpendicular to the surface of a charged conductor.
(c) They always form closed loops.
(d) They are parallel and equally spaced in a region of uniform electric field.

(iii) Which one of the following patterns of electric line of force is not possible in field due to stationary charges?



(iv) Electric field lines are curved
(a) in the field of a single positive or negative charge
(b) in the field of two equal and opposite charges.
(c) in the field of two like charges.
(d) both (b) and (c)

(v) The figure below shows the electric field lines due to two positive charges. The magnitudes E_A, E_B and E_C of the electric fields at point A, B and C respectively are related as



(a) $E_A>E_B>E_C$ (b) $E_B>E_A>E_C$ (c) $E_A=E_B>E_C$ (d) $E_A>E_B=E_C$

Answers: (i) a (ii) (c) (iii) (c) (iv)(d) (v) (a)

2.

Smallest charge that can exist in nature is the charge of an electron. During friction it is only the transfer of electron which makes the body charged. Hence net charge on any body is an integral multiple of charge of an electron (1.6×10^{-19} C) i.e., q=±ne
where r= 1, 2, 3, 4 ….
Hence no body can have a charge represented as 1.8e, 2.7e, 2e/5, etc.
Recently, it has been discovered that elementary particles such as protons or neutrons are elemental units called quarks.

(i) Which of the following properties is not satisfied by an electric charge?
(a) Total charge conservation. (b) Quantization of charge.
(c) Two types of charge. (d) Circular line of force.

(ii) Which one of the following charges is possible?
(a) 5.8×10^{-18} C (b) 3.2×10^{-18} C
(c) 4.5×10^{-19} C (d) 8.6×10^{-19} C

(iii) If a charge on a body is 1 nC, then how many electrons are present on the body?
(a) 6.25×10^{27} (b) 1.6×10^{19} (c) $6.25 X 10^{28}$ (d) $6.25 X 10^{9}$

(iv) If a body gives out 10^9 electrons every second, how much time is required to get a total charge of 1 from it?
(a) 190.19 years (b) 150.12 years (c) 198.19 years (d) 188.21 years

(v) A polythene piece rubbed with wool is found to have a negative charge of 3.2×10^{-7}C. Calculate the number of electrons transferred.
(a) 2×10^{12} (b) 3×10^{12} (c) 2×10^{14} (d) 3×10^{14}

Answers: (i) (d) (ii) (b) (iii) (d) (iv)(c) (v) (a)

PREVIOUS YEAR QUESTIONS

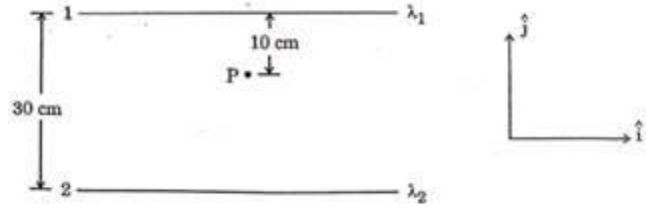
1. Coulomb force F versus ($1/r^2$) graphs for two pairs of point charges (q_1 and q_2) and (q_2 and q_3) are shown in the figure. The ratio of charges (q_2/q_3) is: CBSE 2024
(a) *3* (b) 1/*3* (c) 3 (d) 1/3

2. Two charge particles P and Q having the same charge but different masses m_P and m_Q, starts from rest and travel equal distances in a uniform electric field E in the tome t_P and t_Q respectively. Neglecting the effect of gravity, the ratio (t_P / t_Q) is: CBSE 2024

(a) m_P / m_Q (b) m_Q / m_P (c) $\sqrt{m_P / m_Q}$ (d) $\sqrt{m_Q / m_P}$

3. (i) State Gauss's Law in electrostatics. Apply this to obtain the electric field at appoint near a uniformly charged infinite sheet. CBSE 2024

(ii) Two long straight wires 1 and 2 are kept as shown in the figure. The linear charge density of the two wires are λ_1 = 10 μ C/m and $\lambda 2$ = - 20 μC/m. Find the net force F experienced by an electron held at point P.



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