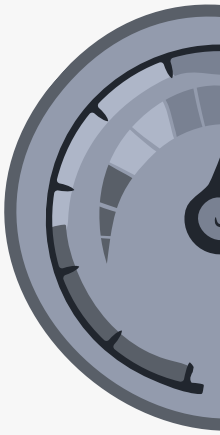
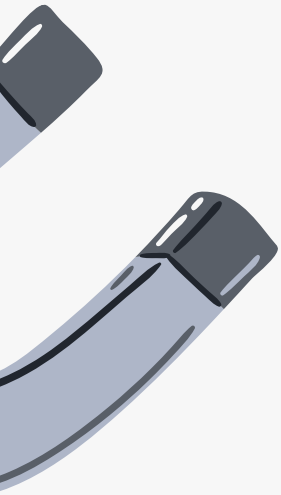


30 day

Physics

Chapter - 1
Electric Charges & Fields

TOPICS

(High + Medium Yield)

- **Electric charge: properties** (quantisation, conservation)
- **Methods of charging:** friction, conduction, induction
- **Earthing** (definition based)
- **Coulomb's law** (statement + numericals)
- **Superposition principle** (basic application)
- **Electric field**: definition, SI unit, alternate unit
- **Electric field lines** (rules + diagrams)
- **Electric flux** (definition + numericals)
- **Gauss's Law**
  - Statement + mathematical form
  - Electric field due to
    - **Thin spherical shell**
    - **Infinite line charge**

Topic 1: Electric Charge & Its Basic Properties

Concept

- Electric charge is a **basic property of matter** due to which it produces electric force.

👉 Electric charge matter ka ek basic gun hai jiske kaaran electric force paida hoti hai.

- **Two types of charge exist:**
  - **Positive charge**
  - **Negative charge**

- Like charges repel, unlike charges attract.

👉 Same charge ek-dusre ko repel (door dhakel) karte hain, different charge attract (kheench) karte hain.

- **SI** Unit of charge is **coulomb** (C).

Key Definitions

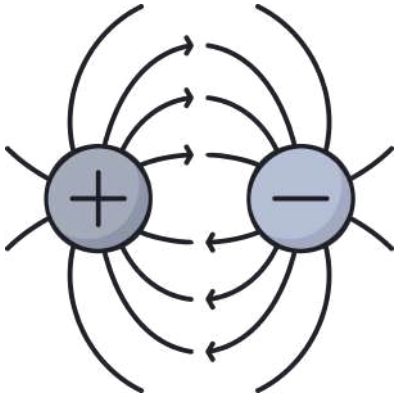
Electric Charge:-

- Electric charge is a **fundamental property of matter** responsible for electrical interaction.

👉 Electric charge matter ka mool (basic) gun hai jo electrical interaction ke liye zimmedaar hota hai.

OR

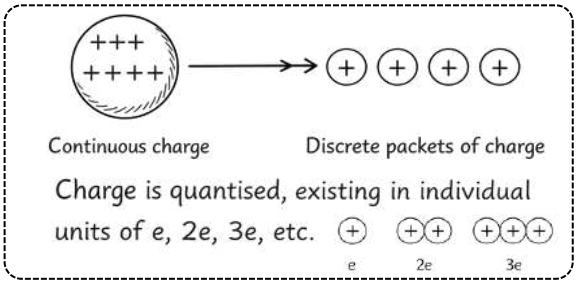
- Electric charge is a **basic property of matter** due to which it produces electric force.



Quantisation of Charge:-

- Electric charge exists in discrete packets, not continuously.
- **Definition**: The charge on any body can be expressed as an integral multiple of basic unit of charge

$$q = \pm ne$$



where

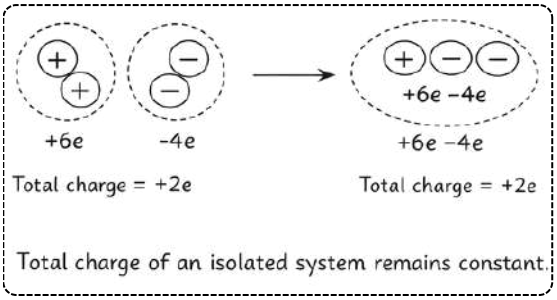
- **n = integer**
- **e = 1.6 × 10^{-19} C**

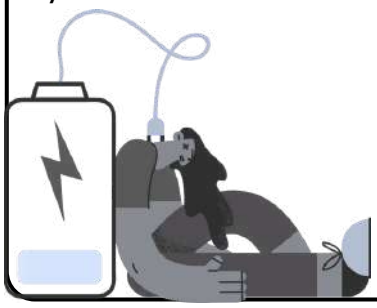
👉 Electric charge chhote-chhote fixed packets me hota hai, continuous nahi hota.
👉 Koi bhi body ka charge hamesha electron ke charge ka poora multiple hota hai.
👉 Charge hamesha ±ne ke form me hota hai.
👉 n ek poora number hota hai (1, 2, 3...)
👉 e ek electron ka charge hai.

Conservation of Charge:-

Total charge of an isolated system remains constant.

👉 Ek akela (isolated) system ka total charge hamesha constant rehta hai.

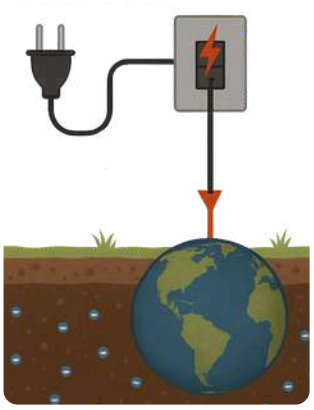


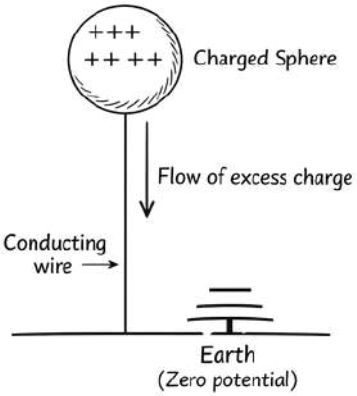


Earthing:-

The process of **transferring excess charge** from a body **to** the **earth** is called earthing.

👉 Body se extra charge ko zameen (earth) me bhejne ki process ko earthing kehte hain.





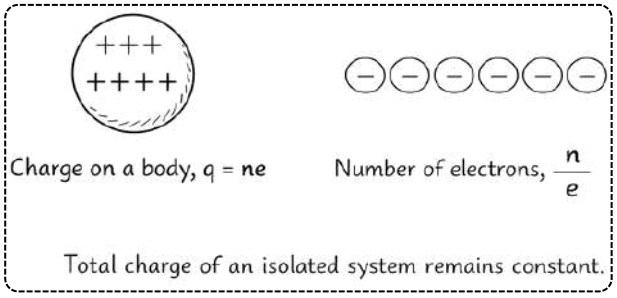
Important Formulas

Charge on a body

$$q = ne$$

Number of electrons

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



👉 Body ka charge = number of electrons × electron charge
👉 Electrons ki sankhya = total charge ÷ electron charge

Typical PYQ Patterns

Boards usually ask:

- "State any one property of electric charge." (1M)
- "How many electrons are present in a body having charge …?" (1M)

Fill in the blank:

- Electric charge is _____ in nature.
  - → Quantised
- "The process of sharing charges with earth is called _____."
  - → Earthing

👉 Electric charge ki koi ek property likho.
👉 Diye gaye charge ke liye electrons ki sankhya batao.
Fill in the blank:
👉 Charge ka nature poocha jaata hai – answer: quantised.
👉 Earth ke saath charge share karna = earthing.

Solved Exam-Level Examples

✅ Example 1 (1 Mark – Direct PYQ Type)

Q: How many <u>electrons</u> are there in a body having charge

$$16 \times 10^{-18} C$$

👉 Diye gaye charge ke liye electrons ki sankhya nikaalo.
👉 Formula use karke value daali.
👉 Body me 100 electrons hain.

Solution:

Given,

$$q = 16 \times 10^{-18} C$$

We know, $n = \frac{q}{e}$

$$\Rightarrow n = \frac{16 \times 10^{-18} C}{1.6 \times 10^{-19} C} = 100$$

Calculation

$$\frac{16 \times 10^{-18} C}{1.6 \times 10^{-19} C} = \frac{16 \times 10^{-18}}{1.6 \times 10^{-19}} = \frac{16}{\frac{16}{10}} \times 10^{-18} \times 10^{-(-19)}$$

$$= \frac{16}{16} \times 10 \times 10^{-18} \times 10^{(+19)} = 1 \times 10^{1} \times 10^{-18} \times 10^{(+19)}$$

$$= 1 \times 10^{1} \times 10^{(-18+19)} = 1 \times 10 \times 10 = 100$$

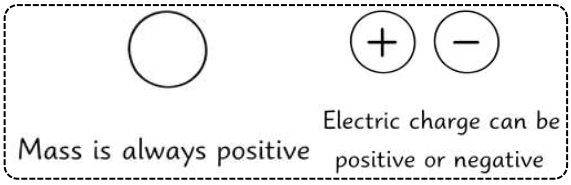
Answer: 100 electrons

✅ **Example 2 (1 Mark – Theory)**

Q: State one difference between mass and electric charge.

Answer:

Mass is always positive, whereas electric charge can be positive or negative.



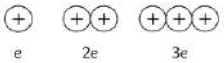
👉 Mass aur charge me ek antar likho.
👉 Mass hamesha positive hota hai, lekin charge positive ya negative dono ho sakta hai.

✅ **Example 3 (Fill in the Blank)**

Q: Electric charge is _____ in nature.

Ans: Quantised

Charge is quantised, existing in individual units of e, 2e, 3e, etc.



👉 Charge discrete packets me hota hai.

🔁 Quick Recall Check (Use for Active Recall)

- **Unit of charge?**
  - 👉 Coulomb
- **Value of elementary charge?**
  - 👉 1.6×10^{-19} C
- **Formula linking charge and electrons?**
  - 👉 q = ne
- **Name the process of removing excess charge?**
  - 👉 Earthing
- **If you can answer these without looking, topic is DONE.**

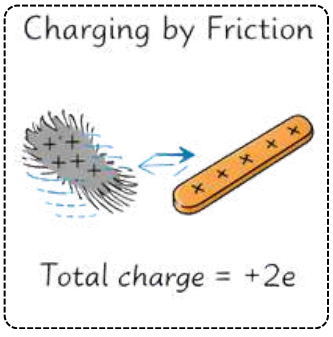
👉 Bina dekhe jawab aa gaya = exam-ready.

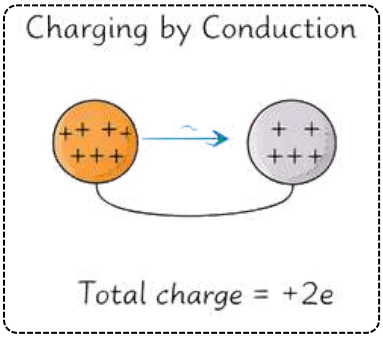
Topic 2: Methods of Charging

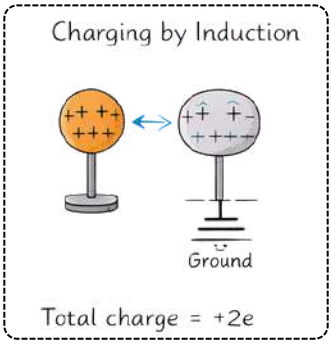
Concept

- A neutral body can be charged by transfer or rearrangement of electrons.
- There are three methods of charging:
- Charging by **Friction**
- Charging by **Conduction**
- Charging by **Induction**

👉 Ek neutral body ko electrons ke transfer ya rearrangement se charged banaya ja sakta hai.
👉 Charging karne ke teen tareeke hote hain:
👉 Ragad (ghisne) ke through charging
👉 Direct contact se charging
👉 Bina touch kiye charging



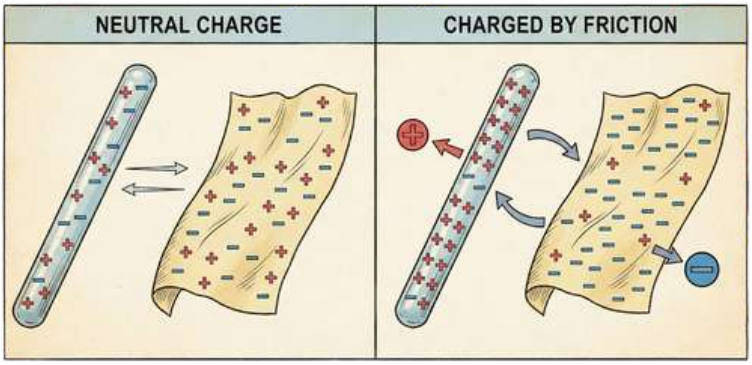




Key Definitions

Charging by Friction:-

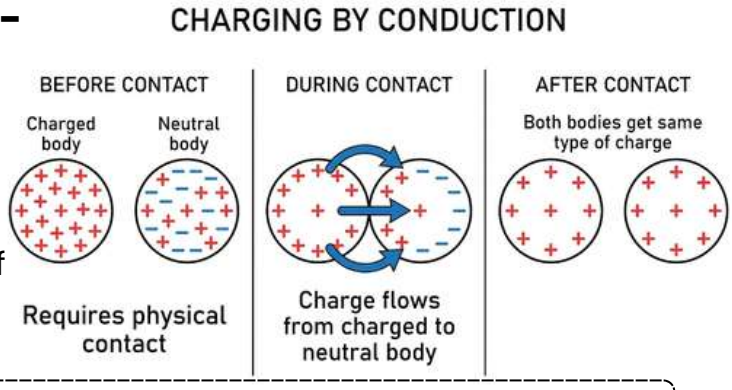
- When **two neutral bodies are rubbed together**, **electrons are transferred** from one body to another.
- **One** becomes **positively** charged
- The **other** becomes **negatively** charged
- Example: Glass rod & silk cloth



👉 Jab do neutral bodies ko aapas me rub kiya jaata hai, to electrons ek body se doosri body me transfer ho jaate hain.
👉 Ek body positive charged ho jaati hai (electrons lose karti hai).
👉 Doosri body negative charged ho jaati hai (electrons gain karti hai).
👉 Example: Glass rod ko silk cloth se rub karna.

