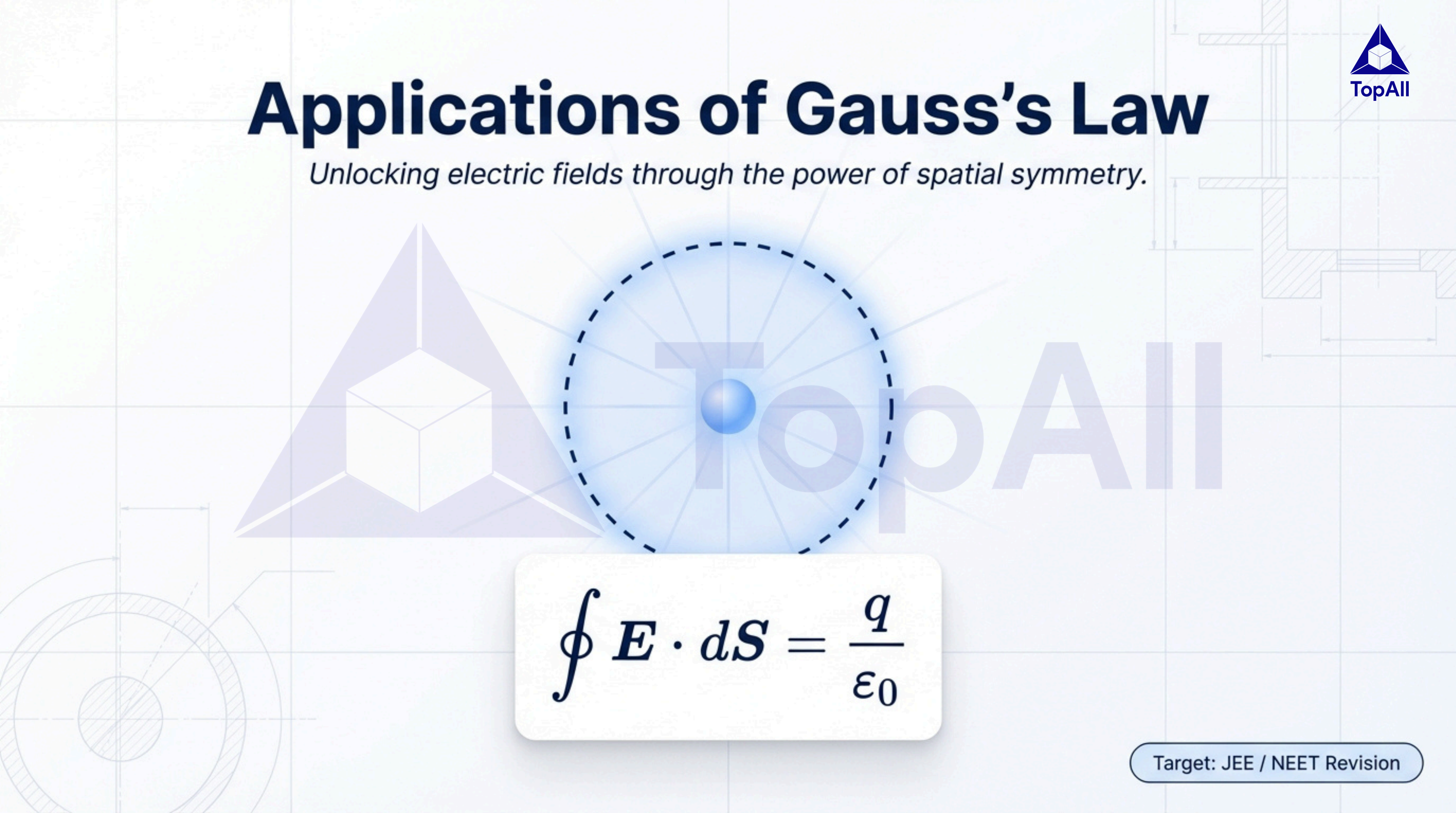


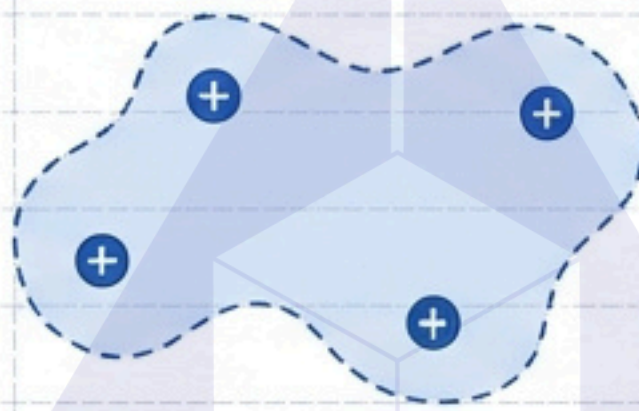
Applications of Gauss's Law

Unlocking electric fields through the power of spatial symmetry.


