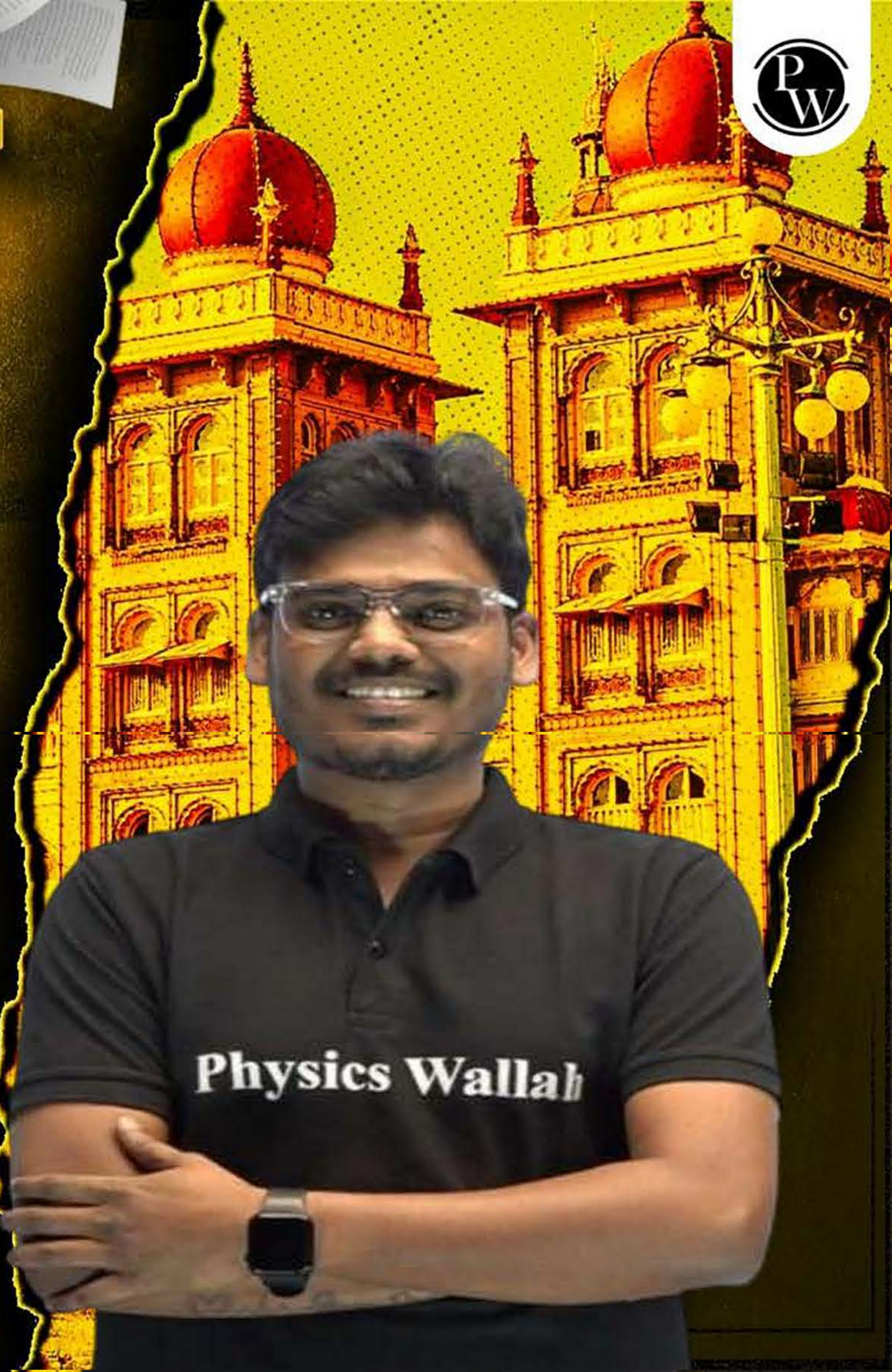
ULTIMATE KCET

CRASH COURSE 2026

PHYSICS | Lecture - 01

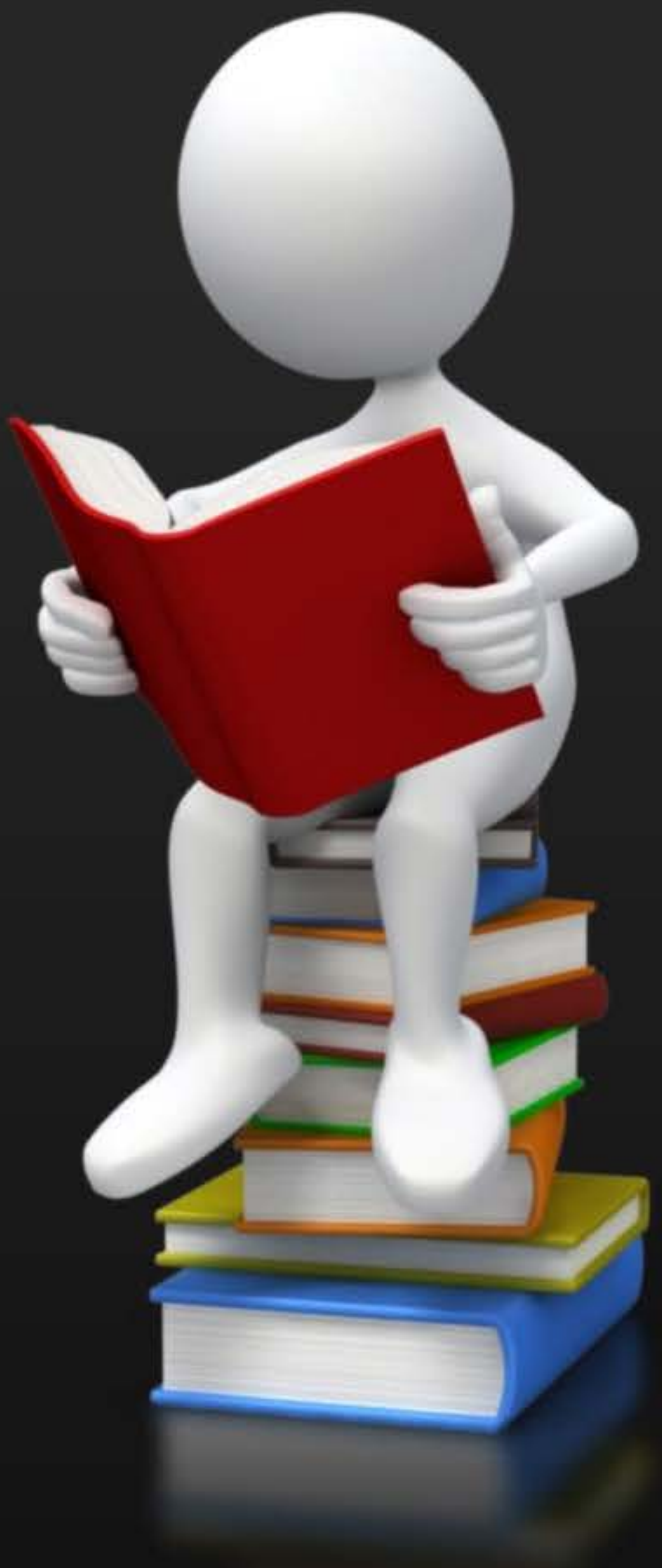
ELECTRIC CHARGES AND FIELDS

By – AK SIR



Topics *to be covered*

1. CHARGE AND ITS PROPERTIES
2. COULOMB'S LAW
3. ELECTRIC FIELD AND FIELD LINES
4. ELECTRIC DIPOLE AND DIPOLE MOMENT



KCET analysis of chapter - Marks weightage

Year	Topic
2025(5Q)	Electric flux(2), Electric field due to spherical shell, Electric dipole and Guass's Law
2024(5Q)	Quantization of charge, Coulomb's law, Electric flux(2), Properties of charges
2023(4Q)	Gaussian surface, EF due to semicircle, Properties of charge and Dipole moment
2022(5Q)	Superposition principle, EF, Motion of EC in uniform EF, Electric dipole, Millikan drop experiment
2021(3Q)	Motion of EC in uniform EF, E.F due to infinite straight wire and EF due to rod

KCET analysis of chapter - Marks weightage

Year	Topic
2020 (4Q)	Electric flux, EF lines, Dipole moment, E.F due to infinite straight wire
2019(3Q)	Electric dipole, Motion of EC in uniform EF and Coulomb's law
2018(1Q)	Electric field due to point charge
2017(4Q)	Coulombs Law, Dipole moment, EF due spherical conductor and Work done
2016(3Q)	EF due to dipole, Motion of EC in uniform EF and Gauss law
2015(3Q)	Coulombs Law, EF lines and Dipole Moment

Electric charges

Charge is an intrinsic property associated with matter due to which it produces and experiences, electric and magnetic effects.

→ Biggest
→ Faraday [F]

EXAMPLES : Proton, α-particle
Electron, β-particle

SI UNIT : Coulomb (C)

$1C = 3\times10^{9}$ esu
$1F = 96500C$

CGS UNIT : Franklin [smallest]
↓ esu - electrostatic unit

FORMULA : $I = \frac{Q}{t}$

$Q = It$

DIMENSIONAL FORMULA :
↳ $[A^1T^1]$
↳ $[M^0L^0T^1A^1]$

TYPE OF QUANTITY :
↳ scalar.

Electric charges

How does an electric charge produce and experience electric and magnetic effect ?

Rest

Only Electric Field.

Uniform

Both Electric + magnetic field

Non-Uniform motion

E.F + M.F + Radiates EMW.

Types of charge

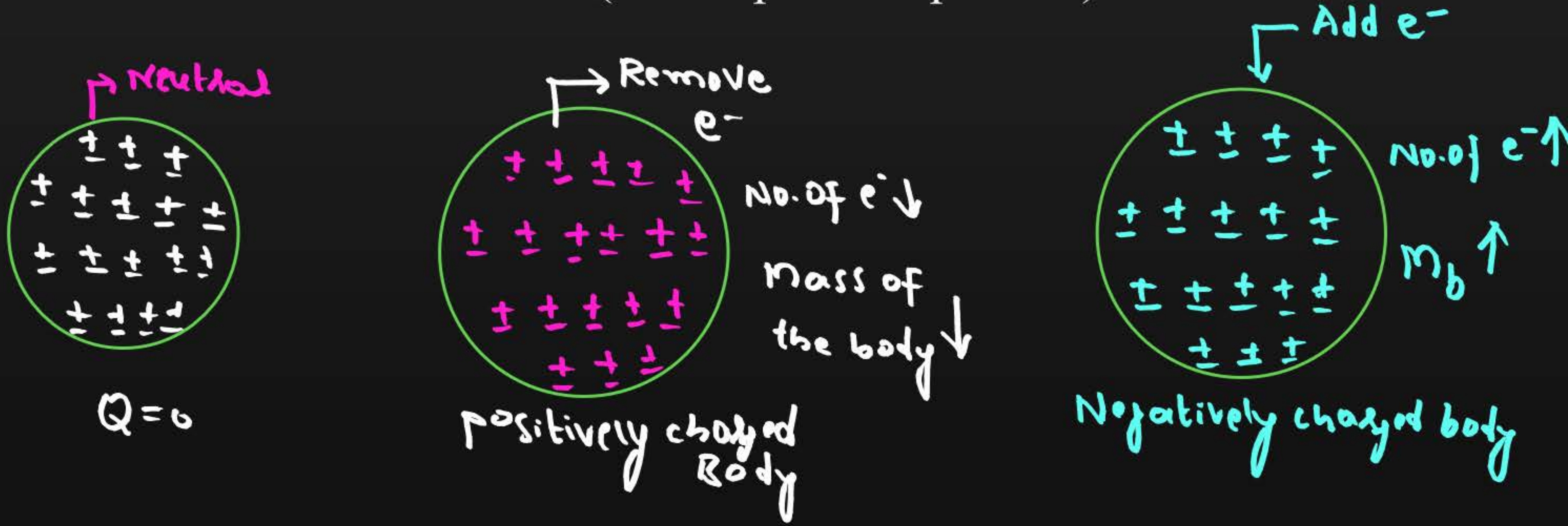
Particle : positive → proton

Negative → Electron.