Charging by Conduction:-

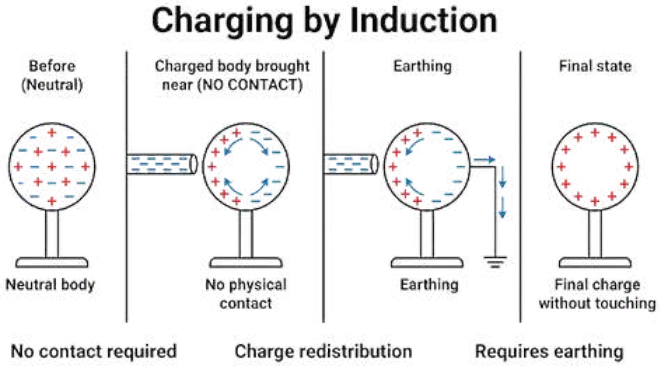
- When a charged body is brought in **direct contact** with a neutral body, charge flows from the charged body to the neutral body.
- **Both bodies** get **same type** of **charge**
- **Requires physical contact**



👉 Jab ek charged body ko neutral body ke direct contact me laate hain, to charge flow karta hai.
👉 Dono bodies par same type ka charge aa jaata hai.
👉 Is method me physical touch zaroori hota hai.

Charging by Induction

- When a charged body is brought near a neutral body without contact, charges are redistributed in the neutral body.
- Final charge appears without touching
- Requires earthing



👉 Jab charged body ko bina touch kiye neutral body ke paas laate hain, to neutral body me charges rearrange ho jaate hain.
👉 Bina touch kiye hi body charged ho jaati hai.
👉 Is process me earthing zaroori hoti hai.

Summery

Method	Contact Needed?	Earthing Needed?	Type of Charge Obtained
Friction	Yes	No	Opposite charges
Conduction	Yes	No	Same charge
Induction	No	Yes	Opposite charge

Typical PYQ Patterns

- "Name the method used to charge a body without contact."
  - → ***Induction***
- *"In which method earthing is necessary?"*
  - → ***Induction***
- *"When a charged rod touches a neutral body, which method is used?"*
  - → ***Conduction***

2-mark question:

- ***Explain charging by induction.***

👉 Bina touch charge karne ka method: Induction.
👉 Jisme earthing chahiye: Induction.
👉 Touch ho raha hai = Conduction.
👉 Induction ka short explanation likho.

Solved Exam-Level Examples

✅ **Example 1 (1 Mark)**

Q: A charged rod is brought near a neutral conductor but does not touch it. The conductor becomes charged. Name the method.

Answer: Charging by induction

✅ **Example 2 (2 Marks)**

Q: Explain charging by conduction.

👉 *Conduction method samjhaao.*

👉 Charged rod paas laayi, touch nahi kiya, phir bhi charge aa gaya – method batao.
👉 Direct touch hone par charge flow karta hai aur neutral body charged ho jaati hai.

Answer:

Charging by conduction is the process by which a neutral body gets charged when a charged body is brought in direct contact with it. Charge flows from the charged body to the neutral body.

🔁 Quick Recall Check (Use for Active Recall)

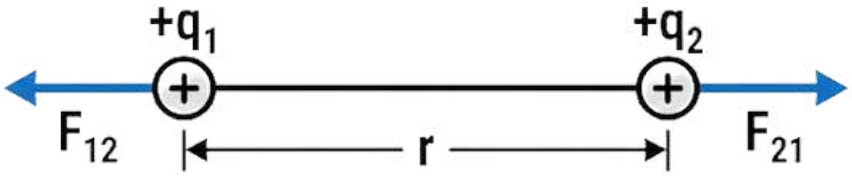
- **Which method needs earthing?**
  - *Induction*
- **Which method gives same type of charge?**
  - *Conduction*
- **Which method works without contact?**
  - *Induction*
- **If instant answers → move on.**
  - 👉 *Agar turant answer aa gaye, topic clear.*

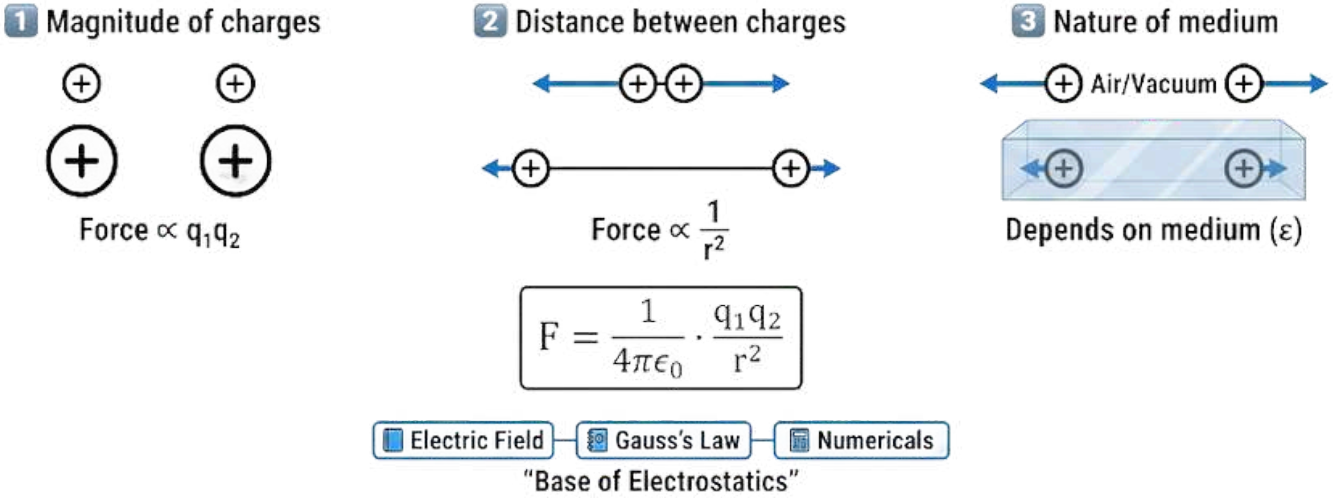
Topic 3: Coulomb's Law

Concept

- Coulomb's law tells us how strong the electrostatic force is between two point charges.
- The force depends on:
- Magnitude of charges
- Distance between them
- Nature of medium
- 👉 This law is the base for electric field, Gauss's law, numericals.

👉 Coulomb ka niyam batata hai ki do point charges ke beech electrostatic force kitni strong hoti hai.
👉 Force in cheezon par depend karti hai:
👉 Charges ki value (kitna charge hai).
👉 Charges ke beech ka distance.
👉 Jis medium me charges rakhe gaye hain (air, vacuum, etc.).
👉 Electric field, Gauss's law aur numericals sab isi law par based hote hain.





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

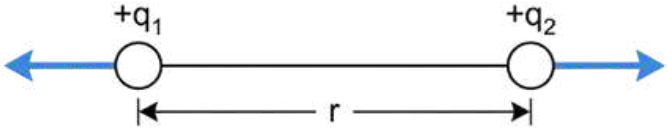
Electric Field — Gauss's Law — Numericals

"Base of Electrostatics"

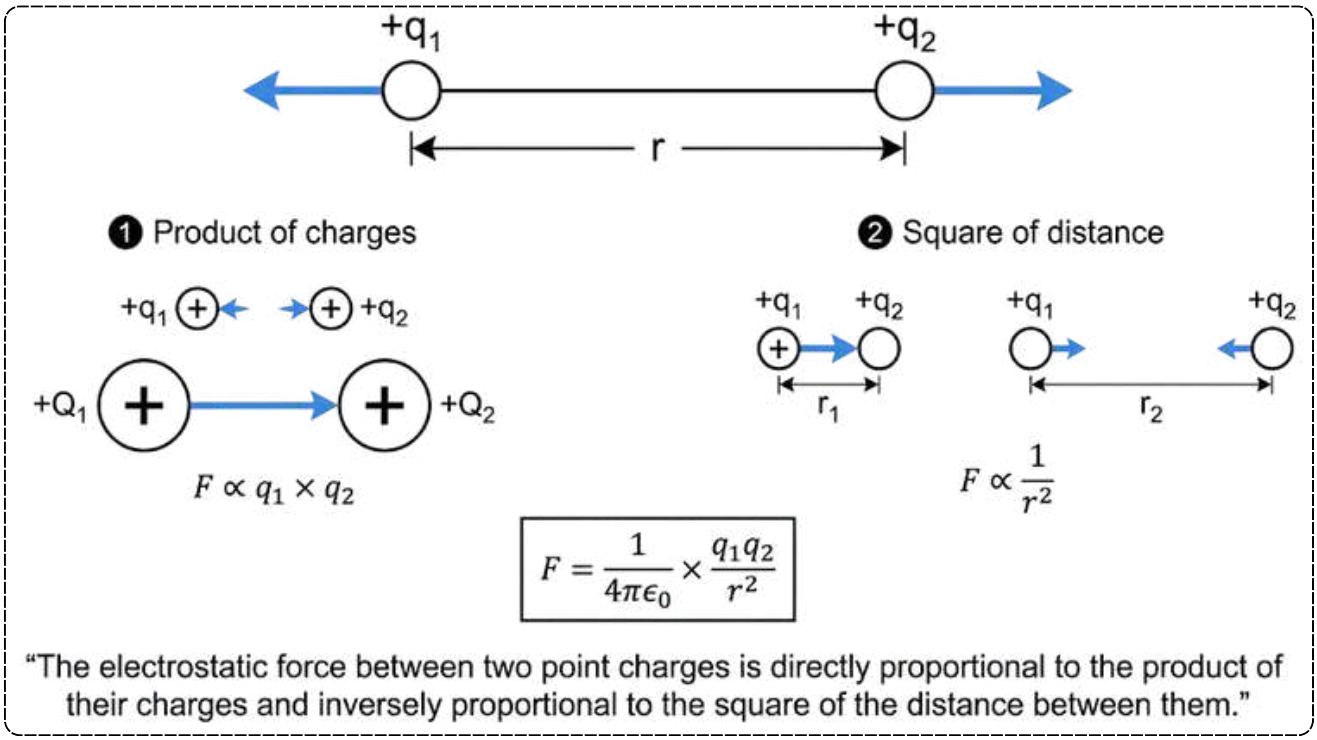
Key Definitions

Coulomb's Law

The electrostatic **force between** two point **charges** is **directly proportional** to the **product** of the **magnitudes** of the charges and **inversely proportional** to the **square** of the **distance** between them.



👉 Do point charges ke beech electrostatic force, charges ke product ke directly proportional aur unke beech ke distance ke square ke inversely proportional hoti hai.
(Definition ko ghuma-phira ke mat likhna.)
👉 Board exact wording chahta hai.



"The electrostatic force between two point charges is directly proportional to the product of their charges and inversely proportional to the square of the distance between them."

In vacuum / air:

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

👉 Vacuum ya air me Coulomb's law ka formula.
👉 q_1 aur q_2 charges hain.
👉 r charges ke beech ka distance hai.
👉 ε_0 free space ki permittivity hoti hai.
👉 Constant ki standard value (yaad honi chahiye).

