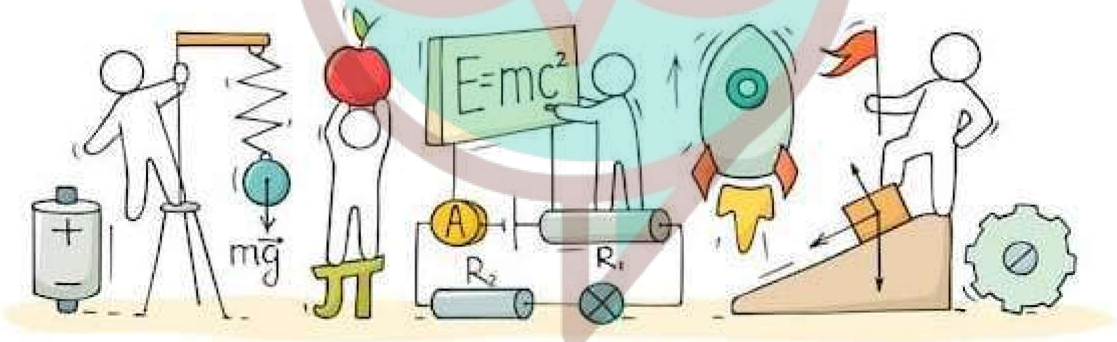
# PHYSICS



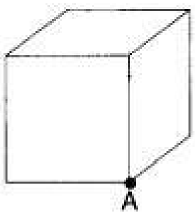
# Important Questions

## Multiple Choice questions-

1. The surface considered for Gauss's law is called

(a) Closed surface
(b) Spherical surface
(c) Gaussian surface
(d) Plane surface

2. The total flux through the faces of the cube with side of length a if a charge q is placed at corner A of the cube is




(a) $\frac{q}{8\varepsilon_0}$ (b) $\frac{q}{4\varepsilon_0}$

(c) $\frac{q}{2\varepsilon_0}$ (d) $\frac{q}{\varepsilon_0}$

3. Which of the following statements is not true about Gauss's law?

(a) Gauss's law is true for any closed surface.
(b) The term q on the right side of Gauss's law includes the sum of all charges enclosed by the surface.
(c) Gauss's law is not much useful in calculating electrostatic field when the system has some symmetry.
(d) Gauss's law is based on the inverse square dependence on distance contained in the coulomb's law

4. A charge Q is placed at the center of the line joining two point charges +q and +q as shown in the figure. The ratio of charges Q and q is


(a) 4
(b) 1/4
(c) -4
(d) -1/4

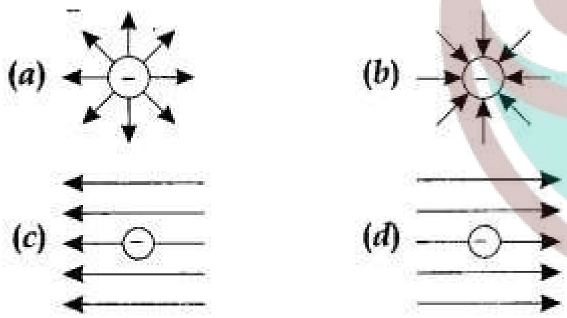
5. The force per unit charge is known as

(a) electric flux
(b) electric field
(c) electric potential
(d) electric current

6. Electric field lines provide information about

(a) field strength
(b) direction
(c) nature of charge
(d) all of these

7. Which of the following figures represent the electric field lines due to a single negative charge?




8. The SI unit of electric flux is

(a) N $C^{-1}$ $m^{-2}$
(b) N C $m^{-2}$
(c) N $C^{-2}$ $m^{2}$
(d) N $C^{-1}$ $m^{2}$

9. The unit of electric dipole moment is

(a) newton
(b) coulomb
(c) farad
(d) Debye

10. Consider a region inside which, there are various types of charges but the total charge is zero. At points outside the region

(a) the electric field is necessarily zero.
(b) the electric field is due to the dipole moment of the charge distribution only.