There exist two types of charges in nature.

(i) Positive charge : Due to deficiency of electrons (as compared to protons).

(ii) Negative charge : Due to excess of electrons (as compared to protons).



Specific Properties of Charge

- Charge is a scalar quantity
- Like point charges always repel each other while unlike point charges always attract each other
- Charge is transferable: If a charged body is kept in contact with an another body, then charge can be transferred to another body.
- Charge is always associated with mass: Charge cannot exist without mass though mass can exist without charge.

+ + → Repel
– – → Repel
+ – → Attract

Proton, Electron: $|e| = 1.6 \times 10^{-19}$ C

$m_p = 1.67 \times 10^{-27}$ kg

$m_e = 9.1 \times 10^{-31}$ kg

Neutron – $q = 0$, $m_n \simeq m_p$ ✓

photon – $q = 0$, Kinetic mass ✓

Neutrino $\bar{\nu}$

Specific Properties of Charge

✓ Charge is realistically invariant, whereas mass is variant : Charge is independent of frame of reference, i.e. charge on a body does not change whatever be its speed.

Rest $q = 2C$
motion $q = 2C$ } same

Rest, $m = 5kg$
motion, $m = 5kg$ → $v << c$
$m \neq 5kg$ → $v \simeq c$

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

✓ Charge is additive : If a system contains n charges q1, q2, -q3 …. qn, then the total charge of the system is obtained simply by adding them algebraically (with their respective signs).

$$Q = q_1 + q_2 + q_3 + \dots + q_n$$

Specific Properties of Charge

✓ Charge is conserved : Total charge of an isolated system always remains constant. This is also called as "Law of conservation of charge." Conservation of charge holds good in all type of reactions, for example

↳ Radioactive → $n \rightarrow p + e + \bar{\nu}$

$0 \rightarrow +1e - 1e + 0$

$0 \rightarrow 0$

↑ Integers

*

✓ Charge is quantized : Charge can have only discrete values, rather than any value. Charge on any body must be an integral multiple of a basic unit of charge represented by e.

$Q = \pm ne$

↳ Nature of the body

$n = 1, 2, 3, 4, 5 \ldots$ $n < 0$, X

Fraction X $n > 0$ → Fraction X

Question

Which of the following charges is/are not possible?

(1) $\sqrt{3}e$ (2) $48 \times 10^{-19} C$ (3) $3.2 \times 10^{-20} C$ (4) 1C

$n = ?$

$n = 1, 2, 3, \ldots$ ✓

$n = 1.2, 2.5, 3.7, 4.9 \ldots$ ✗

$n = 3 \times 10^{-1}$ ✗

$n = 5 \times 10^{-7}$ ✗

$n = 3 \times 10^{1}$ ✓

$n = 5 \times 10^{7}$ ✓

$Q = ne$

(1)

$Q = \sqrt{3}e$

$n = \frac{Q}{e}$

$n = \frac{\sqrt{3}e}{e}$

$n = 1.73$ ✗

(2)

$n = \frac{Q}{e}$

$n = \frac{48 \times 10^{-19}}{1.6 \times 10^{-19}}$

$n = 30$ ✓

(3)

$n = \frac{Q}{e}$

$n = \frac{3.2 \times 10^{-20}}{1.6 \times 10^{-19}}$

$n = 2 \times 10^{-1}$

$n = 0.2$ ✗

(4)

$n = \frac{Q}{e}$

$n = \frac{1C}{1.6 \times 10^{-19} C}$

$n = 0.625 \times 10^{19}$

$n = 6.25 \times 10^{18}$ ✓

Question

$n = ?$

How many electrons must be removed from a body to make it electrified by 3.2C of charge ?

$$n = \frac{Q}{e}$$

$$n = \frac{3.2}{1.6 \times 10^{-19}}$$

$$n = 2 \times 10^{19} \text{ electron}$$

Question

→ Remove

A neutral body ejects 10^{20} electrons in a specific process, find charge acquired by the body?

$Q = +ne$

$Q = +10^{20} \times 1.6 \times 10^{-19}$

$Q = +16C$

Question

A body has −10C of charge, If 3×10^{20} electrons are removed from this, then find new charge on the body?

→ +vely

$Q_1 = -10C$

$Q_2 = +ne$

$Q_2 = +3\times10^{20} \times 1.6\times10^{-19}$

$Q_2 = +4.8\times10^{1}$

$Q_2 = 48C$

$Q = Q_2 + Q_1$

$Q = 48C - 10C$

$Q = +38C$

Question

$\alpha - {}_{2}He^{4}$ $Z = 2q$ $e_\alpha = q_\alpha = 2q$

$A = 4 \Rightarrow m_\alpha = 4m$

10×10^{10} alpha particles are ejected per second from a body, then after how much time, the body will acquire a charge of 8 μC ?

q

$Q = ne_\alpha$

$Q = n \times 2q$

$Q = n \times 2e$

$Q = 2ne$

$$t = \frac{q}{Q} = \frac{q}{ne_\alpha}$$

$$t = \frac{8 \times 10^{-6}}{10 \times 10^{10} \times 2 \times 1.6 \times 10^{-19}}$$

$$t = \frac{8 \times 10^{-6}}{3.2 \times 10^{-8}}$$

$$t = 2.5 \times 10^{2}$$

$$t = 250\ s$$

Question

Which of the following is not true about electric charge?

(A) Charge on a body is always integral multiple of certain charge known as charge of electron

(B) Charge is a scalar quantity

(C) Net charge on an isolated system is always conserved

(D) Charge can be converted into energy and energy can be converted into charge

Question

Which of the following is not true about electric charge?

(A) Charge is a scalar quantity ✓

(B) Charge on an isolated system is always conserved ✓

(C) A particle having non zero rest mass can have zero charge ✓ ⇒ Neutron

$m \neq 0$ $q = 0$

(D) A particle having zero rest mass can have non zero charge ✗

$m = 0$ $e = 0 = q$ ✓ $\neq 0$

Question

Which one of the following statement regarding electrostatics is wrong?

(A) Charge is quantized

(B) Charge is conserved

(C) There is an electron field near an isolated charge at rest

(D) A stationary charge produces both electric and magnetic fields

Question

If a body has positive charge on it, then it means it has

(A) Gained some protons

(B) Lost some protons

(C) Gained some electrons

(D) Lost some electrons

Question

Which of the following option is correct

A. The total number of charged particles in the universe remains conserved

B. The magnitude of total positive charge on the universe is constant

C. The magnitude of total negative charge on the universe is constant

D. The total charge of the universe is constant

Question

e^- Add

During charging of neutral body, mass of the body increases then body becomes

A. Positively charge

B. Remains neutral

C. Negatively charge

D. None of these

Question

A positively charged body can be make neutral by

(A) Giving some electron

(B) Giving some proton

(C) Removing some proton

(D) None of these

Question

Neutral body can be negatively charged by

A. Giving some excess proton

B. Giving some extra neutron

C. Giving some extra electron

D. Removing some proton

Question

Which of the following is not the unit of charge?

(A) Farad → Unit of capacitance

(B) coulomb → SI unit of charge

(C) Stat coulomb → CGS "

(D) Faraday → Biggest " "

Question

Smallest unit of charge is

A. Frankline

B. Faraday

C. Coulomb

D. e.m.u

Question

Electric charges A and B are attracted to each other. Electric charges B and C are also attract each other. If A and C are held close together, they will

- **A** Attract
- **B** Repel
- **C** No effect on each other
- **D** More information is needed to answer

Question

Which of the following is correct regarding electric charges?

$Q = \pm ne$

$n = 1$, $Q = \pm 1 \times 1.6 \times 10^{-19}$ C

A. If a body having positive charge i.e shortage of electrons ✓

B. If a body having negative charge i.e excess of electrons. ✓

C. Minimum charge a body can have $Q = \pm 1.6 \times 10^{-19}$ C ✓

D. All of the above

Question

Which of the following is not possible?

$n \rightarrow$ Fraction ✗

$n = \frac{Q}{e}$

(A) $+3.2 \times 10^{-10}$ C

$n = \frac{3.2 \times 10^{-10}}{1.6 \times 10^{-19}} = 2 \times 10^{+9}$ ✓

(B) -1.6×10^{-18} C

$n = \frac{1.6 \times 10^{-18}}{1.6 \times 10^{-19}} = 1 \times 10^{1} = 1$ ✓

(C) 64×10^{-20} C

$n = \frac{64 \times 10^{-20}}{1.6 \times 10^{-19}} = 40 \times 10^{-1} = 4$ ✓

(D) 4.5×10^{-19} C

$n = \frac{4.5 \times 10^{-19}}{1.6 \times 10^{-19}} = 2.81$ ✗

Question

When 10^{14} electrons are removed (→ positively) from a neutral metal sphere, then the charge on the sphere becomes

(A) 16 μC

(B) –16 μC ✗

(C) 32 μC

(D) –32 μC

$Q = ne$

$Q = 10^{14} \times 1.6 \times 10^{-19}$

$Q = 1.6 \times 10^{-5}\ C$

$Q = 16 \times 10^{-6}\ C$

$Q = 16\ \mu C$

Question

If a charge on the body is 1 nC, then how many electrons arc present on the body?

(A) 1.6×10^{19}

(B) 6.25×10^{9}

(C) 6.25×10^{27}

(D) 6.25×10^{28}

$$n = \frac{Q}{e} = \frac{1 \times 10^{-9}}{1.6 \times 10^{-19}}$$

$$n = 0.625 \times 10^{10}$$

$$n = 6.25 \times 10^{9} \text{ electron}$$

Question

A body has a charge of –3.2 μC. The number of excess electrons it has is

(A) 5.12×10^{25}

(B) 5×10^{12}

(C) 2×10^{13}

(D) 5.12×10^{13}

$n = \frac{Q}{e} = \frac{3.2 \times 10^{-6}}{1.6 \times 10^{-19}}$

$n = 2 \times 10^{+13}$

Conductors & Insulators

Conductors :

Those which allow electricity to pass through them easily are called conductors. They have electric charge (electrons) that are comparatively free to move inside the material.