$$\oint \mathbf{E} \cdot d\mathbf{S} = \frac{q}{\epsilon_0}$$

Why Gauss's Law is Powerful Only With Symmetry

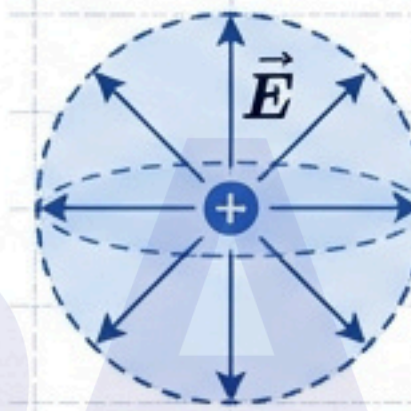
Always True.



Gauss's law always holds, but without symmetry, $\mathbf{E}$ and θ vary at every point on the surface.

Useless for analytically finding $\mathbf{E}$.

Analytically Useful.



Symmetry guarantees $\mathbf{E}$ is constant in magnitude and parallel to $d\mathbf{S}$ over the surface.

Symmetry pulls $\mathbf{E}$ out of the integral!

Integral Bypass

$$\oint \mathbf{E} \cdot d\mathbf{S}$$



$$\oint E dS \cos(0)$$



$$E \oint dS$$

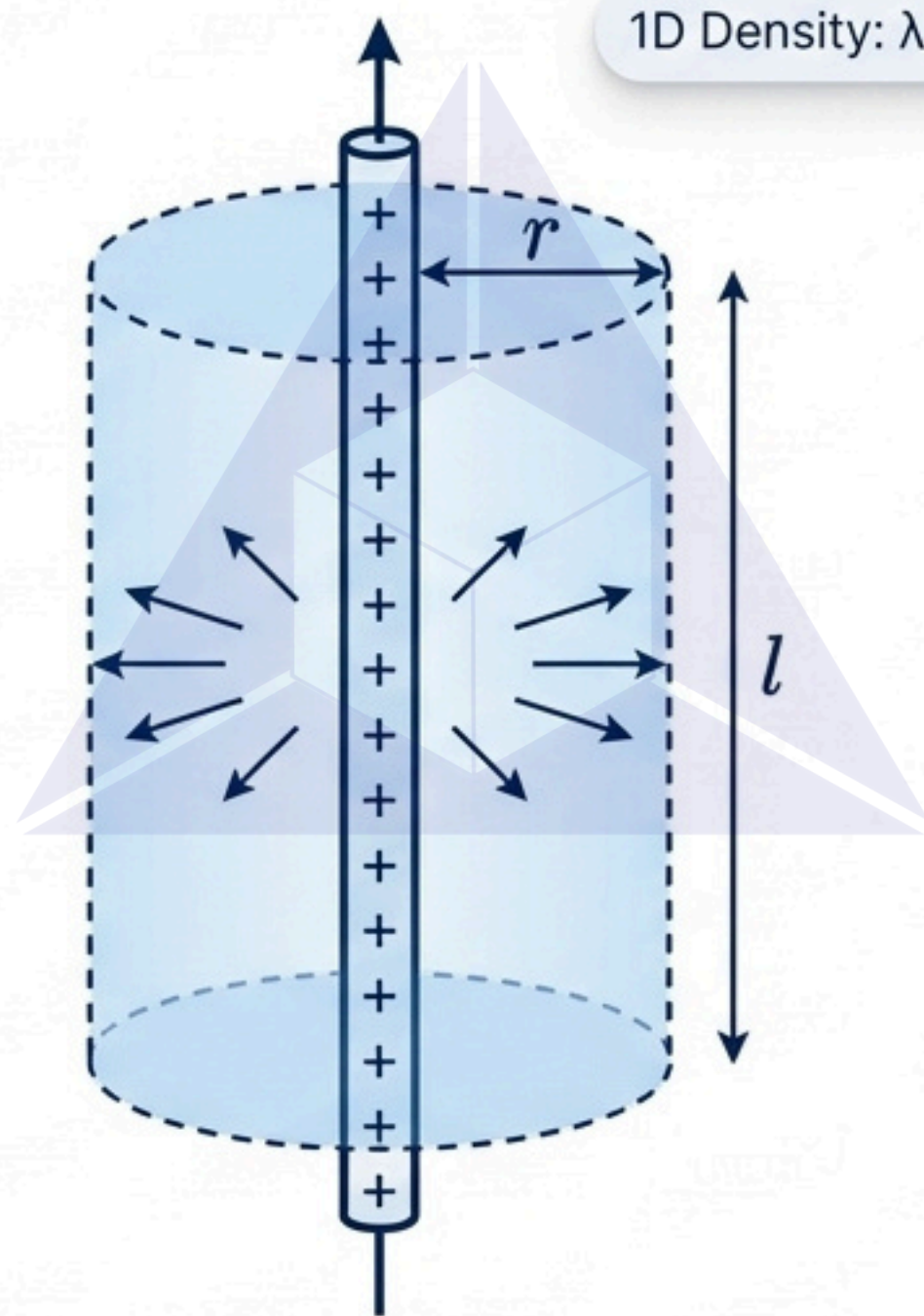


$$E \cdot S$$

Symmetry allows us to bypass integration entirely.

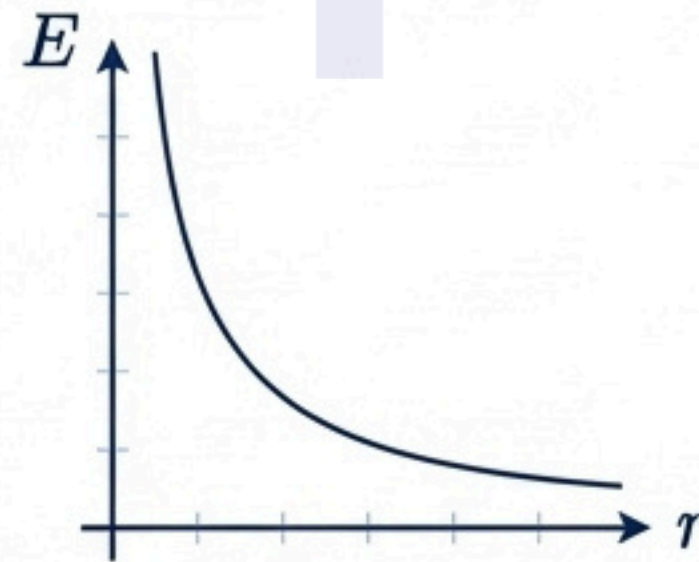
Cylindrical Symmetry

The Infinitely Long Straight Wire



$$E(2\pi r l) = \frac{\lambda l}{\epsilon_0}$$

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$



TRAP: End Effects!