(c) the dominant electric field is inversely pro-portional to r3, for large r (distance from origin).

(d) the work done to move a charged particle along a closed path, away from the region will not be zero.

## Very Short:

1. What is the value of the angle between the vectors $\vec{P}$ and $\vec{E}$ for which the potential energy of an electric dipole of dipole moment $\vec{P}$, kept in an external electric field $\vec{E}$, has maximum value.
2. Define electric field intensity at a point.
3. Two equal point charges separated by 1 m distance experience force of 8 N. What will be the force experienced by them, if they are held in water, at the same distance? (Given: $K_{water}$ = 80) (CBSE AI 2011C)
4. A charge 'q' is placed at the centre of a cube of side l. What is the electric flux passing through each face of the cube? (CBSE AI 2012) (CBSE Sample Paper 2019)
5. Why do the electric field lines not form closed loops? (CBSE AI 2012C)
6. Two equal balls having equal positive charge 'q' coulomb are suspended by two insulating strings of equal length. What would be the effect on the force when a plastic sheet is inserted between the two? (CBSE AI 2014)
7. What is the electric flux through a cube of side l cm which encloses an electric dipole? (CBSE Delhi 2015)
8. Why are electric field lines perpendicular at a point on an equipotential surface of a conductor? (CBSE AI 2015C)
9. What is the amount of work done in moving a point charge Q. around a circular arc of radius 'r' at the centre of which another point charge 'q' is located? (CBSE AI 2016)
10. How does the electric flux due to a point charge enclosed by a spherical Gaussian surface get affected when its radius is increased? (CBSE Delhi 2016)

## Short Questions:

1.

(a) Electric field inside a conductor is zero. Explain.

(b) The electric field due to a point charge at any point near it is given as

$$\mathbf{E} = \lim_{q \to 0} \frac{F}{q}$$

what is the physical significance of this limit?

2. Define the electric line of force and give its two important properties.

3. Draw electric field lines due to (i) two similar charges, (ii) two opposite charges, separated by a small distance.

4. An electric dipole is free to move in a uniform electric field. Explain what is the force and torque acting on it when it is placed

(i) parallel to the field

(ii) perpendicular to the field

5. A small metal sphere carrying charge +Q. is located at the centre of a spherical cavity in a large uncharged metallic spherical shell. Write the charges on the inner and outer surfaces of the shell. Write the expression for the electric field at the point $P_1$ (CBSE Delhi 2014C)

6. Two-point charges q and -2q are kept 'd' distance apart. Find the location of the point relative to charge 'q' at which potential due to this system of charges is zero. (CBSE AI 2014C)

7. Two small identical electrical dipoles AB and CD, each of dipole moment 'p' are kept at an angle of 120° as shown in the figure. What is the resultant dipole moment of this combination? If this system is subjected to the electric field ($\vec{E}$) directed along +X direction, what will be the magnitude and direction of the torque acting on this? (CBSE Delhi 2011)

8. A metallic spherical shell has an inner radius $R_1$ and outer radius $R_2$. A charge Q is placed at the centre of the spherical cavity. What will be surface charge density on (i) the inner surface, and (ii) the outer surface? (NCERT Exemplar)

## Long Questions:

1.

(a) State Gauss theorem in electrostatics. Using it, prove that the electric field at a point due to a uniformly charged infinite plane sheet is independent of the distance from it.

(b) How is the field directed if (i) the sheet is positively charged, (ii) negatively charged? (C8SE Delhi 2012)

2. Use Gauss's law to derive the expression for the electric field ($\vec{E}$) due to a straight uniformly charged infinite line of charge λ $Cm^{-1}$. (CBSE Delhi 2018)

## Assertion and Reason Questions-

**1.** For two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

a) Both A and R are true, and R is the correct explanation of A.
b) Both A and R are true, but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false and R is also false.

**Assertion (A):** The electric flux emanating out and entering a closed surface are $8 \times 10^3$ and $2 \times 10^3$Vm respectively. The charge enclosed by the surface is 0.053μC.