Ex. Metals, human and animal bodies, earth etc.

Insulators :

Those which offer high resistance to the passage of electricity through them, are called insulators.

Ex. Glass, rubber, plastic, nylon, wood etc.

Methods of charging

(1) Charging by friction or rubbing :

If we rub one body with another body, electrons get transferred from one body to the another. Both insulators and conductors can be charged by this method.

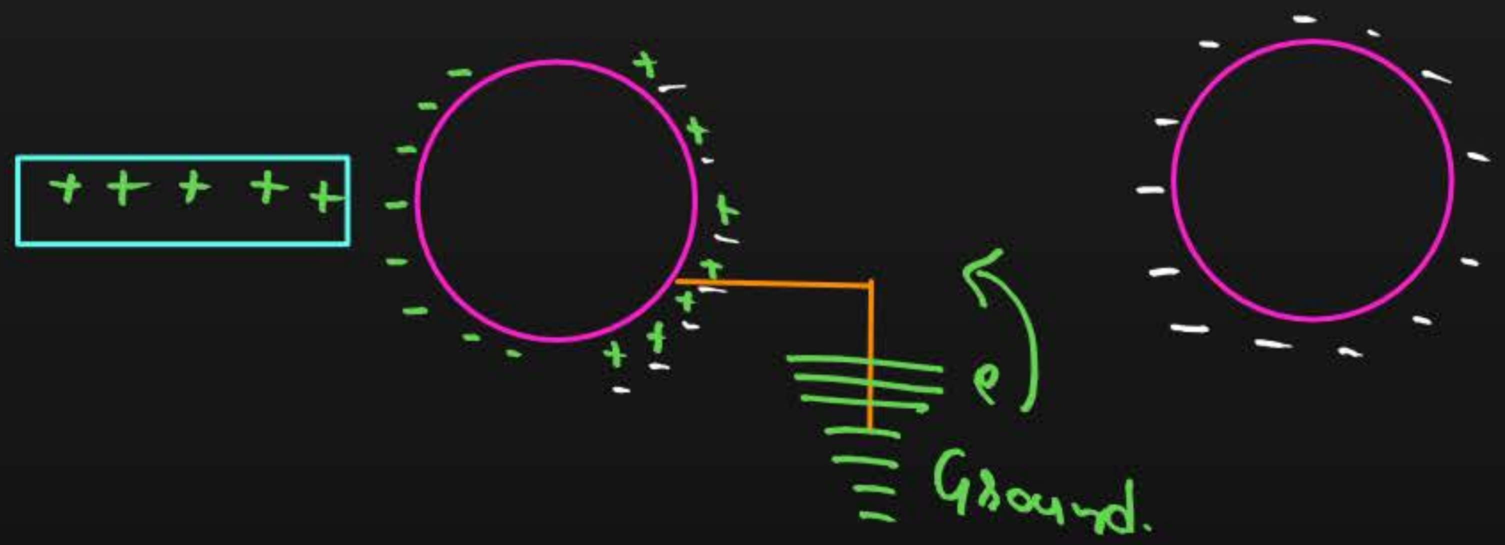
When an object in column-1 is rubbed against the object of column-2 then they acquire charges specified in the following table.

Column-1	Column-2
Positive Charge	Negative Charge
Glass rod	Silk cloth
Cat skin	Ebonite rod
Woollen cloth	Rubber shoe, Amber, Plastic objects
Dry hair	Comb

Methods of charging

(2) Electrostatic induction :

If a charged body is brought near a neutral body, the charged body will attract opposite charges and repel similar charges present in the neutral body. As a result of this one side of the neutral body becomes negative while the other positive, this process is called 'electrostatic induction'. Hence, “Induction is a phenomena of redistribution of charges on a body in the influence of other charged object or external field .”



Methods of charging

(3) Charging by conduction

Whenever a charged conductor brought in contact with other conductor, charge continuously flows from one to another until their potential becomes equal. This is also called sharing of charges.

r_1

After Redestribution.

If $R_1 \neq R_2$

$$Q_1' = \left(\frac{R_1}{R_1+R_2}\right) Q$$

$$Q_2' = \left(\frac{R_2}{R_1+R_2}\right) Q$$

$$Q = Q_1 + Q_2$$

If $R_1 = R_2$ = identical

$$Q_1' = \frac{Q_1+Q_2}{2}, \quad Q_2' = \frac{Q_1+Q_2}{2}$$

Question

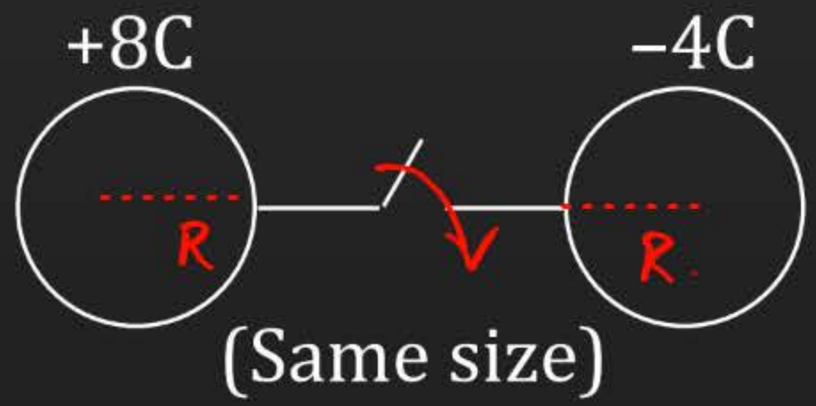
Find charge on identical conducting sphere when they placed in contact

$$Q_1' = \frac{Q_1 + Q_2}{2} = \frac{+8 - 0}{2} = +4C$$

$$Q_2' = \frac{Q_1 + Q_2}{2} = \frac{+8 - 0}{2} = +4C$$

Question

Find charge on each when key is close?



$$Q_1' = \frac{Q_1+Q_2}{2} = \frac{+8-4}{2} = \frac{+4}{2}$$

$$\boxed{Q_1' = +2C}$$

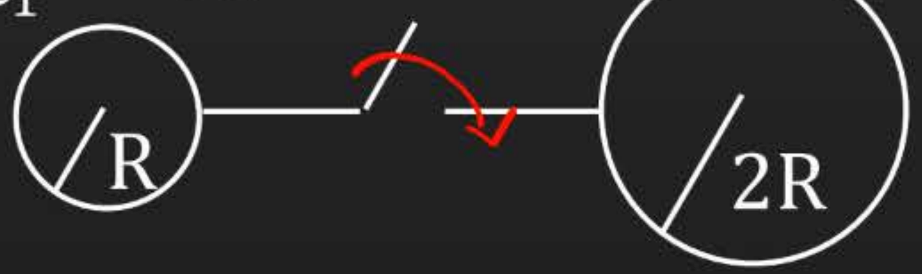
$$Q_2' = \frac{Q_1+Q_2}{2} = \frac{+8-4}{2} = \frac{+4}{2}$$

$$\boxed{Q_2' = +2C}$$

Question

Find charge on each sphere when key is close

$R_1 \neq R_2$



$$Q_1' = \left(\frac{R_1}{R_1+R_2}\right)Q = \frac{R}{R+2R} \times (-12) = \frac{R}{3R}(-12)$$

$$\hookrightarrow \boxed{Q_1' = -4C}$$

$$Q_2' = \left(\frac{R_2}{R_1+R_2}\right)Q$$

$$Q_2' = \left(\frac{2R}{R+2R}\right)(-12) = \frac{2R}{3R}(-12)$$

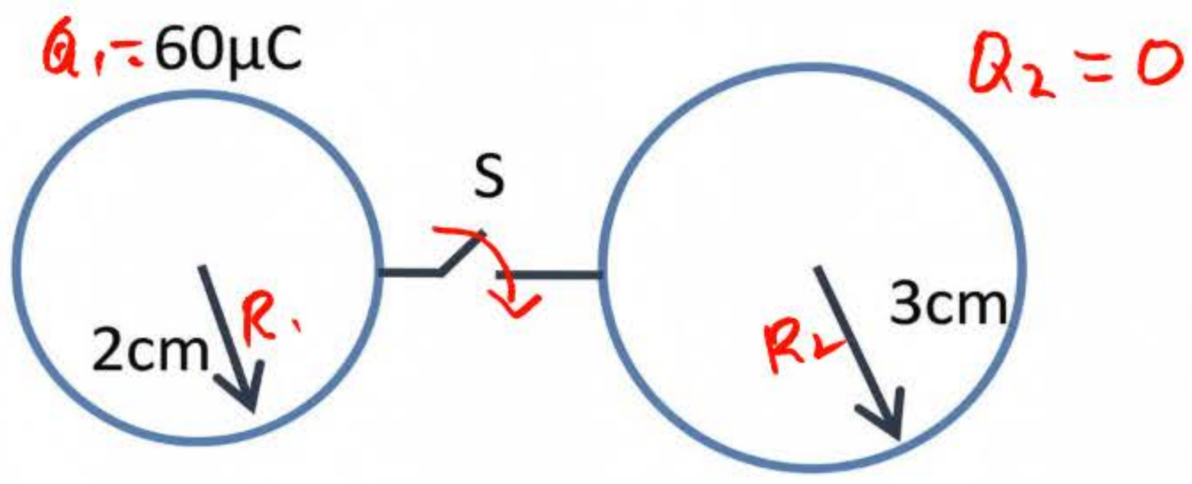
$$\boxed{Q_2' = -8C}$$

$$Q = Q_1 + Q_2$$

$$Q = +5 - 17$$

$$Q = -12C$$

Question



Find final charges on the spheres when switch S is closed.