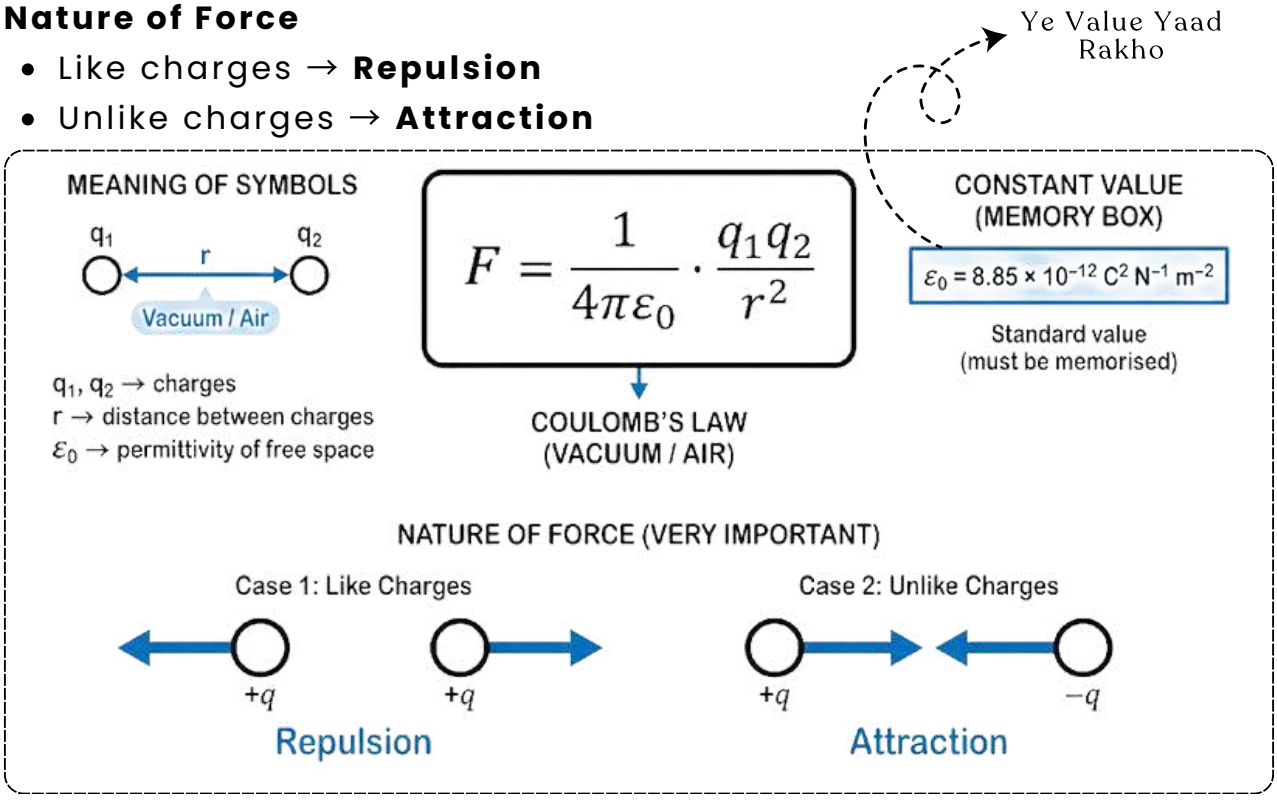
where

- q_1, q_2 = charges
- r = distance between charges
- ε_0 = permittivity of free space

$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$, $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2C^{-2}$

Nature of Force

- Like charges → **Repulsion**
- Unlike charges → **Attraction**



Important Observations (Exam-Focused)

- ***Force is:***
  - *Along the line joining the charges*
  - *Equal and opposite on both charges*
- ***Coulomb's law is valid for:***
  - *Point charges*
  - *Charges at rest*

👉 Force ki kuch khas properties:
- 👉 Force hamesha charges ko jodne wali line ke along hoti hai.
- 👉 Dono charges par force equal magnitude ki aur opposite direction me hoti hai.

👉 Coulomb's law tab valid hota hai jab:
- 👉 Charges point-like hon.
- 👉 Charges stationary hon (move nahi kar rahe hon).

Typical PYQ Patterns

Boards repeatedly ask:

- "State Coulomb's law." (2M)
- "Write the formula of Coulomb's law." (1M)

Numerical:

- Two charges given + distance → find force (2M)
- "Mention two smaller units of coulomb." (1M)

Solved Exam-Level Examples

✅ **Example 1 (2 Marks – PYQ Type)**

Q: Calculate the force between two charges of 1 C each placed 1 m apart in air.

👉 Do 1 C ke charges 1 m door rakhe hain, force nikaalo.
👉 Values formula me daali.
👉 Same charges hain, isliye force repulsive hai.

Solution:

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

Given,

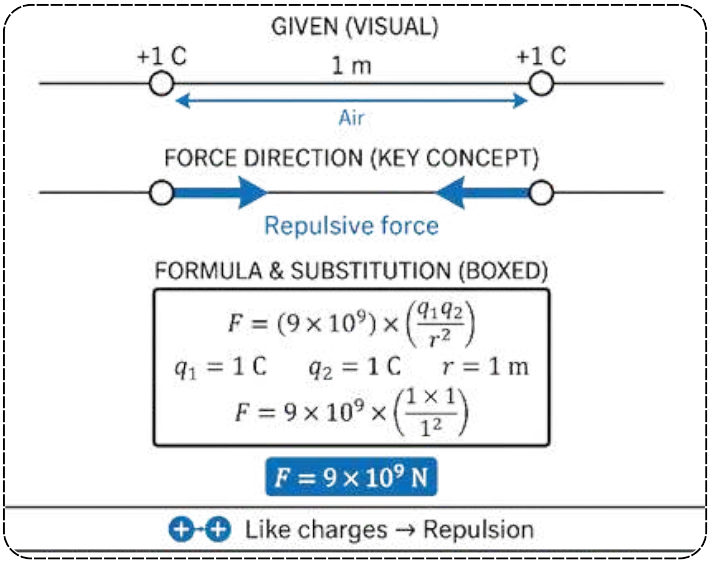
$$r = 30cm = 0.3m, \qquad \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$$

$$q_1 = q_2 = 1 \times 10^{-7} C$$

$$\therefore F = 9 \times 10^9 \times \frac{1 \times 1}{1^2}$$

$$\Rightarrow F = 9 \times 10^9 N$$

Answer: 9 × 10⁹ N (Repulsive)



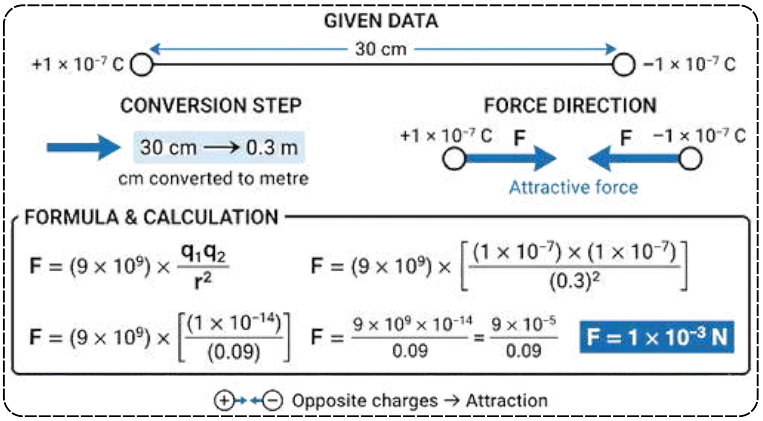
✅ Example 2 (2 Marks – Numerical)

Q: Two charges $+1 \times 10^{-7} C$ and $-1 \times 10^{-7} C$ are placed 30 cm apart. Find the force.

Solution: $r = 0.3\,m$

$$F = 9 \times 10^{9} \times \frac{(1 \times 10^{-7})(1 \times 10^{-7})}{(0.3)^2}$$

$$F = 1 \times 10^{-3}\,N$$



Nature: Attractive

👉 Opposite charges diye gaye hain, distance 30 cm hai.
Solution:
👉 cm ko metre me convert kiya.
👉 Opposite charges → attraction.

One-Line Questions (Very Common)

SI unit of force? → Newton
👉 Force ki SI unit Newton hoti hai.

Two smaller units of charge? → mC, μC
👉 Milli-coulomb aur micro-coulomb.

Force increases when distance decreases? → Yes
👉 Distance kam → force zyada (inverse square law).

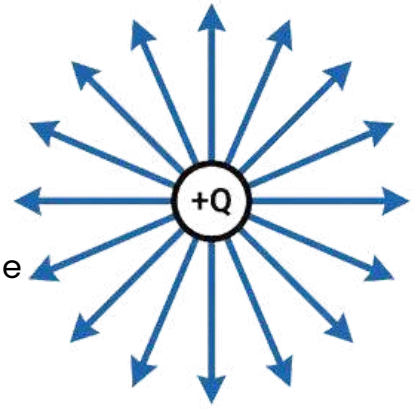
🔁 Active Recall (Test Yourself Now)

- ***Formula of Coulomb's law?***
  - 👉 *$F = (1/4\pi\epsilon_0)(q_1 q_2 / r^2)$*
- ***What happens if distance is doubled?***
  - 👉 *Force 1/4 ho jaati hai.*
- ***Does force depend on medium?***
  - 👉 *Haan, medium par depend karti hai.*
- ***If instant answers → done.***
  - 👉 *Agar bina soche jawab aa gaye, topic clear.*

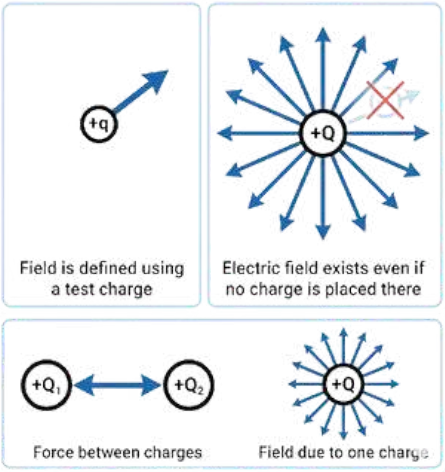
Topic 4: Electric Field & Electric Field Intensity

Concept

- **Electric field** tells us how a charge influences the space around it.
- Instead of talking about force between two charges, we define field using one test charge.
- Electric field exists even if no charge is placed at that point.



Electric field around a charge



👉 Electric field batata hai ki koi charge apne aas-paas ke space ko kaise influence karta hai.
👉 Do charges ke beech force ki baat karne ke bajay, hum ek test charge se field define karte hain.
👉 Electric field tab bhi exist karti hai jab us point par koi charge na ho.

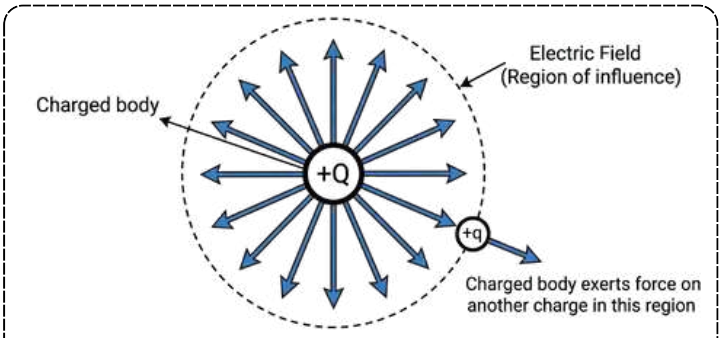
Key Definitions

Electric Field
The region around a charged body in which it can exert force on another charge is called an electric field.

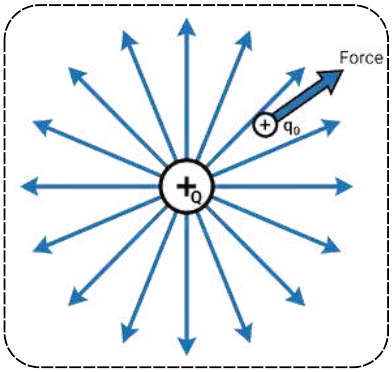
Electric Field Intensity (E)
Electric field intensity at a point is defined as the force experienced by a unit positive test charge placed at that point.

$$E = \frac{F}{q_0}$$

👉 Electric field intensity = force ÷ test charge.
(where q_0 is a small positive test charge)



Electric field exists around a charge even if no test charge is present.
MEMORY LOCK: Field = Region of influence of a charge



Electric field intensity at a point = force on unit positive test charge placed at that point.

$$E = \frac{F}{q_0}$$

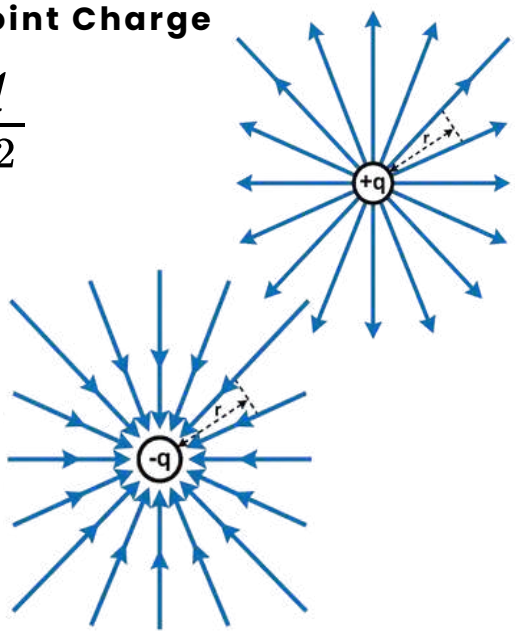
q_0 is a small positive test charge

👉 Charged body ke aas-paas ka wo region jahan wo kisi doosre charge par force laga sakta hai, electric field kehlata hai.
👉 Electric field intensity ka matlab hai: kisi point par rakhe gaye unit positive test charge par lagne wali force.
👉 Yahaan q_0 ek chhota positive test charge hota hai.

Important Formulas

Electric Field due to a Point Charge

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



👉 Point charge ke kaaran electric field ka formula.

👉 Positive charge se bahar ki taraf.
👉 Negative charge ki taraf.
👉 Electric field ki SI unit Newton per Coulomb hoti hai.
👉 Alternate unit Volt per metre hoti hai.