**Reason (R):** Gauss's theorem in electrostatics may be applied to verify.

**2.** For two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

a) Both A and R are true, and R is the correct explanation of A.

b) Both A and R are true, but R is not the correct explanation of A.

c) A is true but R is false.

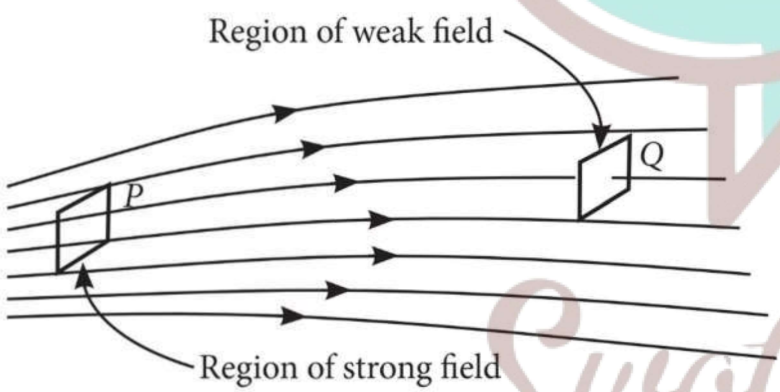
d) A is false and R is also false.

**Assertion (A):** Charge is quantized.

**Reason (R):** Charge which is less than I C is not possible.

## 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 the given figure, the electric field at P is stronger that 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 charges and terminate on negative charges.

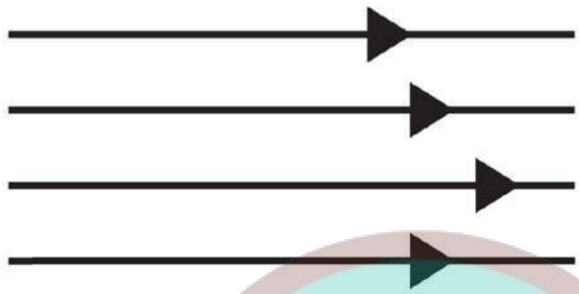
b) They are always perpendicular to the surface of a charged conductor.

c) They always form closed loops.

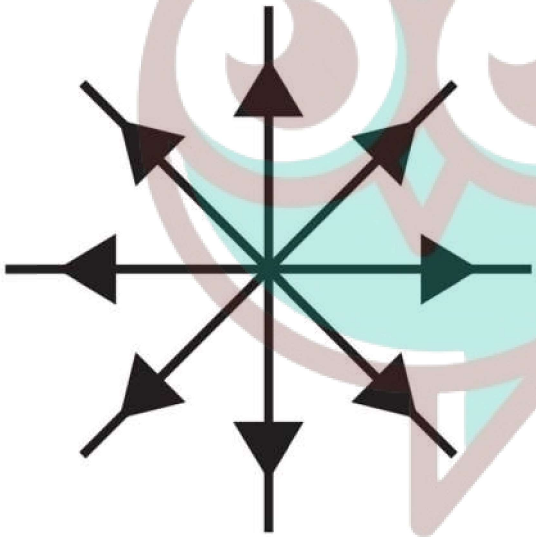
d) They are parallel and equally spaced in a region of uniform electric field.

(iii) Which one of the following pattern of electric line of force in not possible in filed due to stationary charges?