$$Q = Q_1 + Q_2$$

$$Q = 60 + 0$$

$$\boxed{Q = 60\mu C}$$

$$Q_1' = \left(\frac{R_1}{R_1 + R_2}\right) Q$$

$$Q_1' = \left(\frac{2}{2+3}\right) 60 = \frac{2}{5} \times 60$$

$$\boxed{Q_1' = 24\mu C}$$

$$Q_2' = \left(\frac{R_2}{R_1 + R_2}\right) Q$$

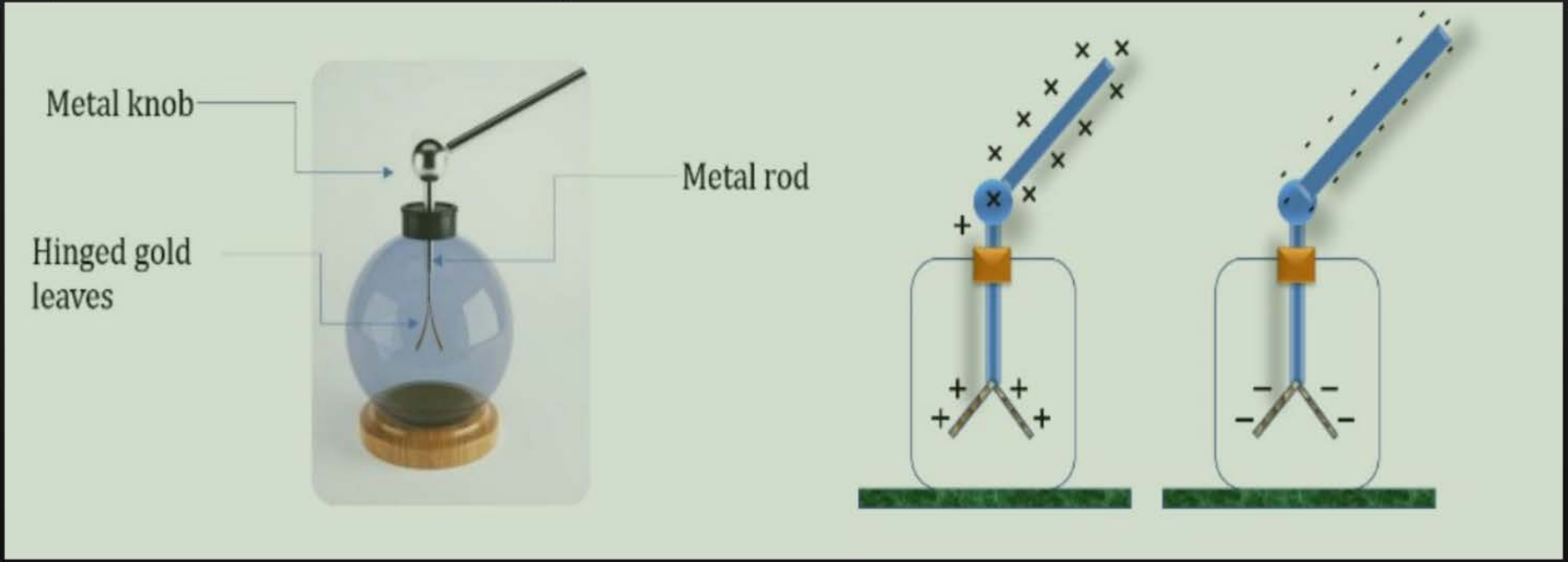
$$Q_2' = \left(\frac{3}{2+3}\right) 60 = \frac{3}{5} \times 60$$

$$\boxed{Q_2' = 36\mu C}$$

Gold leaf electroscope

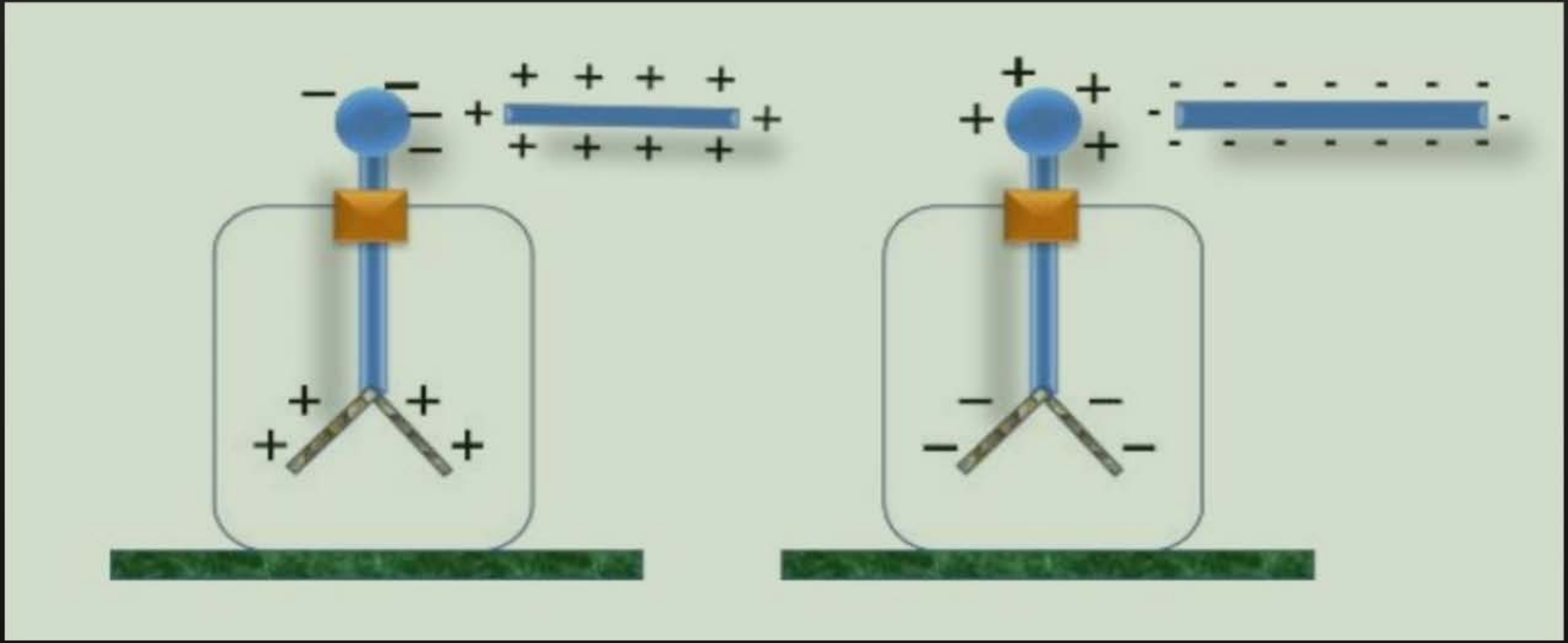
It is used to detect the presence of charge.

When a conducting body touches the metal knob of an electroscope, then knob & leaves both wire acquire same nature of charge.



Gold leaf electroscope

When a charged body is placed near the electroscope then knob will acquire opposite nature of charge & leaves will acquire same nature of charge.



Newton's Law Of Gravitation

$$F = G\frac{m_1 m_2}{r^2}$$

$$F \propto \frac{1}{r^2}$$

$$G = 6.67\times10^{-11}\ Nm^2/kg^2$$

Characteristics:

1. It is valid for point mass and spherical mass.
2. It is always attractive in nature.
3. Its long range force.
4. It is conservative in nature.
5. It is central force.
6. It is medium independent.

Coulomb's Law

stationary point charges is directly proportional to the product of the magnitude of charges and inversely proportional to the square of the distance between them, acting along the line joining the two charges."

$$F \propto q_1 q_2$$

$$F \propto \frac{1}{r^2}$$

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

Where, Permittivity of free space, $\varepsilon_0 = 8.854 \times 10^{-12}\, C^2 N^{-1} m^{-2}$

* **Vector Form**

→ $F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$

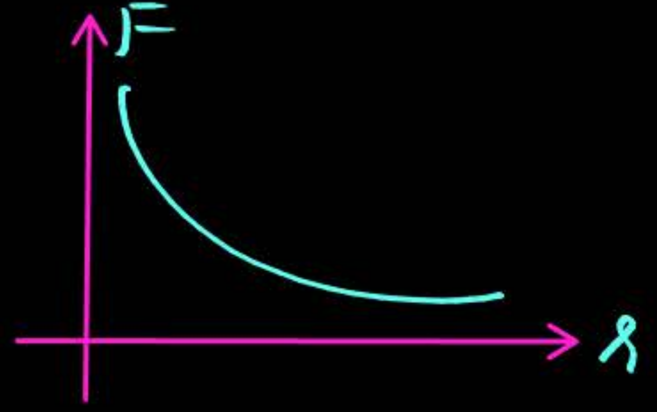
→ $\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12}$

$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_{12}^2} \times \frac{\vec{r}_{12}}{r_{12}}$

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_{12}^3} \vec{r}_{12}$$

$\vec{r}_{12} = \vec{r}_1 - \vec{r}_2$

$\hat{r} = \frac{\vec{r}}{r}$



$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_2 q_1}{r_{21}^3} \vec{r}_{21}$$

$\vec{r}_{21} = \vec{r}_2 - \vec{r}_1$

Delectric medium.

$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$

$$F_m = \frac{F}{K}$$

K - Dielectric constant

Coulomb's Law

Characteristics:

1. It is valid for point charges only.
2. It is attractive and repulsive in nature.
3. It is conservative in nature.
4. It is central force.
5. It is medium dependent.

Limitation

- It holds good only for point charges at rest
- For distances less than 10^{-15}m, it loses its validity
- It is a medium dependent law.
- It is not a universal law.

Superposition principle

Statement: When the number charges are interacting, then net electrostatic force on a given charge is the vector sum of the forces exerted on it due to all other charges.

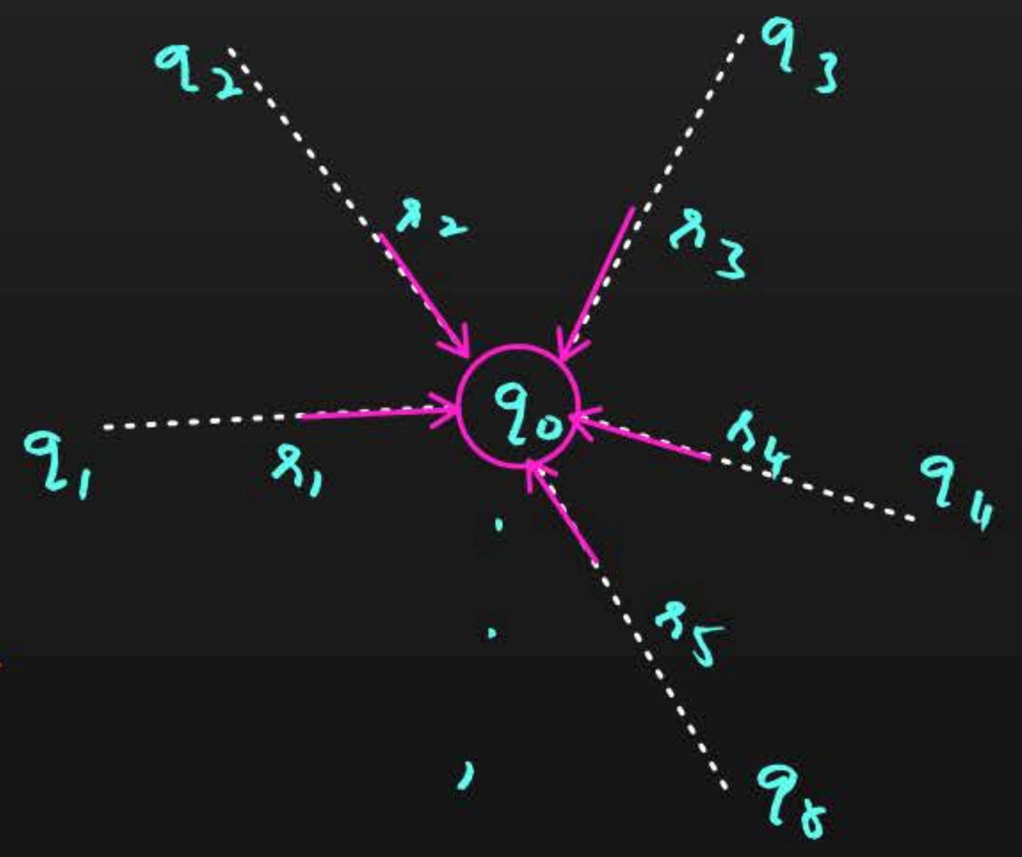
Net force on q_0

$$\vec{F} = \vec{F_1} + \vec{F_2} + \vec{F_3} + \vec{F_4} \dots$$

Vector Addition.