Direction:

Away from **+ve** charge

Towards **-ve** charge

Units of Electric Field

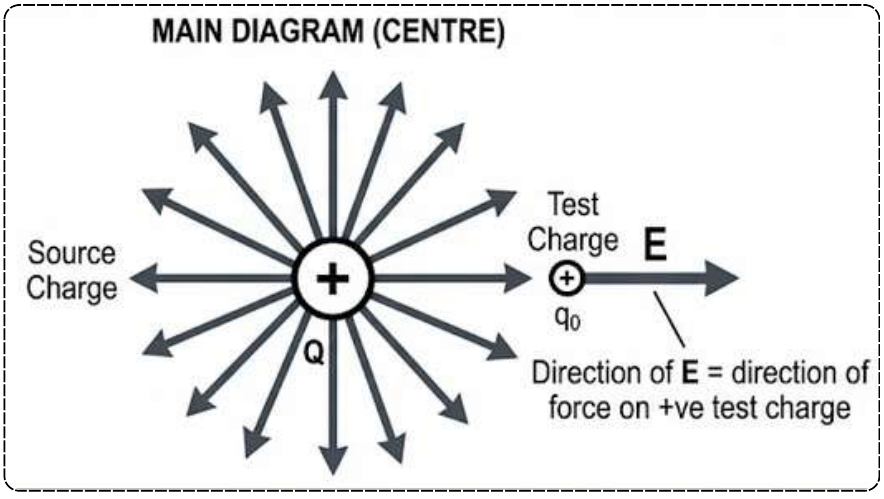
SI unit: **N/C**

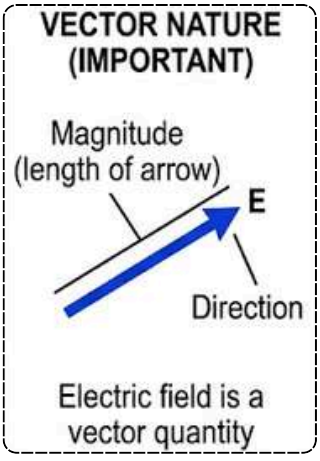
Alternate unit: **V/m**

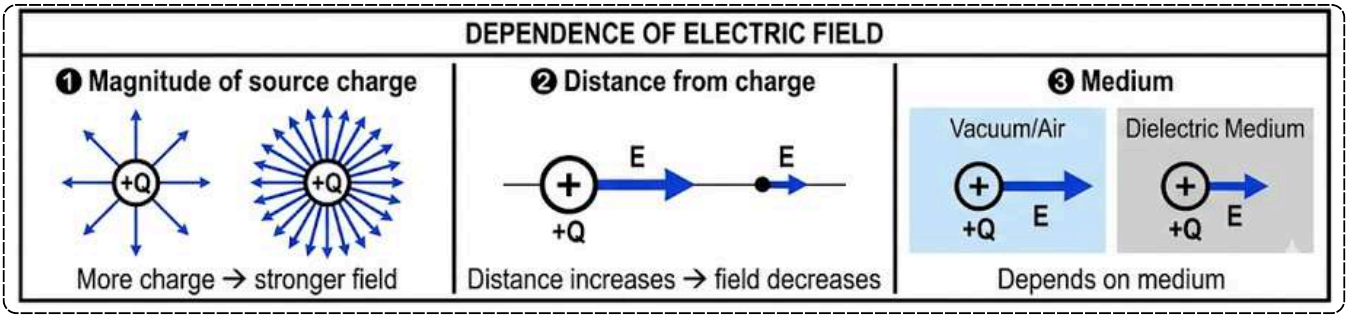
Important Properties (Board Loves These)

- **Electric field is a vector quantity**
- Direction is the direction of force on a positive test charge
- **Depends on:**
  - **Magnitude of source charge**
  - **Distance from charge**
  - **Medium**

👉 Electric field ek vector quantity hai (magnitude + direction dono hota hai).
👉 Direction hamesha positive test charge par lagne wali force ki hoti hai.
👉 Electric field in cheezon par depend karti hai:
👉 Source charge ki value.
👉 Charge se distance.
👉 Jis medium me charge rakha hai.







Typical PYQ Patterns

- "Define electric field intensity." (2M)
- "Write SI unit of electric field and its alternate unit." (2M)
- "Static charges produce _____ field."
- → Electric

Numerical:

- Field due to a point charge (2M)

👉 Electric field intensity ki definition likho.
👉 Electric field ki SI aur alternate unit likho.
👉 Static charge electric field produce karta hai.
👉 Point charge ke liye E calculate karna.

Solved Exam-Level Examples

✅ Example 1 (2 Marks)

Q: Define electric field intensity and write its SI unit.

Answer:

- Electric field intensity at a point is the force experienced by a unit positive test charge placed at that point.
- SI unit: **N/C**

👉 Electric field intensity define karo aur SI unit likho.
👉 Unit positive test charge par lagne wali force ko electric field intensity kehte hain.
👉 SI unit Newton per Coulomb.

✅ Example 2 (2 Marks – Numerical)

Q: Find the electric field at a point 2 m away from a charge of $5 \times 10^{-6} C$

Solution:

Given, $r = 2m$

$q = 5 \times 10^{-6} C$

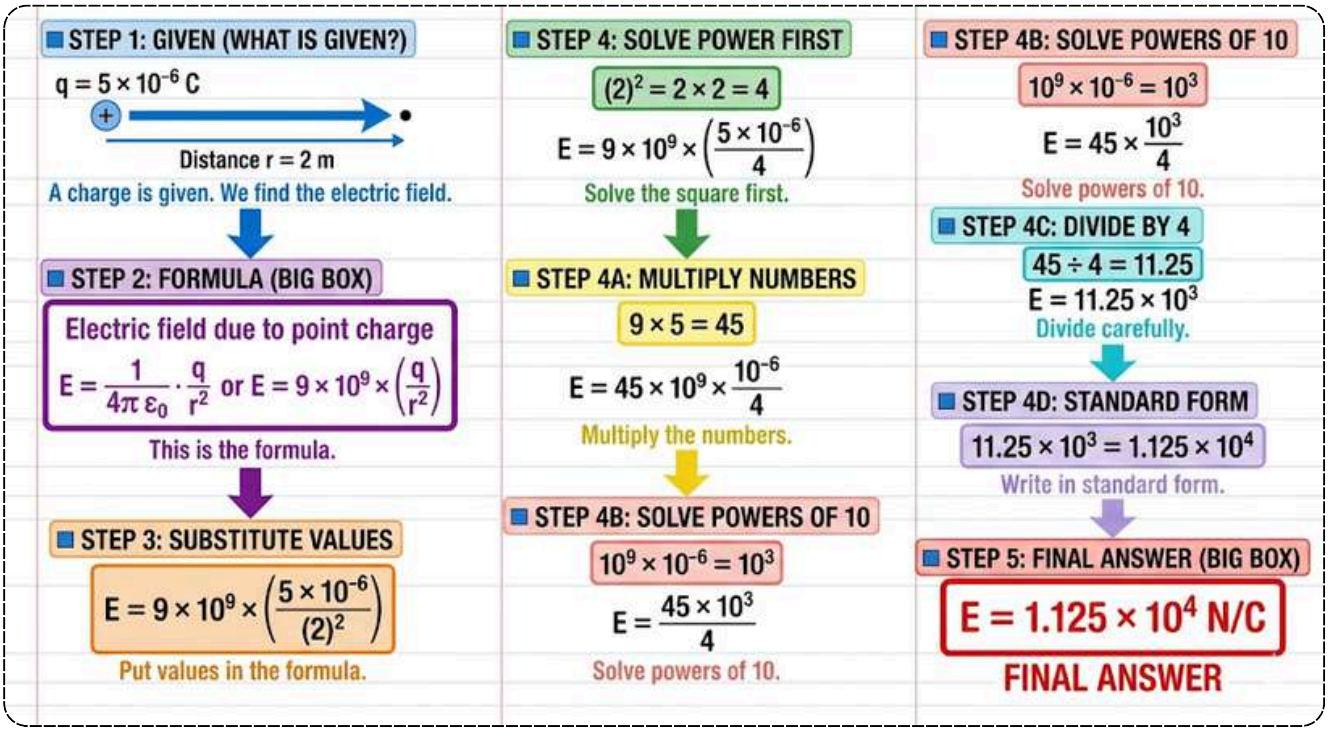
We Know,

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

$$\Rightarrow E = \frac{9 \times 10^9 \times 5 \times 10^{-6}}{(2)^2}$$

$$\Rightarrow E = 1.125 \times 10^4\, N/C$$

👉 2 metre door ek charge diya hai, electric field nikaalo.
👉 Values formula me daali.
👉 Final answer.



✅ **Example 3 (1 Mark – Fill in the Blank)**

Q: Static charges produce _____ field.

- Ans: Electric

👉 Static charge → electric field.

🔁 Active Recall (Non-Negotiable)

- **Definition of electric field?**
  - 👉 Region around charge…
- **Formula of E due to point charge?**
  - 👉 $E = (1/4\pi\epsilon_0)(q/r^2)$
- **Direction of field for + and - charge?**
  - 👉 + se bahar, - ki taraf.
- **SI and alternate units?**
  - 👉 N/C, V/m
- **If yes → move on.**
  - 👉 *Agar turant jawab aa gaya, topic complete.*

Topic 5: Electric Field Lines

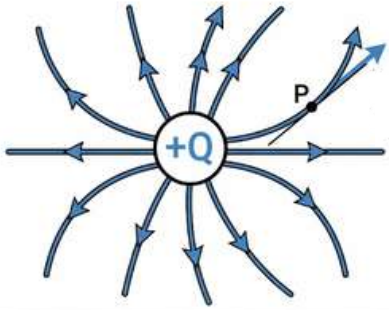
Concept

- Electric field lines are an imaginary representation of an electric field.
- They help us understand:
- Direction of electric field
- Strength of electric field
- 👉 This topic is mostly theory + diagram-based.

👉 Electric field lines electric field ka imaginary (kalpanik) representation hoti hain.
👉 Ye hume samajhne me madad karti hain:
👉 Electric field ki direction.
👉 Electric field ki strength (taakat).
👉 Ye topic mainly theory aur diagram par based hota hai.

Key Definitions

Electric Field Lines
Electric field lines are imaginary lines drawn in an electric field such that the tangent at any point gives the direction of the electric field at that point.
(Definition ko word-to-word yaad rakho.)



Electric field lines are imaginary lines drawn in an electric field such that the tangent at any point gives the direction of the electric field at that point.

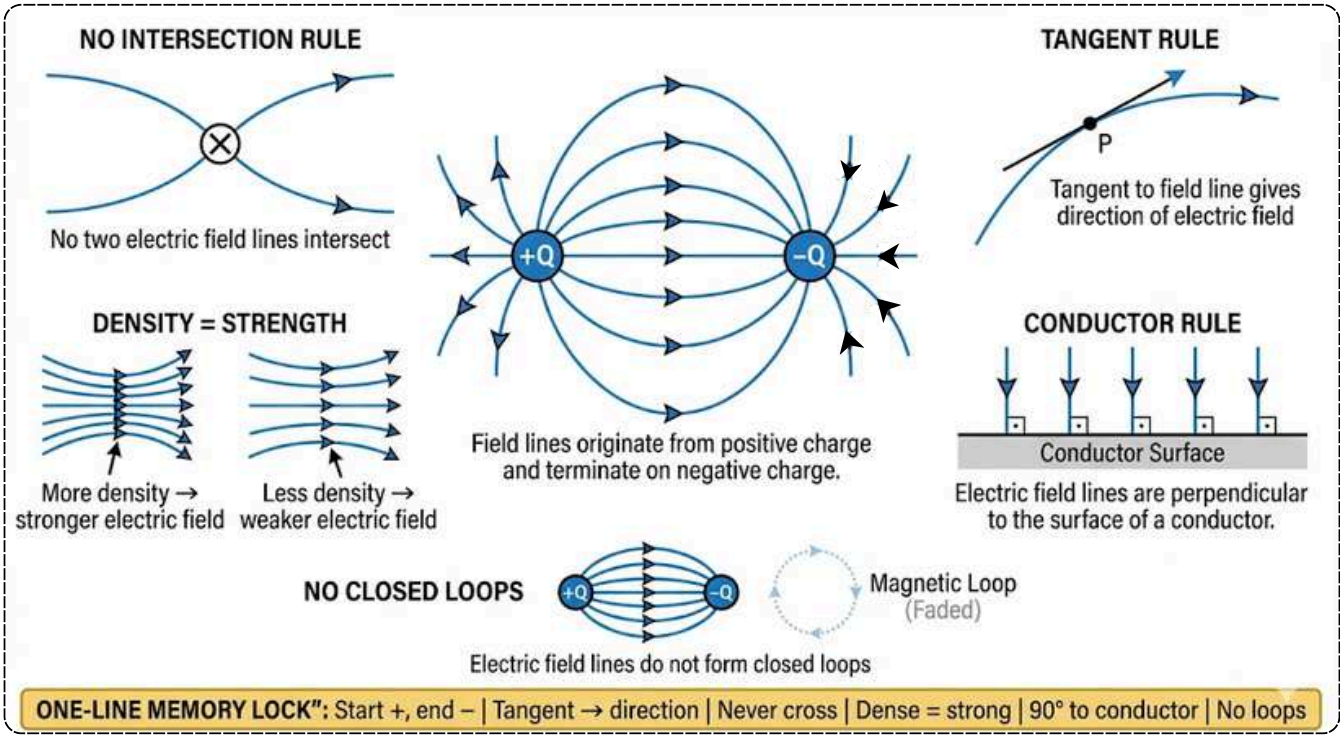
👉 Electric field lines imaginary lines hoti hain, jinke kisi bhi point par tangent lene se electric field ki direction pata chalti hai.
👉 Board exact language expect karta hai.