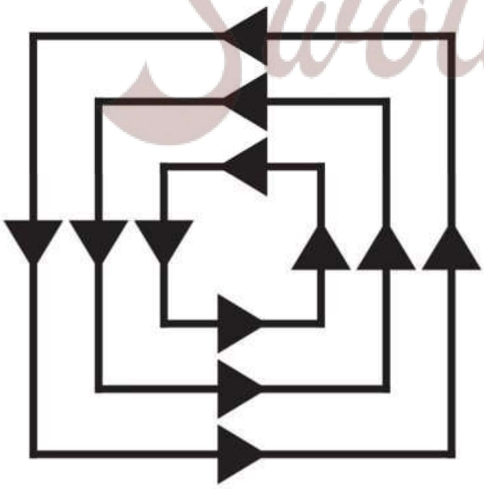
**a)**



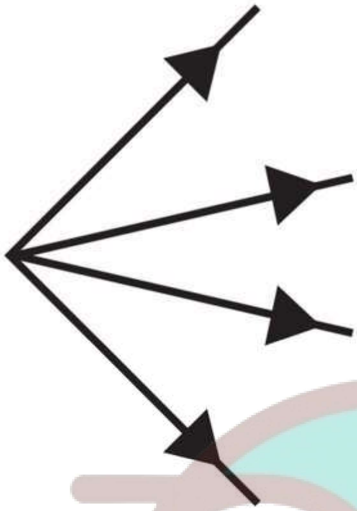
**b)**



**c)**



d)



(iv) Electric lines of force are curved:

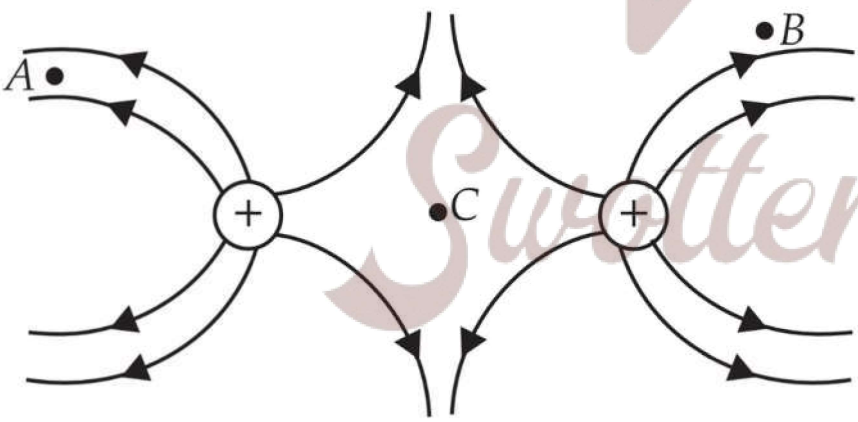
a) In the field of a single positive or negative charge.

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 points A, Band C respectively are related as:



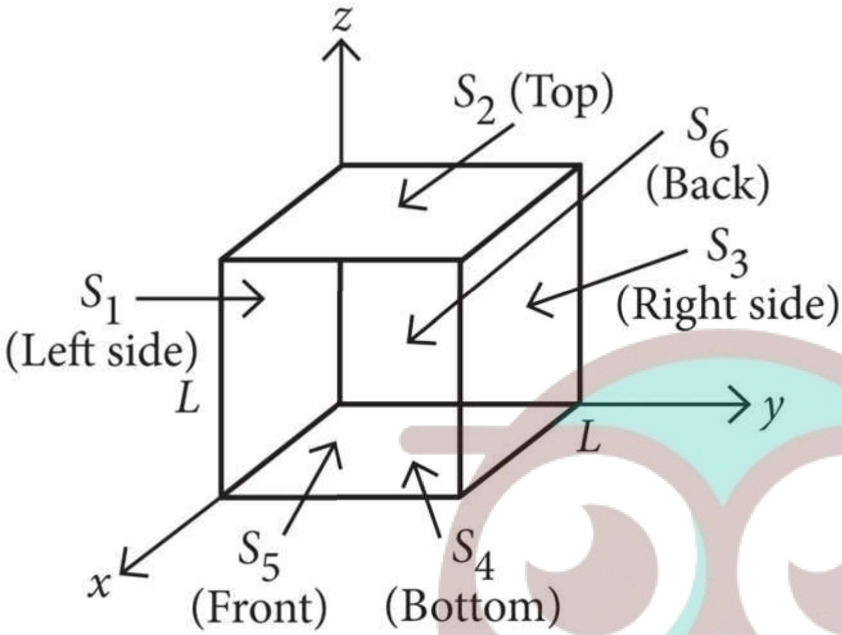

a) $E_A > E_B > E_C$

b) $E_B > E_A > E_C$

c) $E_A = E_B > E_C$

d) $E_A > E_B = E_C$

**2.** Net electric flux through a cube is the sum of fluxes through its six faces. Consider a cube as shown in figure, having sides of length L = 10.0cm. The electric field is uniform, has a magnitude $E = 4.00 \times 10^3 N C^{-1}$ and is parallel to the xy plane at an angle of 37º measured from the + x - axis towards the + y - axis.