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta} \quad F_1 \neq F_2$$

$$R = 2F\cos\left(\frac{\theta}{2}\right) \quad \text{If } F_1 = F_2 = F$$



Question

A point charge q_1 exerts a force F on another point charge q_2 when placed at a fixed distance. If another point charge q_3 is brought near q_2, the force on q_2 due to q_1

(A) Increases

(B) decreases

(C) May increases and decreases

(D) Does not change

Question

A point charge A of +10 μC and another point charge B of +20 μC are kept 1 m apart in free space. The electrostatic force on A due to B is $\vec{F}_1$ and the electrostatic force on B due to A is $\vec{F}_2$. Then

(A) $\vec{F}_1 = -2\vec{F}_2$

(B) $\vec{F}_1 = -\vec{F}_2$

(C) $2\vec{F}_1 = -2\vec{F}_2$

(D) $\vec{F}_1 = \vec{F}_2$

$\vec{F}_1 = -\vec{F}_2$

↳ opposite

$|\vec{F}_1| = |\vec{F}_2|$

$F_1 = F_2$

Question

$q_1 = q_2$

Two identical charges in vacuum are separated by a distance *r*. The electrostatic force between them is given by F. If 75% of the charge is taken from one of the charges and given to the other, then the new force is F'. The ratio F/F' is :

(A) 1

(B) 16/7

(C) 16/9

(D) 7/16

$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

$F = k\frac{q_1 q_2}{r^2}$

$F = k\frac{q q}{r^2}$

$F = \frac{kq^2}{r^2}$ — (1)

$q_1' = q_1 - \frac{3}{4}q_1$

$q_1' = \frac{q_1}{4}$

$q_2' = q_2 + \frac{3}{4}q_2$

$q_2' = \frac{7}{4}q_2$

$q_1' = \frac{q}{4}$

$q_2' = \frac{7q}{4}$

$F' = \frac{k q_1' q_2'}{r^2}$

$F' = \frac{k \frac{q}{4} \times \frac{7q}{4}}{r^2}$

$F' = \frac{7}{16}\left(\frac{kq^2}{r^2}\right)$

$F' = \frac{7}{16}F \Rightarrow \frac{F}{F'} = \frac{16}{7}$

Question

If two charges q_1 and q_2 are separated with distance 'd' and placed in a medium of dielectric constant K. What will be the equivalent distance between charges in air for the same electrostatic force?

(A) $k\sqrt{d}$

(B) $2d\sqrt{k}$

(C) $d\sqrt{k}$

(D) $1.5d\sqrt{k}$

$F = k\frac{q_1 q_2}{r^2}$ — (1) Air

$k \neq K$

$F_m = \frac{F}{K}$

$F_m = \frac{1}{K}\left[k\frac{q_1 q_2}{d^2}\right]$ — (2) medium

$F = F_m$

$\frac{k q_1 q_2}{r^2} = \frac{k q_1 q_2}{K d^2}$

$r^2 = K d^2$

$r = \sqrt{K} d$

$r = d\sqrt{K}$

Question

$R_1 = R_2$ $\quad q_1 \quad q_2$

Two identical spheres of electric charges +2nc and -8nc are placed at a distance d apart. If they are allowed to touch each other, what is the distance between them to get a repulsive force of same magnitude as before? $\quad F = F'$

(A) d

(B) $d/2$

(C) $3d/4$

(D) $4d/3$

Before

$q_1 = +2nc$

$q_2 = -8nc$

$F = \frac{K q_1 q_2}{d^2}$

$F = \frac{K \times 2 \times 8}{d^2}$

$F = \frac{16K}{d^2}$ — (1)

Now: Touch

$q_1' = \frac{q_1 + q_2}{2}$

$q_1' = \frac{2-8}{2} = -\frac{6}{2}$

$q_1' = -3nc$

$q_2' = -3nc$

$F' = \frac{K q_1' q_2'}{r^2}$

$\frac{16K}{d^2} = \frac{K(3)(3)}{r^2} \Rightarrow \frac{16}{d^2} = \frac{9}{r^2}$

$r^2 = \frac{9}{16} d^2$

$r = \frac{3}{4} d$

$r = \frac{3d}{4}$

Question

Two spheres carrying charges $+6\mu C$ and $+9\mu C$ separated by a distance d, experiences a force of repulsion F. When a charge of $-3\mu C$ is given to both the spheres and kept at the same distance as before, the new force of repulsion is

(A) F/3

(B) F

(C) F/9

(D) 3F

$F = \frac{k q_1 q_2}{d^2}$

$F = \frac{k \times 6 \times 9}{d^2}$

$F = \frac{54k}{d^2}$ — (1)

$q_1' = +6-3 = +3\mu C$

$q_2' = +9-3 = +6\mu C$

$F' = \frac{k q_1' q_2'}{d^2}$

$F' = \frac{k \times 3 \times 6}{d^2} = \frac{18k}{d^2}$ — (2)

$\frac{F'}{F} = \frac{18k}{d^2} \times \frac{d^2}{54k}$

$F' = \frac{F}{3}$

Question

Two identical charges repel each other with a force equal to 10 g wt when they are 0.6 m apart in air (g = 10 ms^{-2}). The value of each charge is

F

$W = mg$

$10 \times 10^{-3}\,kg \times 10$

(A) 2 mc

(B) 20 μC

(C) 2 nc

(D) 2 μc

$$F = K\frac{q_1 q_2}{r^2}$$

$$10 \times 10^{-3} \times 10 = \frac{9 \times 10^{9} \times q \times q}{(6 \times 10^{-1})^2}$$

$$10^{-1} = \frac{9 \times 10^{9} \times q^2}{36 \times 10^{-2}}$$

$$q^2 = \frac{36 \times 10^{-2} \times 10^{-1}}{9 \times 10^{9}} = 4 \times 10^{-12}$$

$$q = \sqrt{4 \times 10^{-12}} = 2 \times 10^{-6} \Rightarrow q = 2\mu C$$

Question

Two identical metal spheres charged with +12μF and –8μF are kept at certain distance in air. They are brought into contact and then kept at the same distance. The ratio of the magnitudes of electrostatic forces between after contact is

(A) 12 : 1

(B) 8 : 1

(C) 24 : 1

(D) 4 : 1

Question

Two identical conducting spheres with negligible volume have 2.1nC and –0.1nC charges respectively. They are brought into contact and then separated by a distance of 0.5 m. The electrostatic force acting between the spheres is [Home Work]

(A) 3.6×10^{-8} N

(B) 36×10^{-9} N

(C) 9×10^{-9} N

(D) 4×10^{-8} N

Question

Find the force on a charge $q_1 = 300\mu C$ due to the charge $q_2 = -10\mu C$. If the position of the charges are given as (1, –1, 2) and (–1, 1, 1)

(A) $2\hat{i} - 2\hat{j} + \hat{k}$

(B) $-2\hat{i} + 2\hat{j} - \hat{k}$

(C) $2\hat{i} + 2\hat{j} - \hat{k}$

(D) $2\hat{i} - 2\hat{j} - \hat{k}$

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$\vec{r_1} = \hat{i} - \hat{j} + 2\hat{k}$

$\vec{r_2} = -\hat{i} + \hat{j} + \hat{k}$

$\vec{r_{12}} = \vec{r_1} - \vec{r_2}$

$= \hat{i} - \hat{j} + 2\hat{k} - (-\hat{i} + \hat{j} + \hat{k})$

$= 2\hat{i} - 2\hat{j} + \hat{k}$

$\vec{r_{12}} = 2\hat{i} - 2\hat{j} + \hat{k}$

$\vec{F_{12}} = \frac{k q_1 q_2}{r_{12}^3} \vec{r_{12}}$

$|\vec{r_{12}}| = r_{12} = \sqrt{2^2 + (-2)^2 + (1)^2}$

$r_{12} = \sqrt{4+4+1} = \sqrt{9}$

$r_{12} = 3$

$r_{12}^3 = 3^3 = 27$

$$\vec{F}_{12} = \frac{9 \times 10^9 \times 300 \times 10^{-6} \times (-10 \times 10^{-6}) \times (2\hat{i} - 2\hat{j} + \hat{k})}{27}$$

$$\vec{F}_{12} = 10^9 \times 10^2 \times 10^{-6} \times -10^1 \times 10^{-6} \times (2\hat{i} - 2\hat{j} + \hat{k})$$