Rules / Properties of Electric Field Lines

⚠️ **VERY IMPORTANT – asked directly**
👉 **Ye rules directly question me aate hain.**

- Field lines originate from positive charge and terminate on negative charge.
- Tangent to the field line gives direction of electric field.
- No two field lines intersect each other.
- Density of field lines indicates strength of electric field.
- Field lines are perpendicular to the surface of a conductor.
- Field lines do not form closed loops (unlike magnetic field lines).

👉 Field lines positive charge se start hoti hain aur negative charge par end hoti hain.
👉 Field line ke tangent ki direction hi electric field ki direction hoti hai.
👉 Do electric field lines kabhi ek-dusre ko cut nahi karti.
👉 Jahan field lines zyada close hoti hain, wahan electric field zyada strong hoti hai.
👉 Conductor ki surface par field lines hamesha perpendicular hoti hain.
👉 Electric field lines kabhi closed loop nahi banati (magnetic field ke opposite).

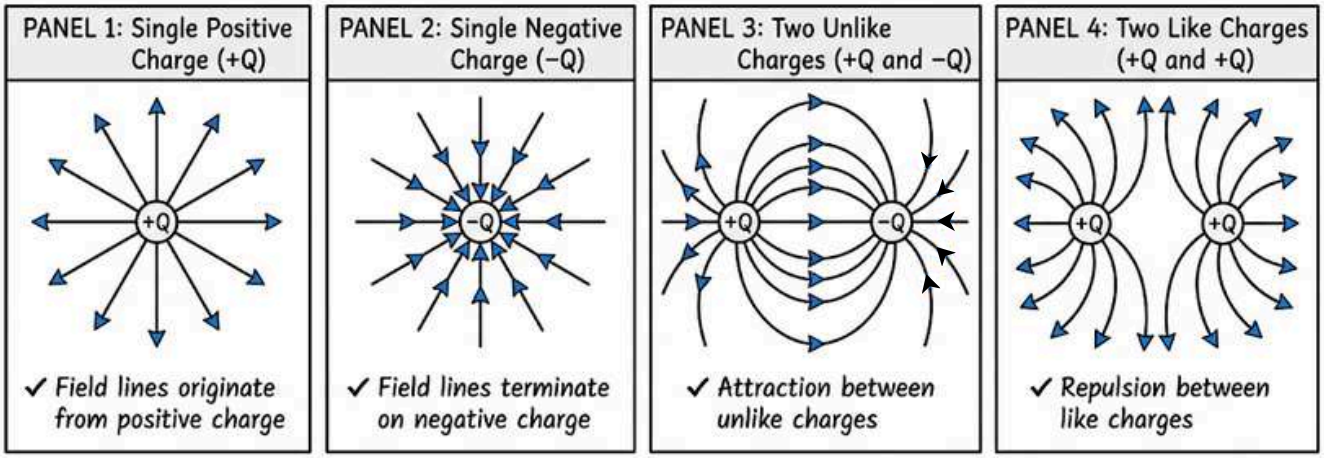


Standard Diagrams You Must Be Able to Draw

Boards commonly ask:

- Field lines for:
  - Single positive charge
  - Single negative charge
  - Two unlike charges
  - Two like charges
- 👉 Neat diagram = easy marks.
- (No fancy art needed; arrows and symmetry are enough.)

👉 Board exam me ye diagrams bahut common hain:
👉 Electric field lines draw karo for:
👉 Ek positive charge.
👉 Ek negative charge.
👉 Do opposite charges (+ and –).
👉 Do same charges (+ + ya – –).
👉 Saaf aur symmetric diagram = direct marks.
👉 Art nahi chahiye, bas arrows aur symmetry sahi honi chahiye.



COMMON EXAM RULES

☐ Arrows compulsory ☐ Lines never intersect ☐ Symmetry is important ☐ No closed loops ☐ Neat > artistic

MEMORY LOCK (for students)

Single → radial
Unlike → connect
Like → bend away
Arrows decide marks

Typical PYQ Patterns

- "What do electric field lines represent?" (1M)
- "Why do electric field lines never intersect?" (2M)
- "Draw electric field lines for two unlike charges." (2M)

MCQ / T-F:

- Electric field lines form closed loops (❌ False)

👉 Electric field lines kya represent karti hain?
👉 Electric field lines intersect kyun nahi karti?
👉 Opposite charges ke field lines draw karo.
👉 Electric field lines closed loop nahi banati.

Solved Exam-Level Questions

✅ **Example 1 (2 Marks)**

Q: Why do electric field lines never intersect?

Answer:

If electric field lines intersect, there would be two directions of electric field at the point of intersection, which is not possible.

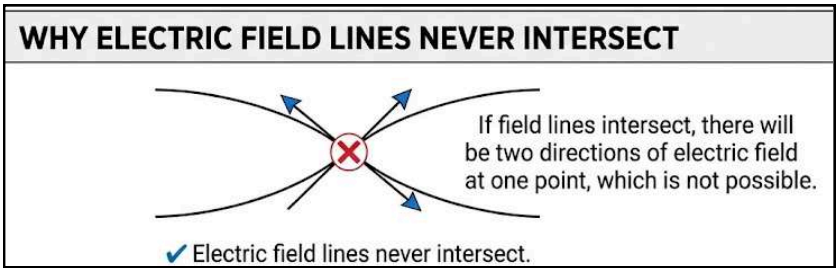
✅ **Example 2 (1 Mark)**

Q: What does the density of electric field lines represent?

Answer:

It represents the strength of the electric field.

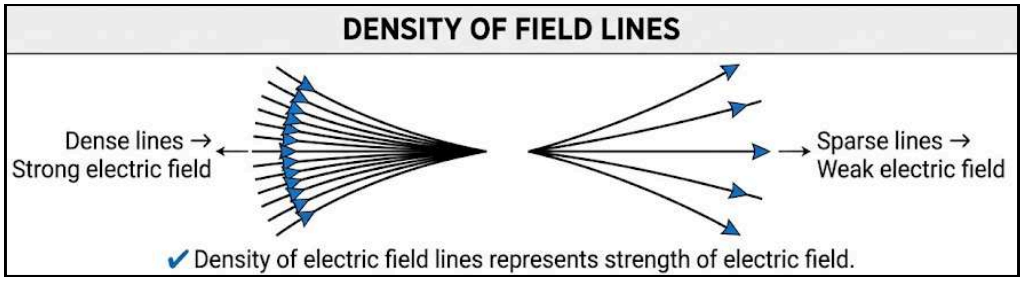
👉 Electric field lines intersect kyun nahi karti?
👉 Agar field lines intersect karein, to ek hi point par electric field ki do directions ho jaayengi, jo possible nahi hai.
👉 Field lines ki density kya batati hai?
👉 Ye electric field ki strength batati hai.



🧠 MEMORY LOCK (FOR EXAM)

Intersect = two directions ❌

More lines = stronger field ✅



🔁 Active Recall (Do This Now)

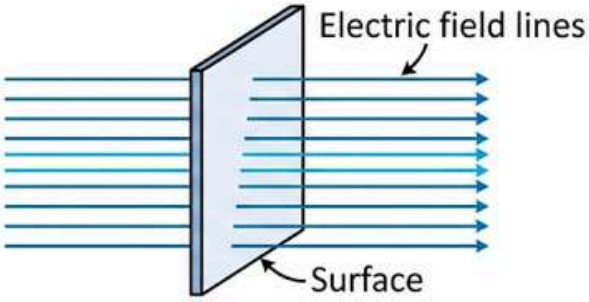
- **Where do field lines start and end?**
  - 👉 Positive se start, negative par end.
- **Do they form closed loops?**
  - 👉 Nahi.
- **What does crowding of lines mean?**
  - 👉 Strong electric field.
- **Are they real or imaginary?**
  - 👉 Imaginary.
- **Instant answers → move on.**
  - 👉 Agar turant jawab aa gaye, topic complete.

Topic 6: Electric Flux

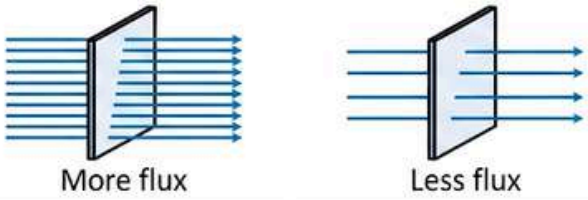
Concept

- Electric **flux** tells us **how much electric** field **passes** through a surface.
- Think of flux as:
  - "Number of electric field lines crossing a surface."
- 👉 Boards test definition, formula, unit, sign, and 1–2 numericals.

👉 Electric flux batata hai ki kisi surface ke through kitna electric field guzar raha hai.
👉 Flux ko aise socho:
👉 Surface ko cross karne wali electric field lines ki sankhya.
👉 Board exam me definition, formula, unit, sign (+/−) aur 1–2 numericals aate hain.



Electric flux = number of electric field lines crossing a surface



Electric flux tells us how much electric field passes through a surface.

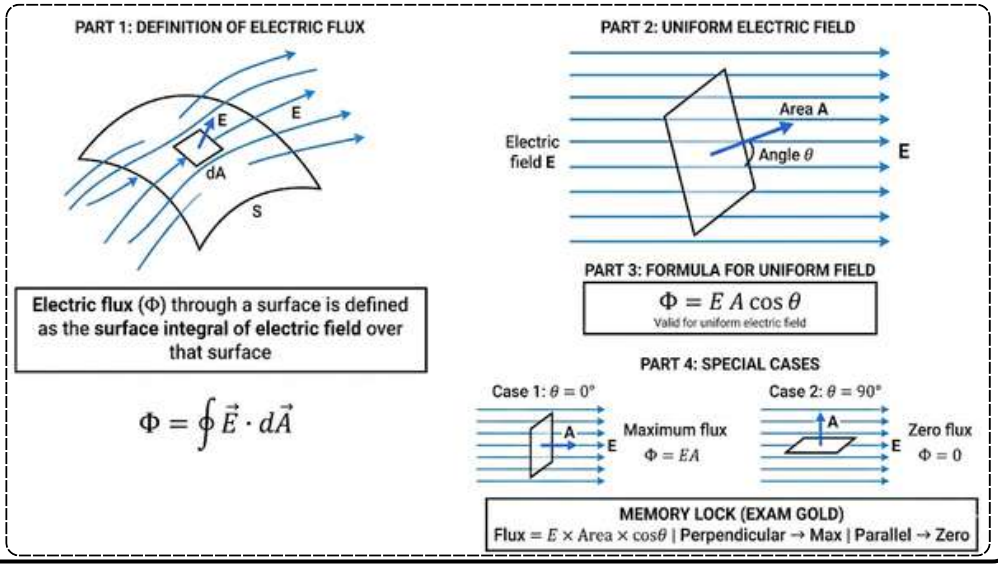
MEMORY LOCK (FOR STUDENTS)
More lines → more flux | Fewer lines → less flux

Key Definition

Electric Flux (Φ)
Electric flux through a surface is defined as the surface integral of electric field over that surface.
For uniform field:

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

👉 Kisi surface ke through electric flux, us surface par electric field ke surface integral ke barabar hota hai.
(Agar integral nahi poocha ho, to uniform field ka formula likhna kaafi hai.)



What Electric Flux REALLY Means:-

Electric flux tells us how much electric field passes through a given surface.

👉 Examiner expectation:

- Meaning + formula + special case (uniform field)

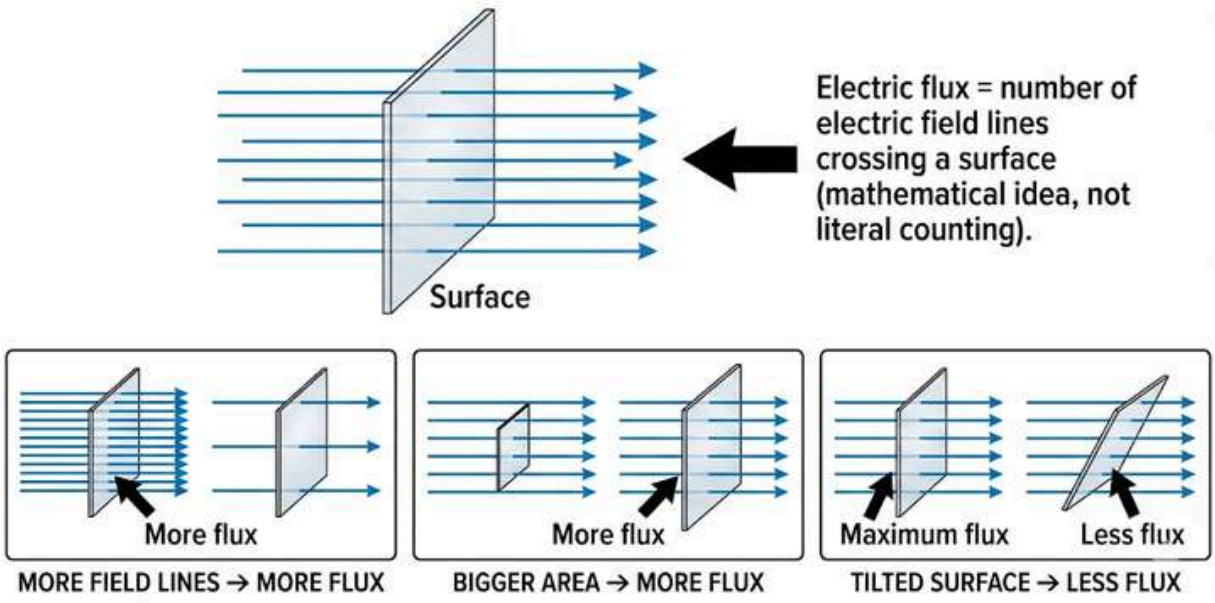
Simple way to remember:

Electric flux = "number of electric field lines crossing a surface" (mathematical idea, not literal counting).