(i) Electric flux passing through surface $S_6$ is:

a) $-24 N m^2 C^{-1}$

b) $24 N m^2 C^{-1}$

c) $32 N m^2 C^{-1}$

d) $-32 N m^2 C^{-1}$

(ii) Electric flux passing through surface $S_1$ is:

a) $-24 N m^2 C^{-1}$

b) $24 N m^2 C^{-1}$

c) $32 N m^2 C^{-1}$

d) $-32 N m^2 C^{-1}$

(iii) The surfaces that have zero flux are:

a) $S_1$ and $S_3$

b) $S_5$ and $S_6$

c) $S_2$ and $S_4$

d) $S_1$ and $S_2$

(iv) The total net electric flux through all faces of the cube is:

a) $8 N m^2 C^{-1}$

b) $-8 N m^2 C^{-1}$

c) $24 N\, m^2\, C^{-1}$

d) Zero.

(v) The dimensional formula of surface integral $\oint \vec{E} . d\vec{S}$ of an electric field is:

a) $[M L^2 T^{-2} A^{-1}]$

b) $[M L^3 T^{-3} A^{-1}]$

c) $[M L^{-1} T^3 A^{-3}]$

d) $[M L^{-3} T^{-3} A^{-1}]$

## ✓ Answer Key:

## Multiple Choice Answers-

1. Answer: c
2. Answer: a
3. Answer: c
4. Answer: d
5. Answer: b
6. Answer: d
7. Answer: b
8. Answer: d
9. Answer: d
10. Answer: c

## Very Short Answers:

1. Answer:

   P.E. = -pEcos θ

   P.E. is maximum when cos θ = - 1, i.e.

   θ = 180°

2. Answer: Electric field intensity at a point is defined as the force experienced by a unit test charge placed at that point. Mathematically

   we have

   $$\vec{E} = \lim_{\delta q \to 0} \frac{\vec{F}}{\delta q}$$

3. Answer: The force in water is given by

$F_W = \frac{F_{air}}{K} = \frac{8}{80} = 0.1$ N

4. Answer: $\Phi = q/6\varepsilon_0$
5. Answer: It is due to the conservative nature of the electric field.
6. Answer: It decreases because force $\propto = \frac{1}{k}$ and k > 1.
7. Answer: Zero
8. Answer: So that no net force acts on the charge at the equipotential surface, and it remains stationary.
9. Answer: Zero.
10. Answer: No change, as flux does not depend upon the size of the Gaussian surface.

## Short Questions Answers:

1. Answer:

   (a) By Gauss theorem $\phi \vec{E} \cdot \overrightarrow{dS} = \frac{q}{\varepsilon_0}$. Since there is no charge inside a conductor therefore in accordance with the above equation the electric field inside the conductor is zero.

   (b) It indicates that the test charge should be infinitesimally small so that it may not disturb the electric field of the source charge.

2. Answer:

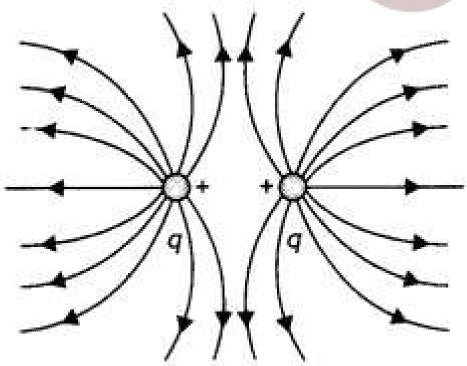
   It is a line straight or curved, a tangent to which at any point gives the direction of the electric field at that point.