$$= -10^{12} \times 10^{-12} \times (2\hat{i} - 2\hat{j} + \hat{k})$$

$$\vec{F}_{12} = -(2\hat{i} - 2\hat{j} + \hat{k})$$

$$\vec{F}_{12} = -2\hat{i} + 2\hat{j} - \hat{k}$$

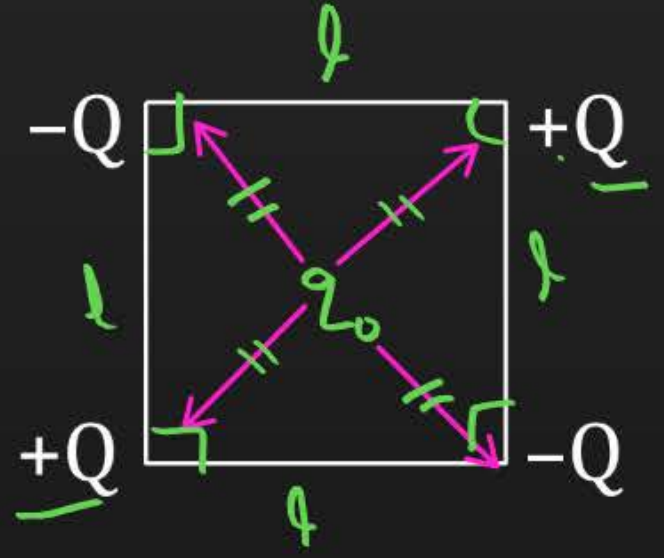
Problems based on symmetry

→ same
↳ Distance ✓
↳ Angles ✓
↳ magnitude

$F = 0$

Find force on charge which is at centre

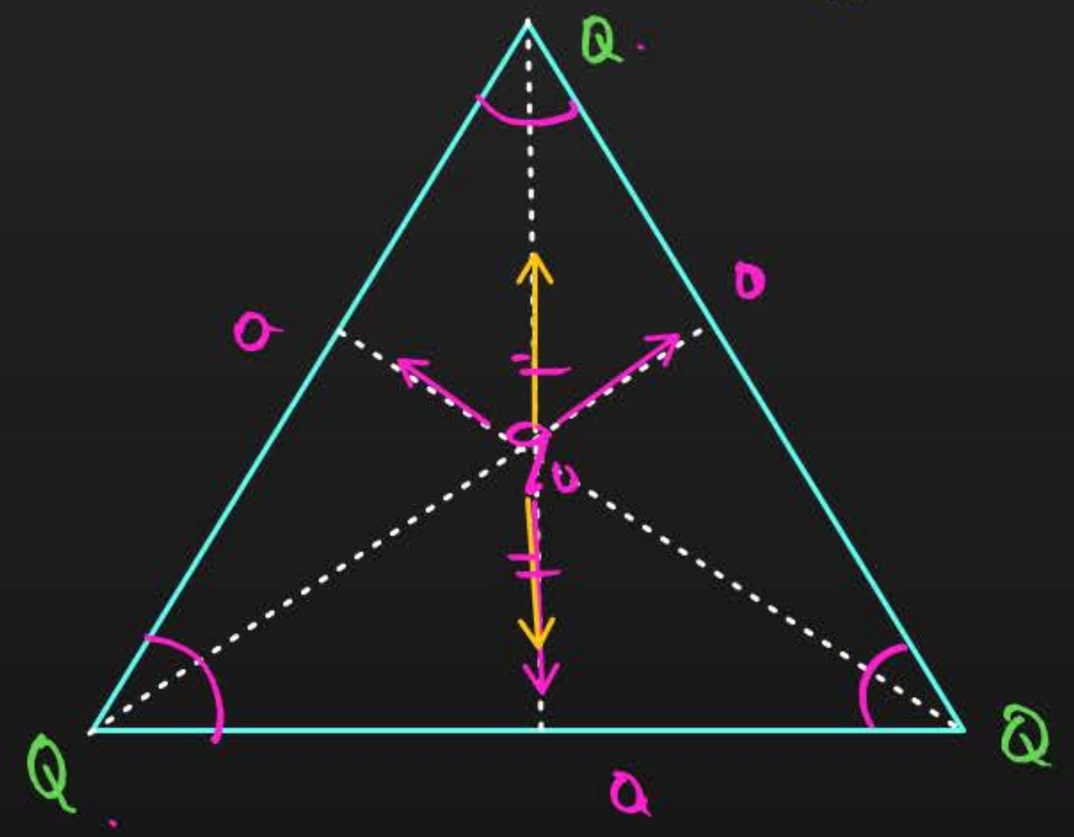
$F_{net} = 0$



Problems based on symmetry

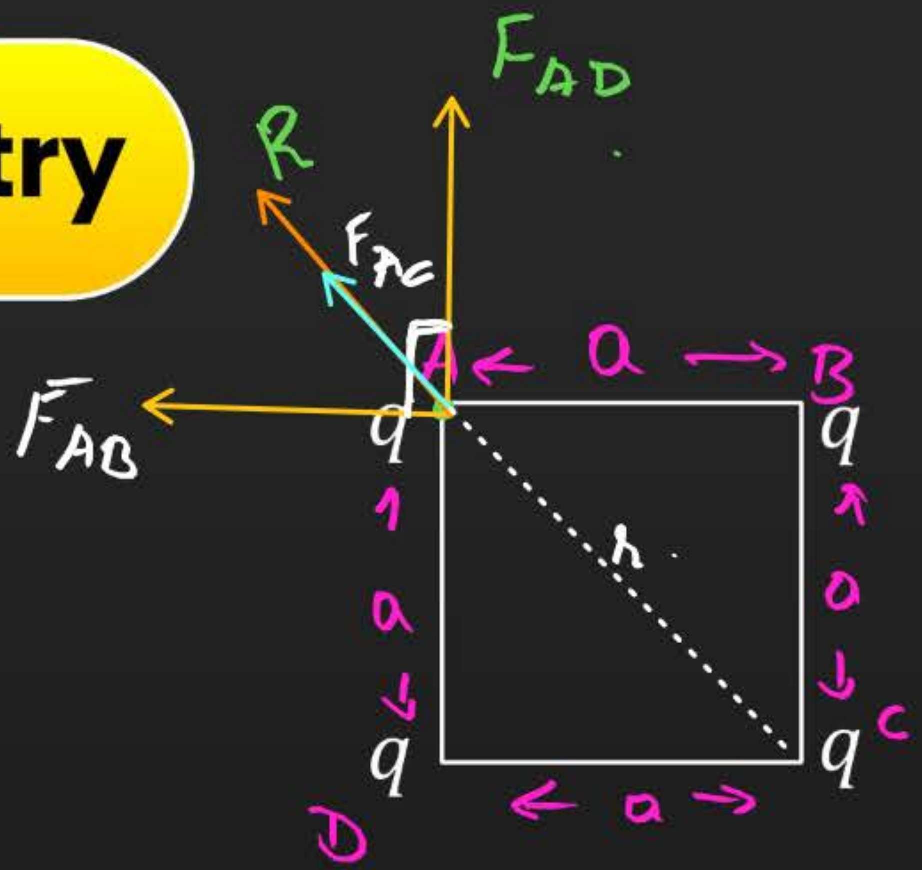
Three identical charge +Q placed at the corner of triangle then find force on 4[th] charge q_0 which is at centre

$F_{net} = 0$



Problems based on symmetry

Find force on any one charge due to other 3 charge



$$F_{AD} = \frac{Kq^2}{a^2} \qquad F_{AB} = \frac{Kq^2}{a^2}$$

$$F_{AB} = F_{AD} = F = \frac{Kq^2}{a^2}$$

$$r = \sqrt{a^2 + a^2} = \sqrt{2}\,a$$

$$R = 2A\cos\left(\frac{\theta}{2}\right)$$

$$R = 2F\cos\left(\frac{90^\circ}{2}\right)$$

$$R = 2F\frac{1}{\sqrt{2}} = \sqrt{2}F$$

$$F_{Net} = R + F_{AC}$$

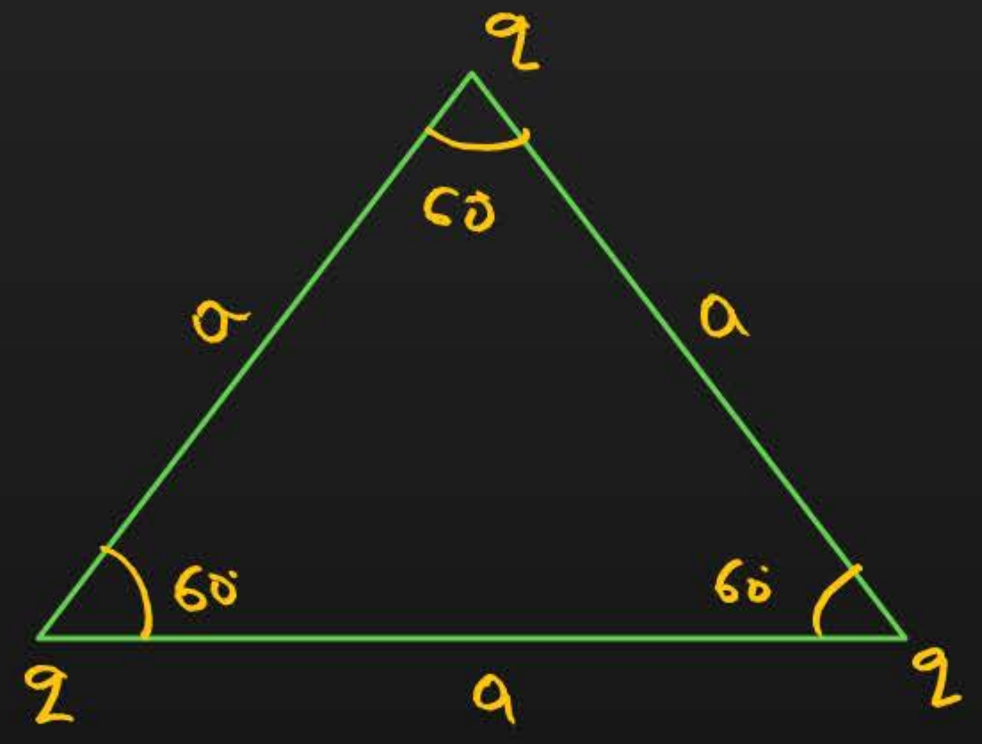
$$= \sqrt{2}F + \frac{F}{2}$$

$$F_{AC} = \frac{Kq^2}{r^2} = \frac{Kq^2}{2a^2} = \frac{F}{2}$$

$$F_{net} = F\left(\sqrt{2} + \frac{1}{2}\right) \Rightarrow F_{net} = \frac{Kq^2}{a^2}\left(\sqrt{2} + \frac{1}{2}\right)$$

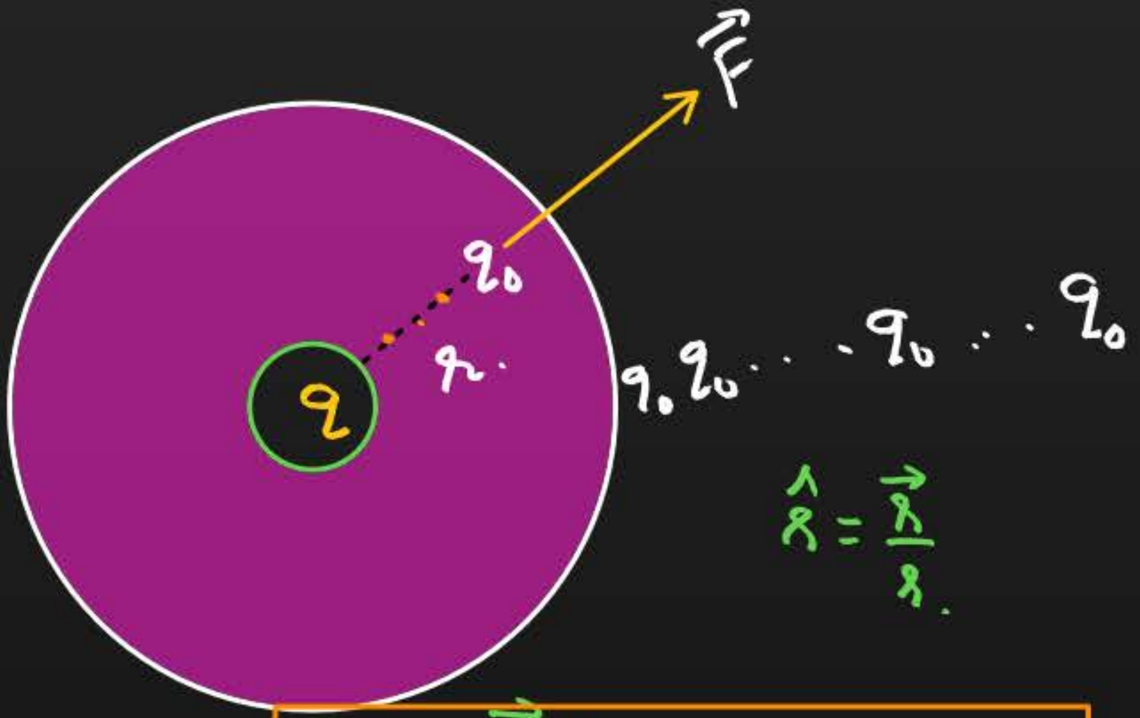
Problems based on symmetry

Find force on any one charge due to other 2 charge in a triangle



ELECTRIC FIELD

"A 3D space around a charge in which it can exert force on another charge particle is called Electric field"



$\hat{r} = \frac{\vec{r}}{r}$

Electric field intensity due to point charge -

"It is defined as force per unit charge"

Formula - $E = \frac{F}{q_0}$ → Test charge

Unit - N/C or Vm^{-1}

Quantity - Vector quantity

$E = \frac{F}{q_0} = \frac{1}{q_0} \times \frac{kqq_0}{r^2}$

$E = \frac{kq}{r^2}$ ⇒ Source charge

$\vec{E} = \frac{\vec{F}}{q_0}\hat{r}$ → Test charge

$\vec{E} = \frac{kq}{r^3}\vec{r}$ → Source charge

ELECTRIC FIELD

$$E = \frac{F}{q_0} = \frac{[M^1L^1T^{-2}]}{[A^1T^1]}$$

$$E = [M^1L^1T^{-3}A^{-1}]$$

Properties of Electric Field Intensity :

- ✓ It is vector quantity. Its direction is the same as the force.
- ✓ Electric field due to positive charge is always away from it while due to negative charge it is always towards it.