- 🔸 More field lines → more flux
- 🔸 Bigger area → more flux
- 🔸 Tilted surface → less flux

Electric Flux ka real matlab kya hai?
Electric flux batata hai ki kisi surface ke through kitna electric field pass ho raha hai.
👉 **Examiner kya expect karta hai:**
Meaning, Formula, Uniform field ka special case
Yaad rakhne ka easy tareeqa:
Electric flux = "surface ko cross karne wali electric field lines ki quantity"
(yeh sirf mathematical idea hai, actual ginti nahi).

- 🔸 Zyada field lines cross karengi → flux zyada
- 🔸 Surface ka area bada hoga → flux zyada
- 🔸 Surface tilted (tedhi) hogi → flux kam

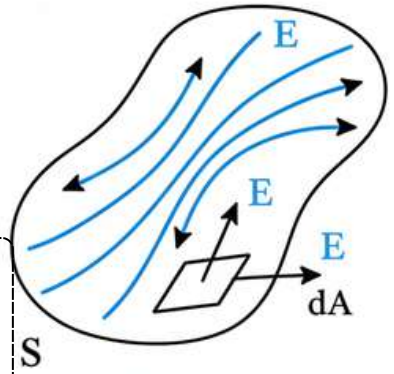


Key Definition (EXAM LANGUAGE – USE AS IT IS):-

Electric flux (Φ) through a surface is defined as the surface integral of the electric field over that surface.

Mathematically,

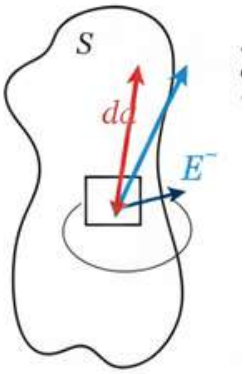
$$\Phi = \int \vec{E} \cdot d\vec{A}$$



Electric flux ka matlab hai kisi surface ke through kitna electric field pass ho raha hai. Mathematically, ye electric field ka surface ke upar integral hota hai, jo batata hai total field ka effect us poori surface par. Exam me isse surface ke through electric field ka measure maana jaata hai.

Important Formulas (BOX THESE)

(A) General Expression (Any Surface)



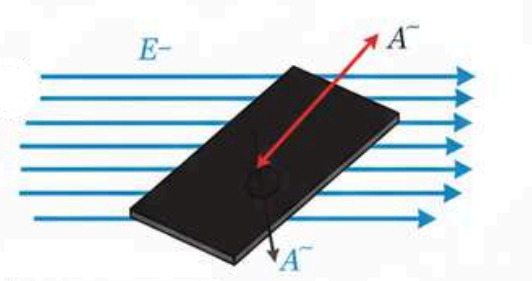
$$\boxed{\Phi = \int \vec{E} \cdot d\vec{A}}$$

Where:

- $\vec{E}$ = Electric field
- $d\vec{A}$ = Area vector (perpendicular to surface, outward for closed surface)

(B) Uniform Electric Field (VERY IMPORTANT)

If electric field is uniform and surface is plane:



$$\boxed{\Phi = EA\cos\theta}$$

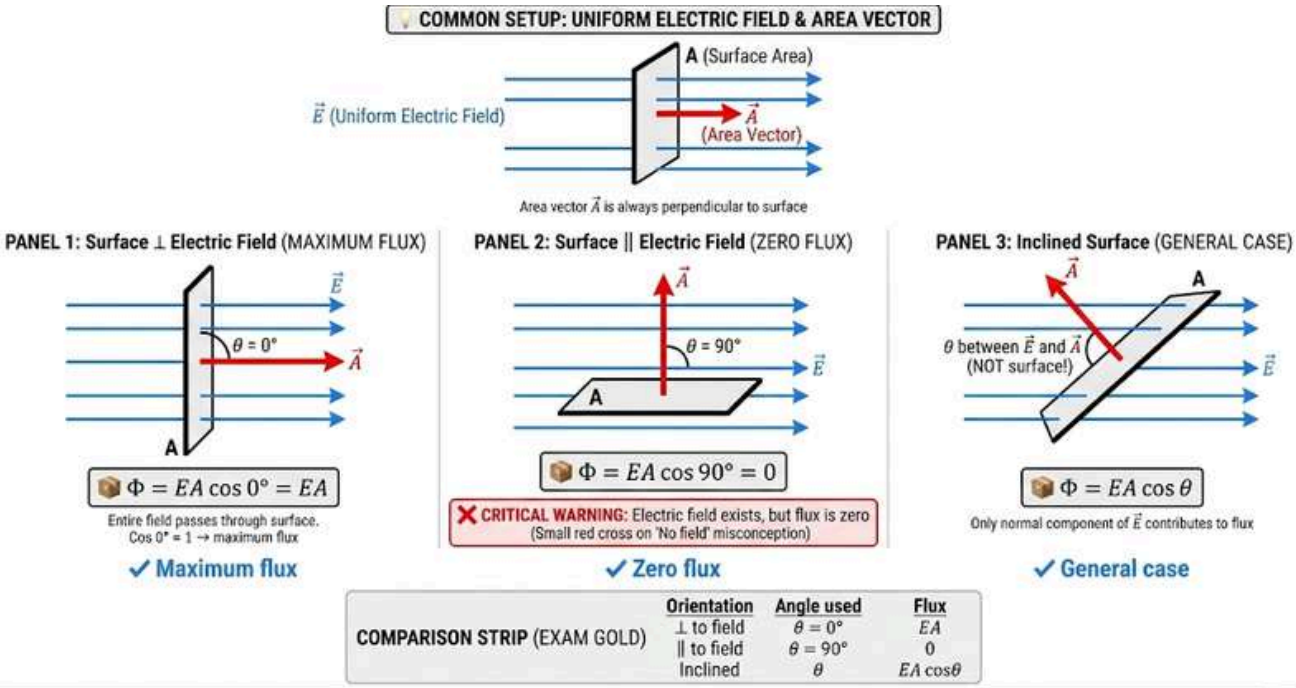
Where:

- E = magnitude of electric field
- A = area of surface
- θ = angle between $\vec{E}$ and area vector $\vec{A}$

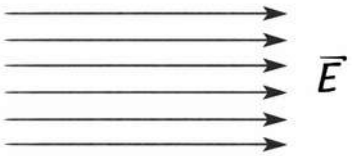
(C) Special Angles (EXAM FAVOURITE)

Orientation of Surface	θ	Flux (Φ)
Surface ⊥ field (maximum flux)	0°	$\Phi = EA$
Surface ∥ field	90°	$\Phi = 0$
Inclined surface	θ	$\Phi = EA\cos\theta$

👉 **Zero flux ≠ zero electric field** (students mess this up).



🧠 **FINAL MEMORY LOCK** (EXAM SAFE): Angle is between $\vec{E}$ and $\vec{A}$ — never between $\vec{E}$ and surface. **Zero flux ≠ zero electric field**

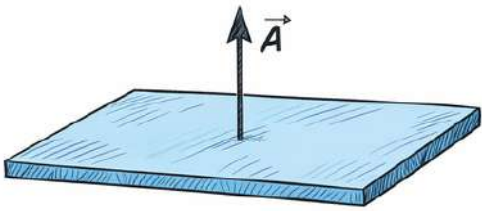


$\vec{E}$

E = electric field

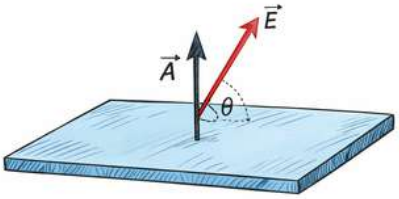
Unit = N/C

First, find the value of E.



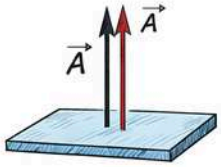
A = area of surface

Unit = m^2



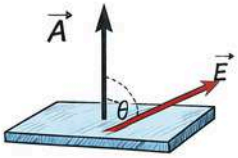
θ = angle between $\vec{E}$ and $\vec{A}$

⚠ θ is NOT the angle with the surface.



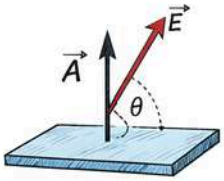
If $\theta = 0°$

$\cos\theta = 1$



If $\theta = 90°$

$\cos\theta = 0$



$0 < \theta < 90°$

$0 < \cos\theta < 1$

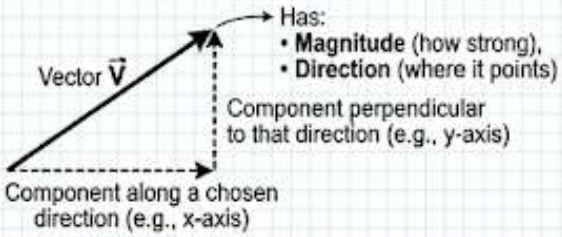
$\theta = 0°$	⟶	$\cos\theta = 1$
$\theta = 30°$	⟶	$\cos\theta = \frac{\sqrt{3}}{2}$
$\theta = 60°$	⟶	$\cos\theta = \frac{1}{2}$
$\theta = 90°$	⟶	$\cos\theta = 0$

Choose $\cos\theta$ based on the angle between $\vec{E}$ and $\vec{A}$.

$$\Phi = E \times A \times \cos\theta$$

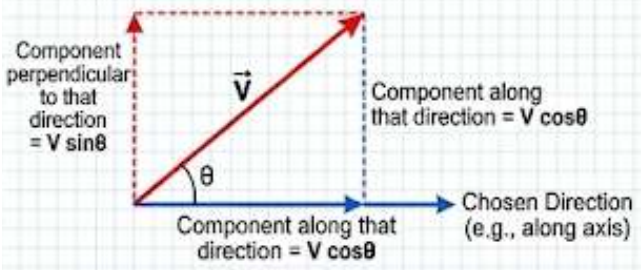
This formula is used to calculate electric flux.

1 WHAT DOES "SPLITTING A VECTOR" MEAN?



Splitting means finding how much of $\vec{V}$ acts along a ***chosen direction*** (e g., x-axis, normal to surface, along string, perpendicular to motion).

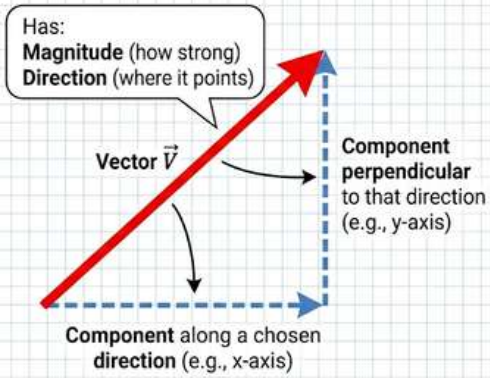
2 THE GENERAL VECTOR RULE (VERY IMPORTANT)



4 APPLYING THIS TO ELECTRIC FIELD & SURFACE

MASTERING VECTORS: THE ART OF SPLITTING (RESOLVING INTO COMPONENTS)

1 WHAT DOES 'SPLITTING A VECTOR' MEAN?

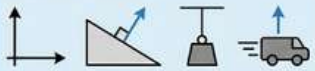


Splitting means finding how much of $\vec{V}$ acts along a chosen direction.

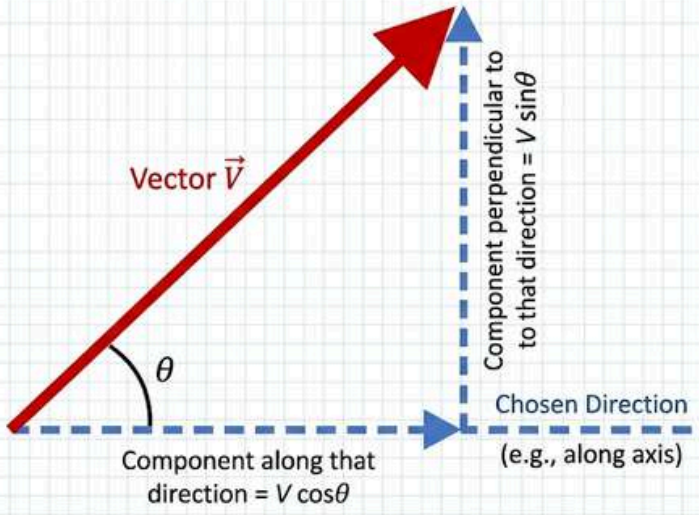
That chosen direction could be:

- **x-axis / y-axis**
- **normal to a surface**
- **along a string**
- **perpendicular to motion**, etc.

This is called **resolving a vector into components**.