   (a) No two field lines can cross, because at the point of intersection two tangents can be drawn giving two directions of the electric field which is not possible.

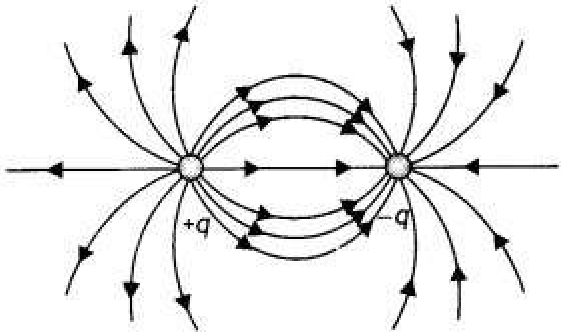
   (b) The field lines are always perpendicular to the surface of a charged conductor.

3. Answer:

   (a) The diagram is as shown.




   (b) The diagram is as shown.

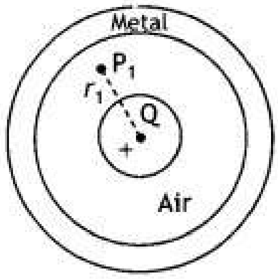



4. Answer:

   (i) When an electric dipole is placed parallel to a uniform electric field, net force, as well as net torque acting on the dipole, is zero and, thus, the dipole remains in equilibrium.

   (ii) When the dipole is placed perpendicular to the field, two forces acting on the dipole form a couple, and hence a torque acts on it which aligns its dipole along the direction of the electric field.

5. Answer:



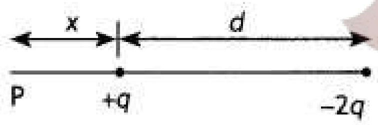

   Charge on inner surface – Q.

   Charge on outer surface + Q.

   Electric field at point P = E = $k\frac{Q}{r_1^2}$

6. Answer:

   Let the potential be zero at point P at a distance x from charge q as shown




   Now potential at point P is

   $V = \frac{kq}{x} + \frac{k(-2q)}{d+x} = 0$

   Solving for x we have

   x = d

7. Answer:

The resultant dipole moment of the combination is

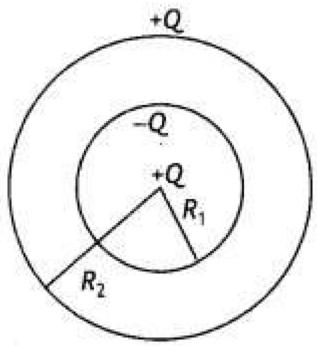
$P_R = \sqrt{p^2 + p^2 + 2p^2 \cos 120^\circ} = p$

since cos 120° = -1/2

This will make an angle of 30° with the X-axis, therefore torque acting on it is

τ=PE sin 30° = pE/2 (Along Z-direction)

Answer: The induction of charges is as shown.




Therefore, surface charge density on the inner and the outer shell is on the outer surface is

$$\sigma_{inner} = \frac{-Q}{4\pi R_1^2}$$

$$\sigma_{outer} = \frac{+Q}{4\pi R_2^2}$$

## Long Questions Answers:

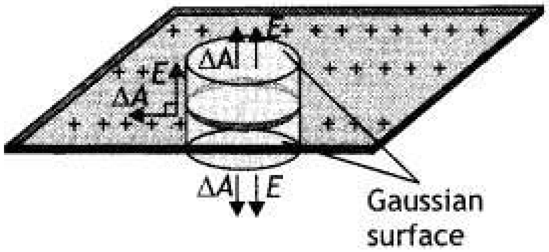
1. Answer:

   It states, "The net electric flux through any Gaussian surface is equal to $\frac{1}{\varepsilon_0}$ times the net electric charge enclosed by the surface.