- Its unit is newton/coulomb. N/C
- Its dimensional formula : $[M^1L^1T^{-3}A^{-1}]$
- It obeys superposition principle. $\Rightarrow \vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \cdots$

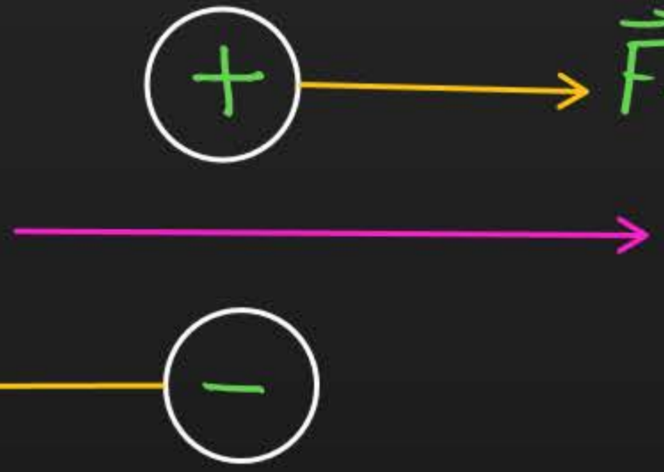
Force on +ve charge , ⇒ Upcoming slides.

Force on a –ve charge,

MOTION OF A CHARGED PARTICLE IN A UNIFORM ELECTRIC FIELD

FOR POSITIVE CHARGE

FOR NEGATIVE CHARGE



$\vec{F}_+ = qE\hat{i} \Rightarrow \vec{F}_+ = q\vec{E}$

$\vec{E}$

$\vec{F}_- = q\vec{E}$

$\vec{F}_- = qE(-\hat{i})$

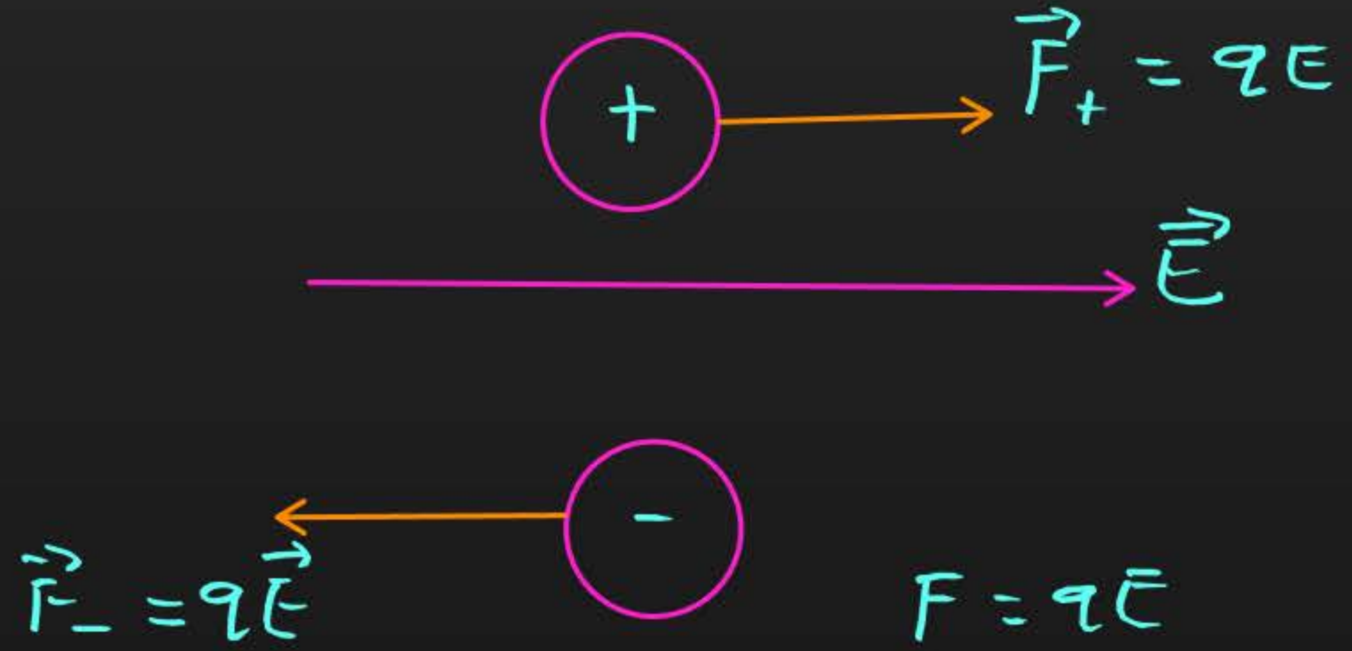
FORCE ON A CHARGE IN ELECTRIC FIELD

$F = ma$

$qE = ma \Rightarrow \boxed{a = \frac{qE}{m}}$

Question

A charge of 10μC and -10 μC is placed in uniform electric field of 5×10^6 N/C directed along positive x axis, find out force acting on positive and negative charge?



$F = qE$

$F_+ = 10 \times 10^{-6} \times 5 \times 10^6$

$F_+ = 50N$

$\vec{F}_+ = 50N\ \hat{i}$

$F = qE$

$F_- = 10 \times 10^{-6} \times 5 \times 10^6$

$F_- = 50N$

$\vec{F}_- = 50(-\hat{i})N$

Question

Calculate the electric field intensity which would be just sufficient to balance the weight of a particle of charge -10 **μC** and mass 10 **μg**. (take g = 10 ms-2).

$W = F$ ↳ $10 \times 10^{-6}\, g$

↳ $10 \times 10^{-6} \times 10^{-3}\, kg$

$mg = qE$

$$E = \frac{mg}{q} = \frac{10 \times 10^{-6} \times 10^{-3} \times 10}{10 \times 10^{-6}}$$

$$E = 10 \times 10^{-3}\ N/C$$

Question

A charge particle of $1\mu C$ is placed at origin, Find intensity of electric field due to the charge at position (3, 4)m.

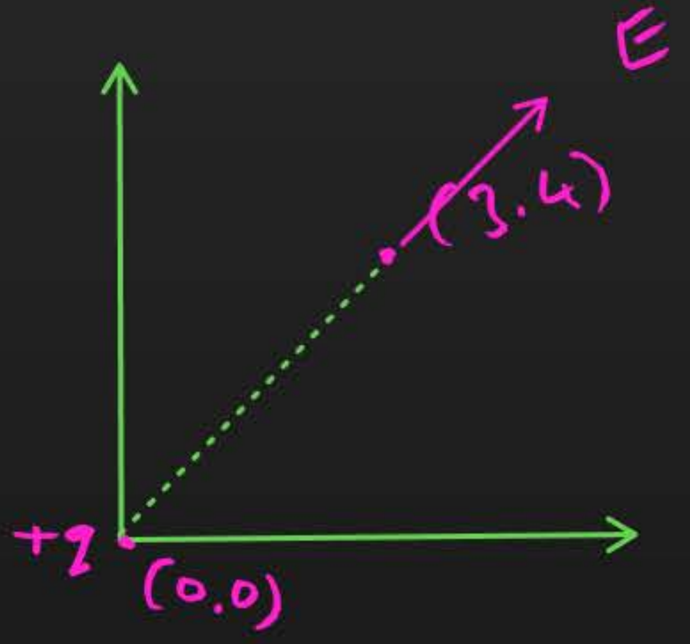
$$\vec{r} = 3\hat{i} + 4\hat{j}$$

$$|\vec{r}| = r = \sqrt{3^2 + 4^2}$$

$$r = \sqrt{9+16} = \sqrt{25}$$

$$r = 5\,m$$

$$E = \frac{Kq}{r^2}$$



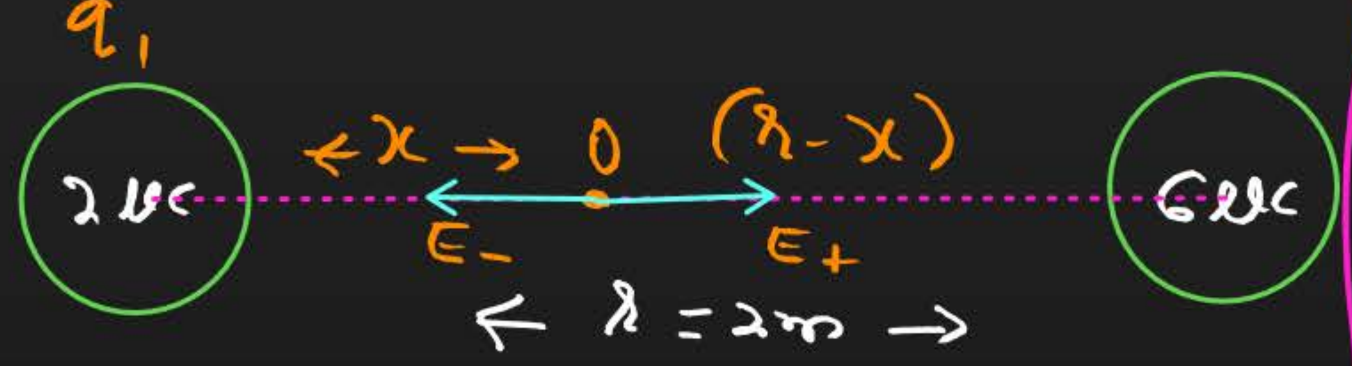
$$\vec{E} = \frac{Kq}{r^3}\vec{r} = \frac{9\times10^{9}\times1\times10^{-6}}{(5)^3}\times(3\hat{i}+4\hat{j})$$

$$\vec{E} = \frac{9\times10^{3}}{125}(3\hat{i}+4\hat{j}) = 72\,(3\hat{i}+4\hat{j})\ N/C$$

Question

Find the point at which resultant $\vec{E}$ of the systems will become zero. For the system of $2\mu C$ and $6\mu C$ separated by a distance 2 m.