2 The general vector rule (VERY IMPORTANT)



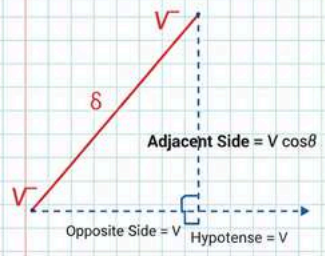
Suppose:
You have a vector $\vec{V}$.
You choose a direction.
The angle between $\vec{V}$ and that direction is θ.

Then:

- Component along that direction = $V \cos\theta$
- Component perpendicular to that direction = $V \sin\theta$.

This rule is universal in physics.

3 Why cos for one and sin for the other?



Based on Right-Triangle Geometry.

$\cos\delta$ = (adjacent side) (hyportenye)
$\sin\delta$ = opposite side) (hyportenye)

Here:

Hypoutense = V

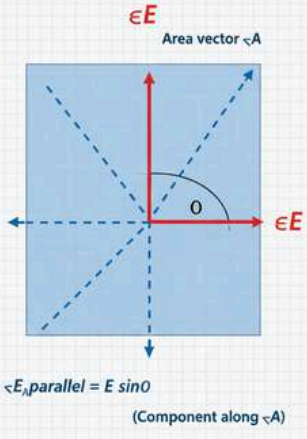
- Adjacent Side component along the chosen direction
- Opposite Side component perdaducular to it

So:

Along direction → V cosδ

Perpricender direction → V sinδ

4 Appling this to electric field & surface



Step 1: Choose the reference direction. For flux, the important direction is:
→ normal to the surface (area vector ϵA).

Step 2: Identify angle 0.
0 = anglen along surface ϵA).

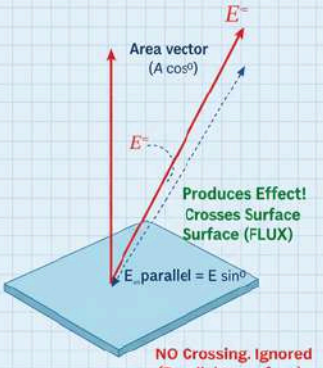
0 = angle between:
ϵE (electric field) & A (normal to surface.

Step 2: Resolve $E \epsilon A$ (perpcuddar to surface:
ϵE_Aperpecudar = E cos0

Step 3: Resolve ϵE.

- Component along A (perpoudtar to parille)
- Component along surface (parallel).

5★ Why only the perpereudrar component matters (again, but clearly)



Physics rule: Only Dre component of vector that acts along the vetto the directiort produces effect in in that dirrction.

For **flux:**

- Direction of interest = through surface
- That direction = normal to surface

Hence we take E cos⁰

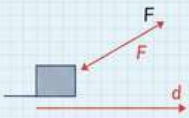
The parallel component:

- Lies along the surface
- Produces no crossing

So ignored

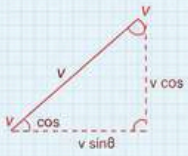
6 General usage of cos & sin in physics (VERY IMPORTANT)

Force on an object



If force F makes angle θ with dispacement: Work
Work = F cosθ × displosement

Projectile motion



Velocity v at angle θ:
Horizonal component = v cosθ
Vertical component = v sinθ

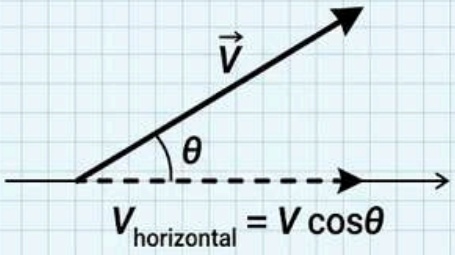
Magnetic force

Velocity v at angle θ with angle with an mageid:
Effective component = v sinθ
(because force is perrcecuduar there)

→ **Same rule, different context.**

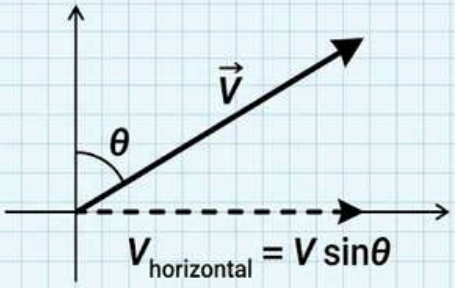
7 How to decide: cos or sin? (EXAM-SAFE METHOD)

If θ is measured from the direction you want the component → use cosθ



Angle θ is measured from the horizontal axis.

If θ is measured from the perpendicular direction → use sinθ



Angle θ is measured from the vertical (perpendicular) axis.

8ȣ One-line universal memory lock

Component = magnitude × cosine of angle with that direction

Everything else is secondary.

Condition	Flux
θ = 0° (surface ⊥ field)	Φ = EA (maximum)
θ = 90° (surface // field)	Φ = 0
Field entering surface	Flux is negative
Field leaving surface	Flux is positive

Unit of Electric Flux

SI unit: N m² C⁻¹
Alternate unit: V m

👉 Electric flux ki SI unit Newton metre square per Coulomb hoti hai.
👉 Alternate unit Volt metre hoti hai.
👉 Kabhi-kabhi dono units pooch leta hai.

Typical PYQ Patterns

- "Define electric flux." (1–2M)
- "Write SI unit of electric flux." (1M)
- Numerical:

Circular surface in uniform electric field (2M)

- Concept:
  - When is flux maximum or zero?

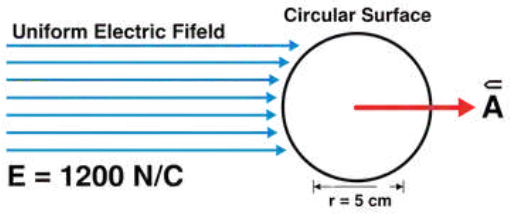
👉 Electric flux ki definition likho.
👉 Electric flux ki SI unit likho.
👉 Circular area diya hoga, flux nikaalna hoga.
👉 Flux kab maximum aur kab zero hota hai?

Solved Exam-Level Examples

Q: Calculate electric flux through a circular area of radius 5 cm placed perpendicular to a uniform electric field of $1200\ N/C$.

👉 Circular surface diya hai, field perpendicular hai.
👉 cm ko metre me convert kiya.
👉 Area nikaala.
👉 Final answer.

Solution:

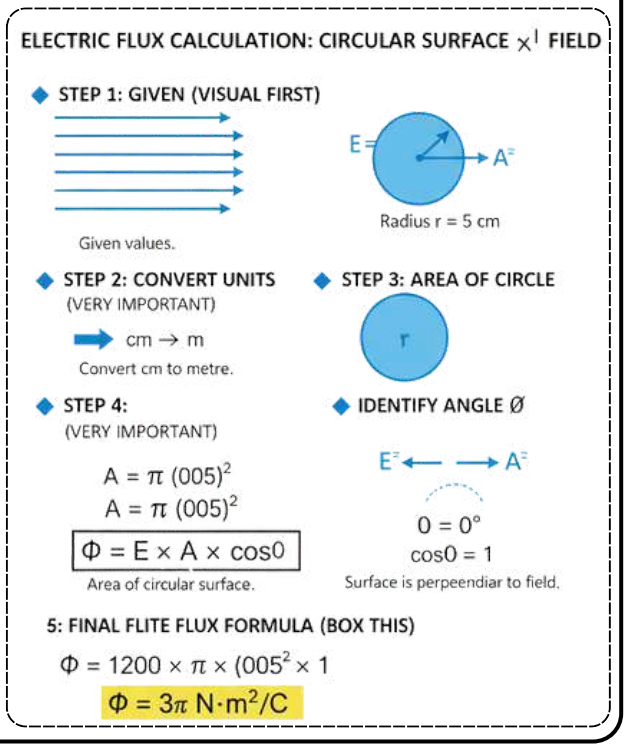


$$r = 5\ \text{cm} = 0.05\ \text{m}$$

$$A = \pi r^2 = \pi (0.05)^2$$

$$\Phi = EA = 1200 \times \pi \times (0.05)^2$$

$$\Phi \approx 9.42\ \text{N m}^2\text{C}^{-1}$$



✅ **Example 2 (1 Mark – Concept)**
Q: When is electric flux zero?
Answer:
When the electric field is parallel to the surface (θ = 90°).

👉 Electric flux kab zero hota hai?
👉 Jab electric field surface ke parallel hota hai.

🔁 Active Recall (Non-Negotiable)

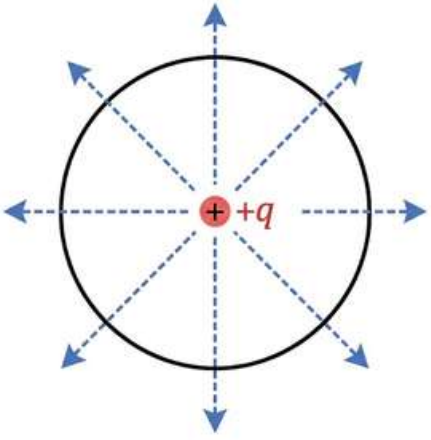
- **Formula of electric flux?**
  - 👉 Φ = EA cosθ
- **Is flux scalar or vector?**
  - 👉 Scalar
- **Unit of flux?**
  - 👉 N m² C⁻¹ or V m
- **When is flux maximum?**
  - 👉 θ = 0° (surface ⊥ field)
- **If instant → proceed.**
  - 👉 Agar bina soche jawab aa gaya, topic done.

Topic 7: Gauss's Law

Concept

- Gauss's law links electric flux with charge enclosed.
- It tells us:
- Electric flux through a closed surface depends only on charge inside,
- not on shape, size, or position of charges.
- 👉 Examiner wants statement + formula + one application.

👉 Gauss ka niyam electric flux ko enclosed charge se jodta hai.
👉 Ye hume batata hai:
👉 Closed surface ke through electric flux sirf andar ke charge par depend karta hai,
👉 Surface ke shape, size ya charge ki position par depend nahi karta.
👉 Examiner sirf statement, formula aur ek application chahta hai.



Electric flux through a closed surface depends only on the charge enclosed.

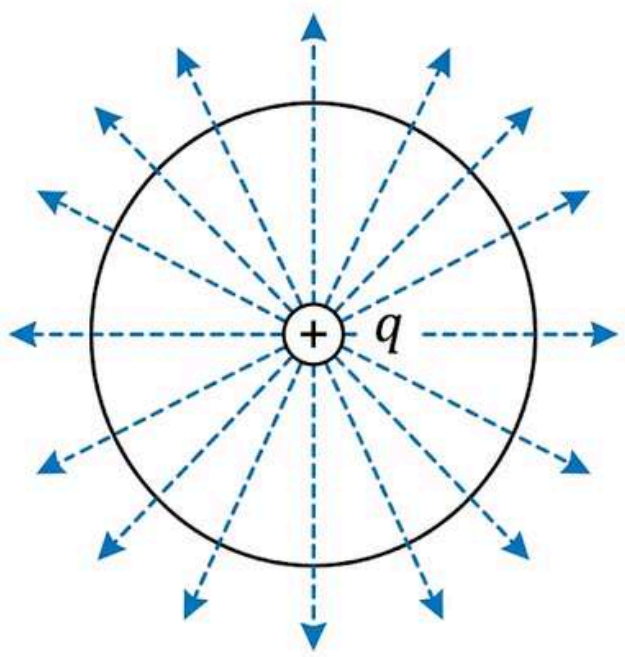
$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enclosed}}}{\varepsilon_0}$$

Used to calculate electric field for symmetric charge distributions.

Statement of Gauss's Law

- Gauss's law states that the total electric flux through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the surface.

👉 Gauss ka niyam kehta hai ki kisi bhi closed surface ke through total electric flux, us surface ke andar band charge ke $\frac{1}{\varepsilon_0}$ guna hota hai.
⚠️ Statement ko bilkul same likhna – wording change mat karna.



Gauss's Law:

The total electric flux through any closed surface is equal to $1/\varepsilon_0$ times the total charge enclosed enclosed by the surface.

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enclosed}}{\varepsilon_0}$$

Where

$\vec{E}$ = electric field

$d\vec{A}$ = area vector

q_{enclosed} = total charge inside surface

Important Points

- Gauss's law is valid for any closed surface
- Flux depends only on:
  - Charge enclosed
  - Charges outside the surface do not contribute to net flux
- Shape of Gaussian surface:
  - Spherical / cylindrical (chosen for symmetry)

👉 Gauss's law har closed surface ke liye valid hota hai.
👉 Flux sirf in par depend karta hai:
👉 Surface ke andar ka charge.
👉 Surface ke bahar ke charges ka net flux par koi effect nahi hota.
👉 Gaussian surface ka shape:
👉 Spherical ya cylindrical – symmetry ke liye choose kiya jaata hai.

PYQ Pattern

Boards ask Gauss's law in three fixed ways:

👉 Board exam me Gauss's law teen fixed tareeke se poocha jaata hai:

🔹 **Type 1: Statement + Formula (2–3M)**

"State Gauss's law in electrostatics."

👉 Statement aur formula likhna.

🔹 **Type 2: Flux Proof (2M)**

"A closed spherical surface encloses a charge q. Show that electric flux is $\frac{q}{\varepsilon_0}$

Ans:

Consider a point charge **q** placed at the centre of a spherical Gaussian surface of radius **r**.