This formula strictly assumes an infinitely long wire so we can ignore the non-radial field at the edges.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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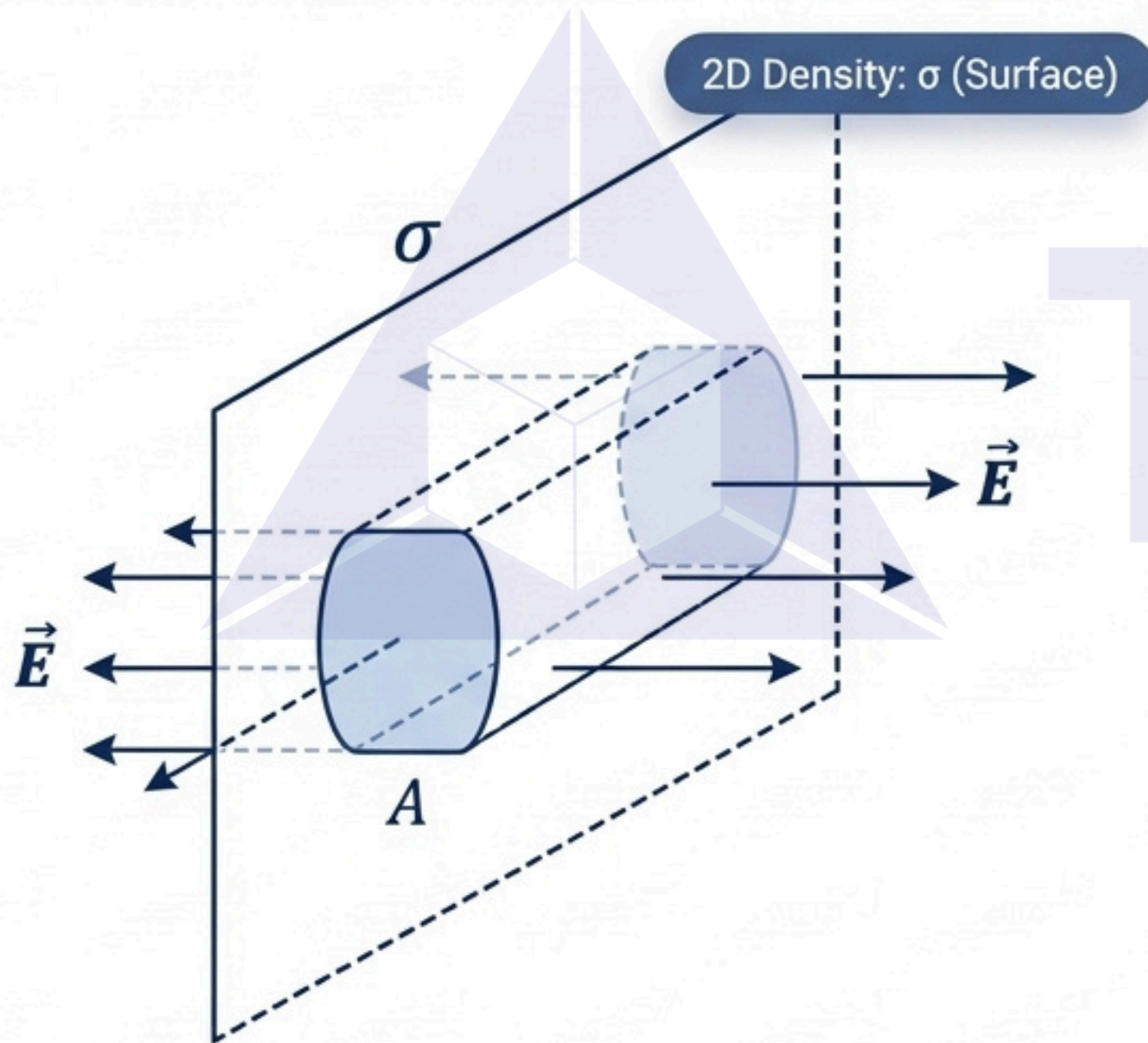
Key Highlights