$E = \frac{Kq}{r^2}$



$E_1 = E_2$

$\frac{Kq_1}{x^2} = \frac{Kq_2}{(r-x)^2} \Rightarrow \frac{2\times10^{-6}}{x^2} = \frac{6\times10^{-6}}{(2-x)^2}$

$\frac{1}{x} = \frac{3}{(2-x)}$

$2 - x = 3x$

$2 = 3x + x = 4x$

$x = \frac{2}{4} = \frac{1}{2}$

$x = \frac{1}{2}$ m From $2\mu C$

$r - x = 2 - \frac{1}{2} = \frac{3}{2}$ m from $6\mu C$

Electric field lines or Lines of forces

$E \propto \frac{1}{\text{spacing}}$

Properties: These are the imaginary lines of force in electric field of charge.

1. Electric field lines are geometrical representation of strength of electric field.
2. Electric field lines originate from positive charge and terminate on the negative charge.
3. Electric field lines are always perpendicular to the surface of the conductor.
4. Electric field lines do not pass through the conductor.
5. Electric field lines do not intersect.
6. They do not form any closed loops.

Question

Which of the electrostatic lines of forces are correct drawn?

(A) 

(B) 

(C) 

(D) All of these

Question

Electric field lines about a negative point charge are

(A) Circular, anticlockwise

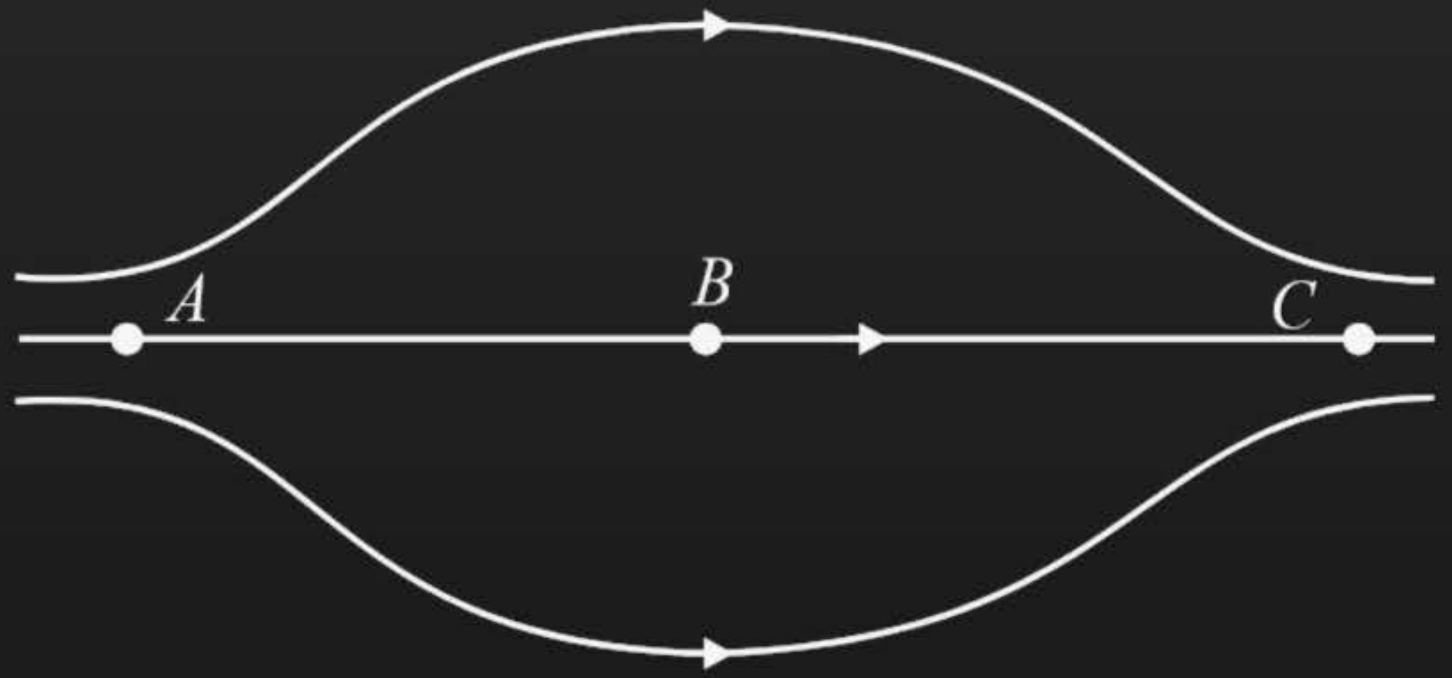
(B) Circular, clockwise

(C) Radial, inwards

(D) Radial, outwards

Question

The figure shows some of the electric field lines corresponding to an electric field. The figure suggests



A) $E_A > E_B > E_C$

B) $E_A = E_B = E_C$

C) $E_A = E_C > E_B$

D) $E_A = E_C < E_B$

Question

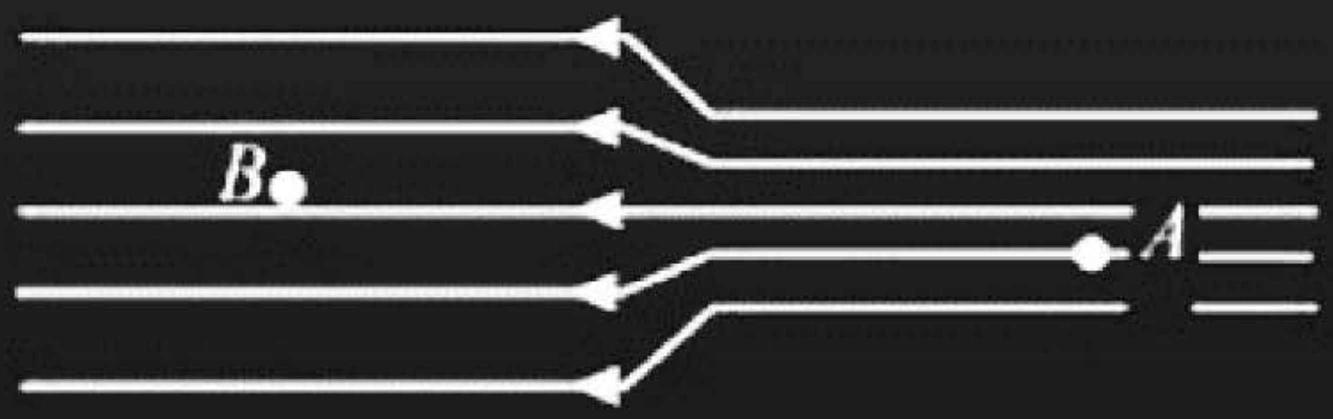
The electric field lines on the left have twice the separation on those on the right as shown in figure. If the magnitude of the field at A is 40 vm^{-1} what is the force on 20 μC charge kept at B

(A) 4×10^{-4} N

(B) 8×10^{-4} N

(C) 16×10^{-4} N

(D) 1×10^{-4} N



Question

Pick out the statement which is incorrect?

(A) A negative test charge experiences a force opposite to the direction of the field

(B) The tangent drawn to a line of force represents direction of electric field

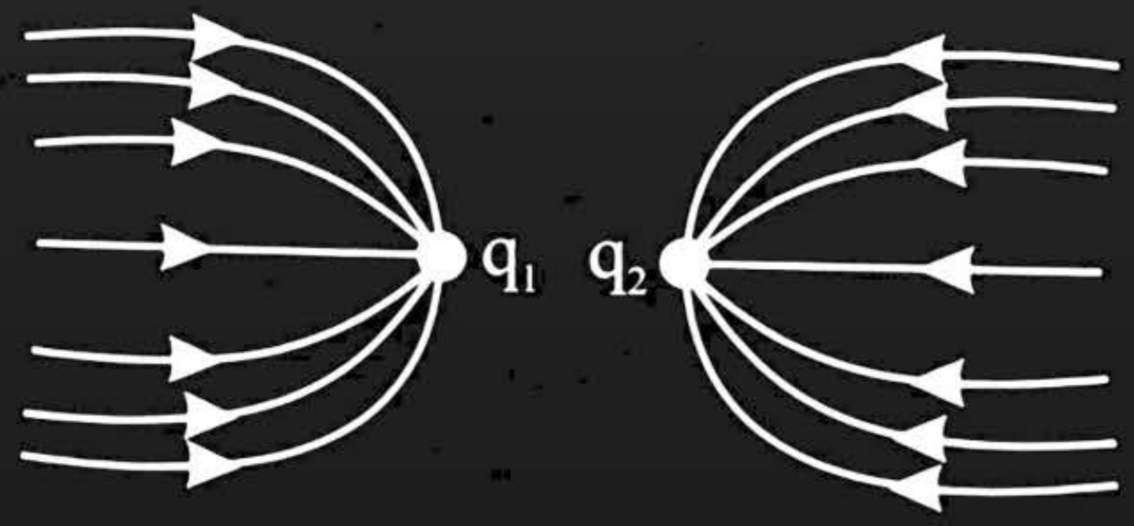
(C) Field lines never intersect

(D) The electric field lines forms closed loop

Question

H.W

The given figure gives electric lines of force due to two charges q_1 and q_2. What are the signs of the two charges?



A) q_1 is positive but q_2 is negative

B) q_1 is negative but q_2 is positive

C) Both are negative

D) Both are positive

Question

H.W

Calculate the magnitude of an electric field which can just suspend a deutron of mass $3.2 \times 10^{-27} kg$ freely in air

Question

$H.\omega$

A charged particle of mass m and charge q is released from rest in an uniform electric field E. Neglecting the effect of gravity, the kinetic energy of the charged particle after t seconds is

(A) $\dfrac{Eq^2m}{2t^2}$

(B) $\dfrac{Eqm}{t}$

(C) $\dfrac{E^2q^2t^2}{2m}$

(D) $\dfrac{2E^2t^2}{mq}$

Question

A particle of mass m and charge q is placed at rest in uniform electric field E and then released. The kinetic energy attained by the particle after moving a distance y is

A. qEy^2

B. qE^2y

C. qEy

D. q^2Ey

Question

H.W

In the uniform electric field of $E = 1 \times 10^4$ NC^{-1} an electron is accelerated from rest. The velocity of the electron when it has travelled a distance of 2×10^{-2} m is nearly

$\frac{e}{m}$ of electron $\approx 1.8 \times 10^{11}$ $C\ kg^{-1}$

(A) 8.5×10^6 ms^{-1}

(B) 1.6×10^6 ms^{-1}

(C) 0.85×10^6 ms^{-1}

(D) 0.425×10^6 ms^{-1}

Question

An electron of mass m, charge e falls through a distance h metre in a uniform electric field E. Then, time of fall

(A) $t = \sqrt{\frac{2hm}{eE}}$

(B) $t = \frac{2hm}{eE}$

(C) $t = \sqrt{\frac{2em}{hE}}$

(D) $t = \frac{2eE}{hm}$

Question

What is the flux through a cube of side ‘a’ if a point charge q is at one of its corners?

A $\frac{2q}{\varepsilon_0}$

B $\frac{q}{8\varepsilon_0}$

C $\frac{q}{\varepsilon_0}$

D $\frac{q}{2\varepsilon_0}$

Thank

You