Electric field at every point on the spherical surface is given by:

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

Electric flux through a closed surface is:

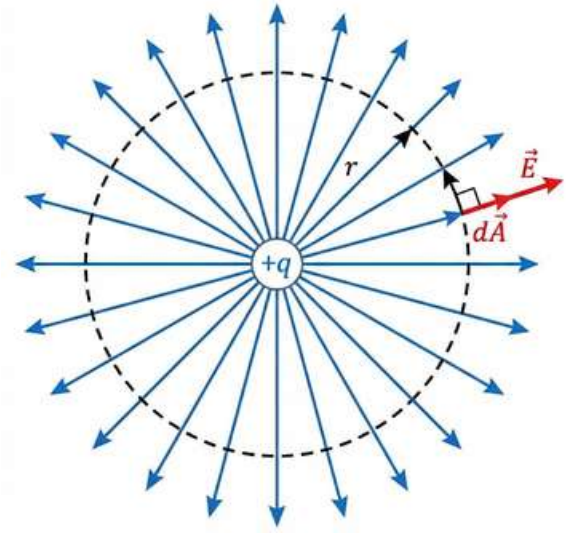
$$\Phi = \oint E \cdot dA$$

For a spherical surface, $\vec{E}$ and $\vec{A}$ are along the same direction, hence:

$$\vec{E} \cdot d\vec{A} = EdA$$

Therefore,

$$\Phi = \oint EdA$$



Since **E** is constant over the spherical surface,

$$\Phi = E\oint dA$$

But,

$$\oint dA = 4\pi r^2$$

Hence,

$$\Phi = E\times 4\pi r^2$$

Substituting the value of ***E***:

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

$$\therefore \boxed{\Phi = \frac{q}{\varepsilon_0}}$$

Thus, the total electric flux through a closed surface enclosing charge ***q*** is equal to q/ϵ_0 , which verifies Gauss's law.

🔹 **Type 3: Application (5M)**
"Using Gauss's law, find electric field due to ..."
👉 Gauss's law ka use karke electric field nikaalna.

Applications of Gauss's Law

Boards repeatedly ask ONLY these two:

- **Electric field due to:**
  - Thin spherical shell
  - Infinite line charge
- 👉 We will do them one by one, not together.

🔁 Active Recall (Pause & Answer)

- What does Gauss's law relate?
- Does flux depend on shape?
- Do outside charges contribute?
- Formula of Gauss's law?
- **If answers are instant → you're ready.**

Topic 8: Electric Field due to a Thin Spherical Shell (Using Gauss's Law)

Derivation

Case 1: Outside the Shell (r > R)

Consider a thin spherical shell of radius *R* carrying a total charge *q*.
A spherical Gaussian surface of radius (r >R) is drawn concentric with the shell.
By symmetry, the electric field $\vec{E}$ is radial and has the same magnitude at all points on the Gaussian surface.
According to Gauss's law,

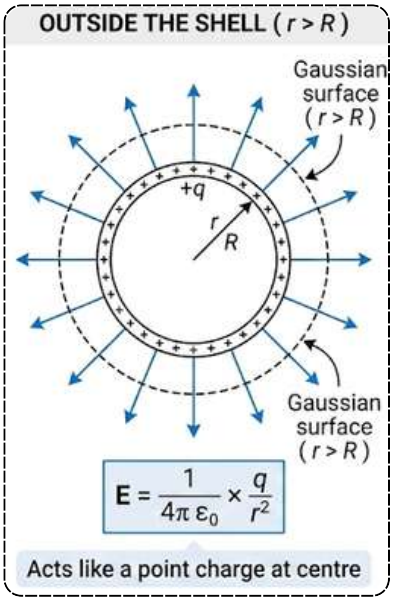
$$\oint E \cdot dA = \frac{q}{\varepsilon_0}$$

Since $\vec{E}$ is parallel to $d\vec{A}$,

$$\vec{E} \cdot d\vec{A} = E \oint dA$$

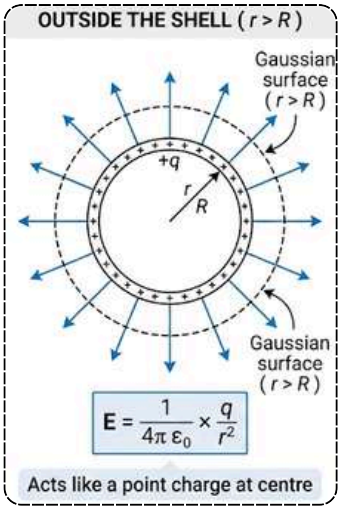
$$\implies E(4\pi r2) = \frac{q}{\varepsilon_0}$$

$$\implies E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$



Thus, the electric field outside the spherical shell is the same as that due to a point charge placed at its centre.

Case 2: On the Surface of the Shell (r = R)



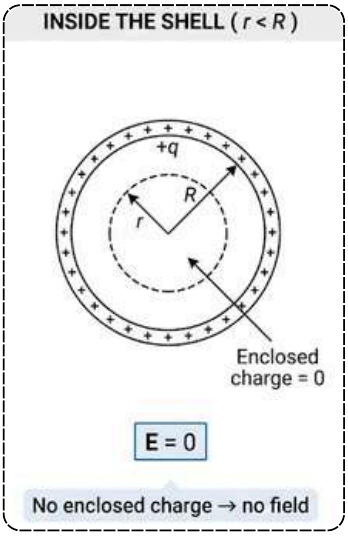
At the surface of the shell,

$$E\frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}$$

Case 3: Inside the Shell (r < R)

A spherical Gaussian surface of radius **r (<R)** is drawn inside the shell.
Charge enclosed by the Gaussian surface,

$$q_{enclosed} = 0$$



By Gauss's law,

$$\oint \vec{E}\cdot d\vec{A} = 0$$

$$\implies E(4\pi r^2) = 0$$

$$\implies E = 0$$

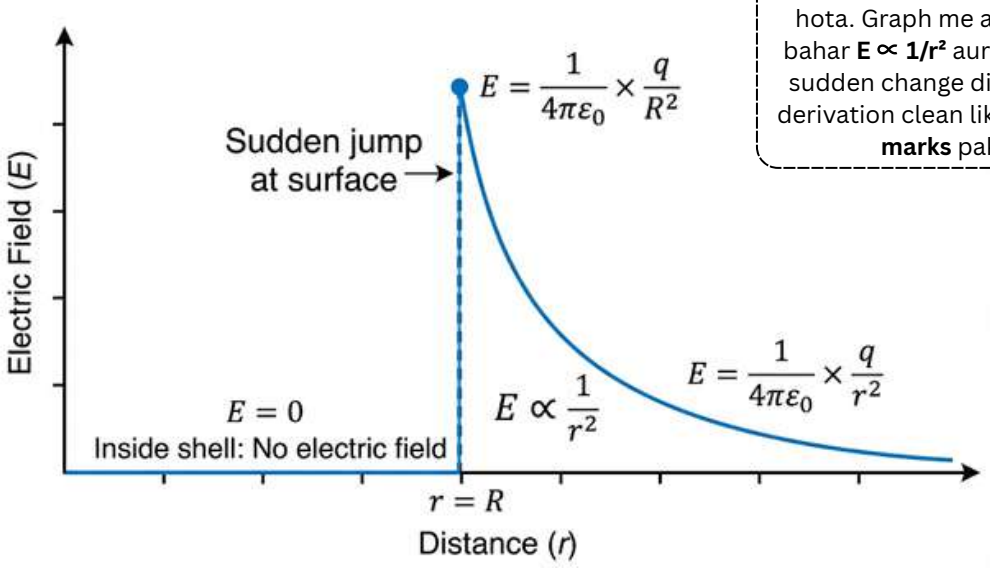
Hence, the electric field inside the spherical shell is zero.

Final Result

- For *r* > *R* : Electric field behaves as that of a point charge
- For *r* = *R* : Electric field is **maximum**
- For *r* < *R* : Electric field is **zero**

Graph

- The graph between electric field *E* and distance *r* shows:
- E=0 for r < R
- Sudden jump at r = R
- $E \propto \frac{1}{r^2}$ for r > R



Is topic me hum **Gauss's law** ka use karke thin spherical shell ke electric field ko samajhte hain. Examiner ko hamesha **teen cases** chahiye—**outside**, **on** surface, aur **inside**. Bahar shell ke liye electric field bilkul point charge jaisa behave karta hai. Surface par field maximum hota hai. Aur shell ke andar electric field zero hota hai, kyunki andar koi net charge enclosed nahi hota. Graph me andar **E = 0**, bahar **E ∝ 1/r²** aur surface par sudden change dikhta hai. Ye derivation clean likha to pure **5 marks** pakke.

PYQ Pattern (Extremely Predictable)

- "Using Gauss's law, find electric field due to a charged spherical shell." (5M)
- "What is the electric field inside a charged spherical shell?" (1M)
- MCQ: Field inside shell is zero → True

Exam-Level Short Answer

Q: Why is electric field zero inside a charged spherical shell?
Answer:
Because the net charge enclosed by the Gaussian surface inside the shell is zero.

🔁 Active Recall Check

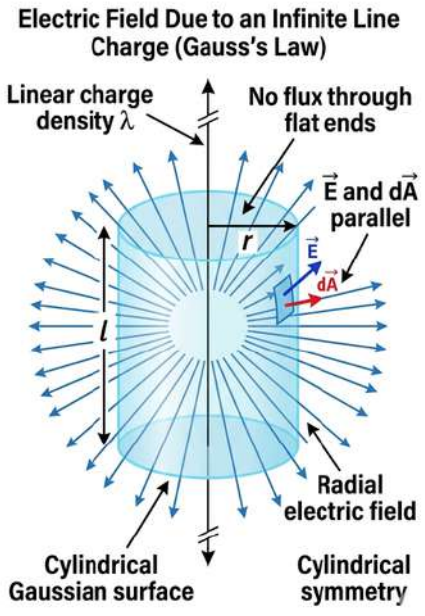
- Field outside shell?
- Field inside shell?
- Why Gaussian surface is spherical?
- How many cases?

If instant → topic locked.

Topic 9: Electric Field due to an Infinite Line Charge (Using Gauss's Law)

Derivation

Consider an infinitely long straight wire having a **uniform linear charge density λ**.
A **cylindrical Gaussian surface** of radius *r* and length *l* is drawn coaxially with the line charge.
Due to cylindrical symmetry, the electric field $\vec{E}$ is **radially outward** and has the same magnitude at all points on the curved surface of the cylinder.
The electric field is perpendicular to the curved surface and parallel to the flat ends.



Standard Setup (As in Boards)
An infinitely long straight wire
Uniform linear charge density = λ (C/m)
Find electric field at distance r from the wire
👉 Always assume cylindrical symmetry.

Choice of Gaussian Surface (VERY IMPORTANT)
Cylindrical Gaussian surface
Radius = r
Length = l
Why?
Because electric field is:
Same at every point on curved surface
Radial and perpendicular to surface

Applying Gauss's Law (Step-by-Step)

Ek infinitely lambi seedhi wire hai jisme uniform linear charge density λ hai.
Line charge ke saath coaxial ek cylindrical Gaussian surface li jaati hai jiska radius r aur length l hota hai.
Cylindrical symmetry ki wajah se electric field radially bahar ki taraf hoti hai aur curved surface par har jagah same magnitude ki hoti hai.
Electric field curved surface ke perpendicular aur flat ends ke parallel hoti hai.

According to Gauss's law,

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enclosed}}}{\varepsilon_0}$$

Charge enclosed by the Gaussian surface,

$$q_{enclosed} = \lambda l$$

Uniform linear charge density = λ (C/m)

Electric flux through the flat ends of the cylinder is **zero**.
Electric flux through the curved surface,

$$\oint \vec{E} \cdot d\vec{A} = E(2\pi rl)$$

$$\implies \frac{q_{enclosed}}{\varepsilon_0} = E(2\pi rl)$$

$$\implies \frac{\lambda l}{\varepsilon_0} = E(2\pi rl)$$

$$\implies E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

Gauss ke niyam ke anusaar total electric flux enclosed charge ke ε_0 se bhaag ke barabar hota hai.
Gaussian surface ke andar enclosed charge λl hota hai.
Cylinder ke flat ends se electric flux zero hota hai.
Curved surface se electric flux E(2πrl) hota hai.
Isliye E(2πrl) = $\lambda l/\varepsilon_0$ hota hai.
Isse electric field ka maan E = $\lambda/(2\pi\varepsilon_0 r)$ milta hai.
Infinite line charge se r distance par electric field ka maan $\lambda/(2\pi\varepsilon_0 r)$ hota hai.
Electric field distance ke saath inverse proportion me vary karti hai.

Final Result
The magnitude of electric field at a distance ***r*** from an infinite line charge is,

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

The electric field varies **inversely** with distance from the line charge.

PYQ Patterns (Highly Repeated)

🔹 "Using Gauss's law, derive expression for electric field due to infinite line charge." (5M)
Ans: Upar wala Derivation
🔹 "Why is flux through flat ends zero?" (1–2M)
Ans: The electric field due to an infinite line charge is radial, whereas the area vector of the flat ends is along the axis of the cylinder.
Since the electric field is perpendicular to the area vector,

$$\vec{E} \cdot d\vec{A} = 0$$

Hence, electric flux through the flat ends is zero.

🔹 MCQ:
- Field varies inversely with distance

Ans: True, since

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

🔁 Active Recall (Final Check)

- Which Gaussian surface is used?
- Why cylindrical?
- Formula of electric field?
- How does field vary with r?
- If **yes** → **Chapter 1** is **DONE**.