   Mathematically, Φ =$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0}$

   Consider an infinite plane sheet of charge. Let a be the uniform surface charge density, i.e. the charge per unit surface area. From symmetry, we find that the electric field must be perpendicular to the plane of the sheet and that the direction of E on one side of the plane must be opposite to its direction on the other side as shown in the figure below. In such a case let us choose a Gaussian surface in the form of a cylinder with its axis perpendicular to the sheet of charge, with ends of area A.

   The charged sheet passes through the middle of the cylinder's length so that the cylinder's ends are equidistant from the sheet. The electric field has a normal component at each end of the cylinder and no normal component along the curved surface of the cylinder. As a result, the electric flux is linked with only the ends and not the curved surface.




Therefore, by the definition of electric flux, the flux Linked with the Gaussian surface is given by

$\Phi = \oint_A \vec{E} \cdot \vec{\Delta} A$

$\Phi = E_A + E_A = 2E_A$ ... (1)

But by Gauss's Law

$\Phi = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0}$ [$\because q = \sigma A$] ... (2)

From equations (1) and (2), we have

$2E_A = \frac{\sigma A}{\varepsilon_0}$ ... (3)

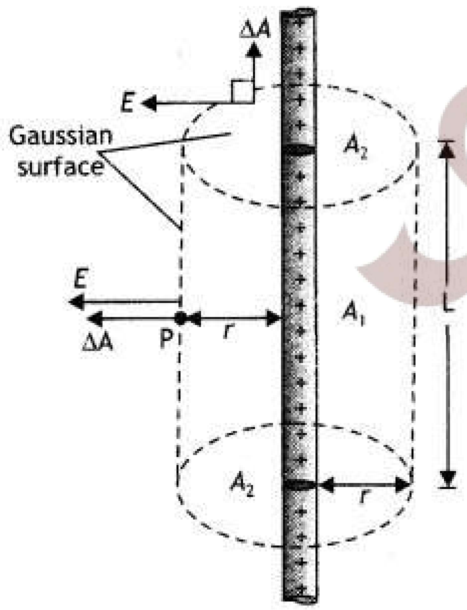
$E = \frac{\sigma}{2\varepsilon_0}$ .... (4)

(b)

(i) directed outwards

(ii) directed inwards.

2. Answer:




Consider an infinitely Long, thin wire charged positively and having uniform Linear charge density λ. The symmetry of the charge distribution shows that must be perpendicular to the tine charge and directed outwards. As a result of this symmetry, we consider a

Gaussian surface in the form of a cylinder with arbitrary radius r and arbitrary Length L. with its ends perpendicular to the wire as shown in the figure. Applying Gauss's theorem to curved surface $\Delta A_1$ and circular surface $\Delta A_2$.

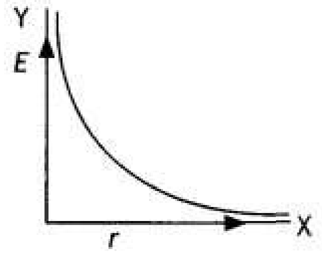
$\Phi$ $E\Delta A1 \cos 0° + E\Delta A2 \cos 90° = \frac{q}{\varepsilon_0} = \frac{\lambda l}{\varepsilon_0}$ [$\because \lambda = \frac{q}{e}$]

Or

$E . 2\pi r l = \frac{\lambda l}{\varepsilon_0} \Rightarrow E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$

This is the expression for the electric field due to an infinitely long thin wire.

The graph is as shown.




## Assertion and Reason Answers-

**1.** (a) Both A and R are true, and R is the correct explanation of A.

**Explanation:**

According to Gauss's theorem in electrostatics, $\phi = \frac{q}{\epsilon_0}$

$$\phi = \frac{q}{\epsilon_0} = 8.85 \times 10^{-12}[8 \times 10^3 - 2 \times 10^3]$$

$$= 53.10 \times 10^{-9} C = 0.053 \mu C.$$

**2.** (c) A is true but R is false.

**Explanation:**

The charge q on a body is given as q = ne where n is any integer positive or negative. The charge on the electron is $q = 1.6 \times 10^{-19}$C which is less than 1C.

## Case Study Answers-

**1. Answer :**

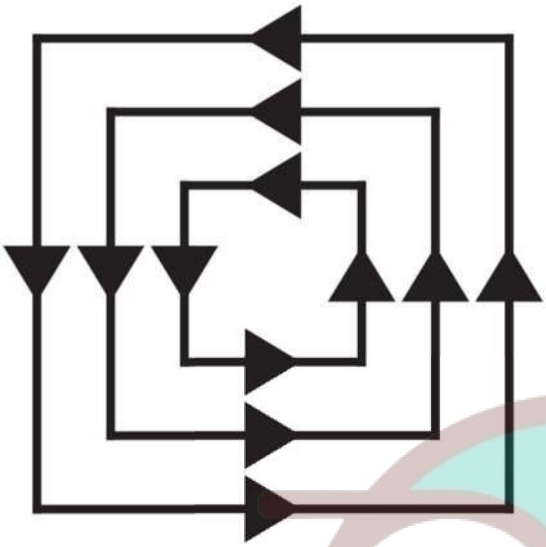
(i) (a) Radially outwards.

(ii) (c) They always form closed loops.

**Explanation:**

Electric lines of force do not form any closed loops.

(iii) (c)



**Explanation:**

Electric field tines can't be closed.

(iv) (d) Both (b) and (c).

(v) (a) $E_A > E_B > E_C$

**2. Answer :**

i. (d) -32N $m^2$ $C^{-1}$

**Explanation:**

Electric flux, $\phi = \vec{E} \cdot \vec{A} = EA\cos\theta.$

Where $\vec{A} = \widehat{An}$

For electric flux passing through $S_6, \hat{n}_{s_6} = -\hat{i}$ (Back)

$\therefore \phi_{s_6} = -(4 \times 10^3 \text{ N C}^{-1})(0.1\text{m})^2 \cos 37^\circ$

-32N $m^2$ $C^{-1}$

ii. (a) -24N $m^2$ $C^{-1}$

**Explanation:**

For electric flux passing through $S_1, \widehat{n}_{s_1} = -\hat{j}$ (Left)

$$\therefore \phi_{s_1} = -(4 \times 10^3 \text{ N C}^{-1})(0.1\text{m})^2 \cos(90^\circ - 37^\circ)$$

-24 N $m^2$ $C^{-1}$

iii. (c) $S_2$ and $S_4$

**Explanation:**

Here, $\widehat{n}_{s_2} = +\widehat{k}$ (Top)

$$\therefore \phi_{s_2} = -(4 \times 10^3 \text{ N C}^{-1})(0.1\text{m})^2 \cos 90^\circ = 0$$

$$\widehat{n}_{s_3} = +\hat{j} \text{ (Right)}$$

$$\widehat{n}_{s_4} = -\widehat{k} \text{ (Bottom)}$$

$$\therefore \phi_{s_4} = -(4 \times 10^3 \text{ N C}^{-1})(0.1\text{m})^2 \cos 90^\circ = 0$$

And, $\widehat{n}_{s_5} = -\hat{i}$ (Fornt)

$$\therefore \phi_{s_5} = -(4 \times 10^3 \text{ N C}^{-1})(0.1\text{m})^2 \cos 37^\circ$$

= 32N $m^2$ $C^{-1}$

$S_2$ and $S_4$ surface have zero flux.

iv. (d) Zero.

**Explanation:**

As the field is uniform, the total flux through the cube must be zero, i.e., any flux entering the cube must leave it.

v. (b) [M $L^3$ $T^{-3}$ $A^{-1}$]

**Explanation:**

Surface integral $\oint \vec{E} \cdot d\vec{S}$ is the net electric flux over a closed surface S.

$$\therefore [\phi_E] = [\text{M L}^3 \text{ T}^{-3} \text{ A}^{-1}]$$