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Planar Symmetry

The Infinite Charged Sheet



$$E(2A) = \frac{\sigma A}{\epsilon_0}$$

$$E = \frac{\sigma}{2\epsilon_0}$$

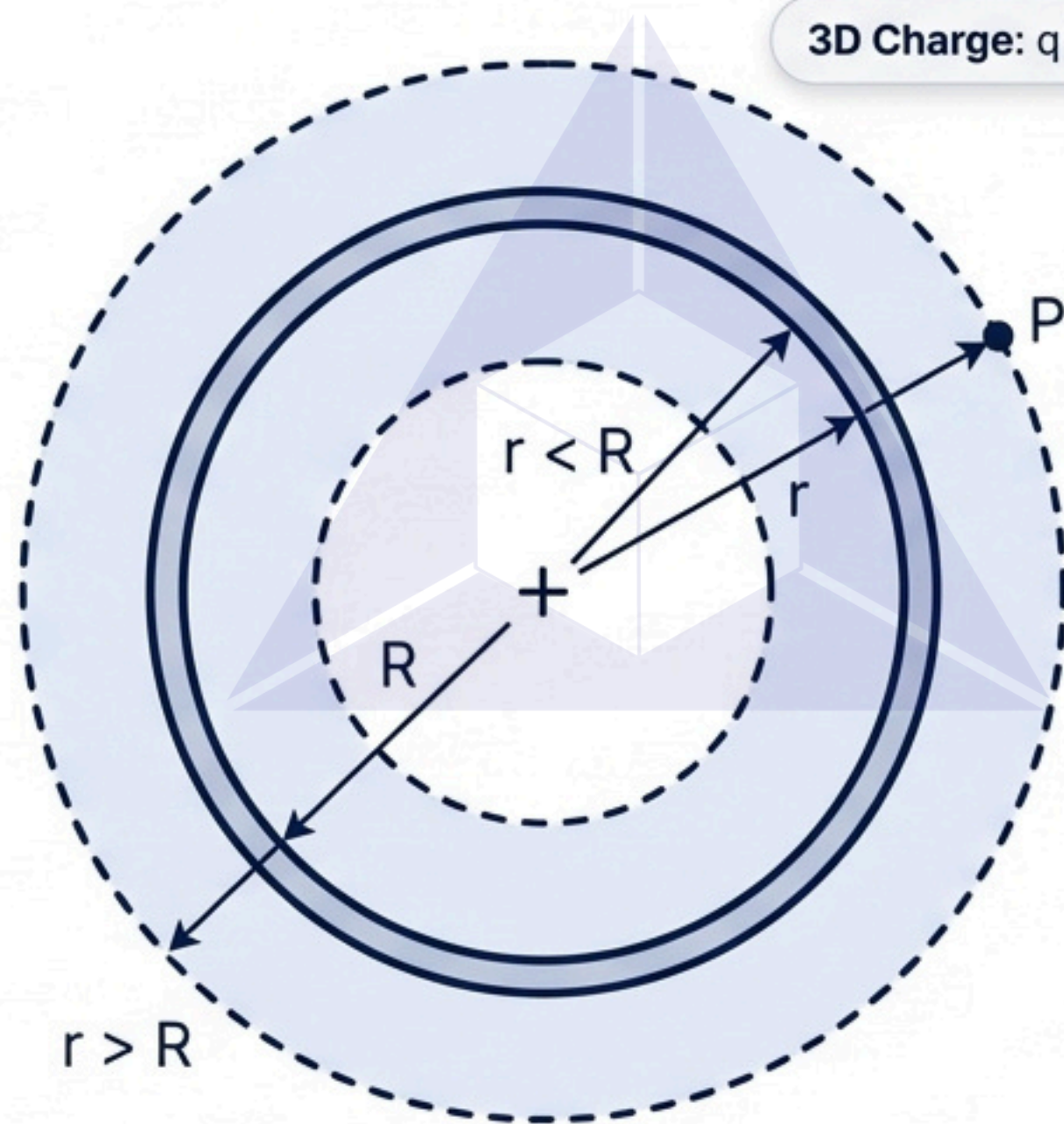


TRAP: Field Weakening!

The field does NOT weaken with distance. E is entirely independent of r .

Spherical Symmetry

The Thin Spherical Shell



Outside ($r \geq R$)

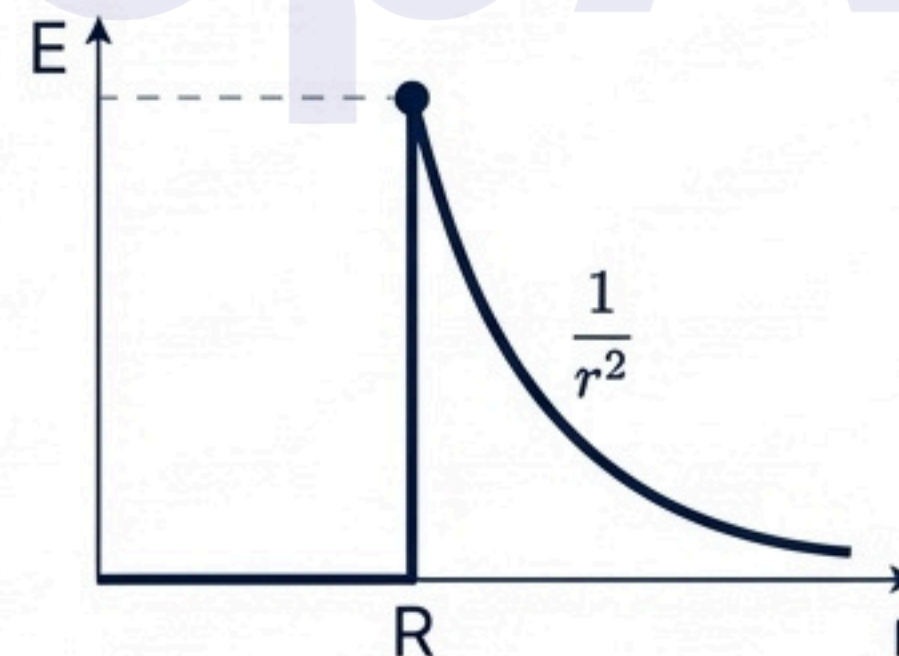
$$\mathbf{E} = \frac{q}{4\pi\epsilon_0 r^2}$$

(Acts like a point charge)

Inside ($r < R$)

$$\mathbf{E} = 0$$

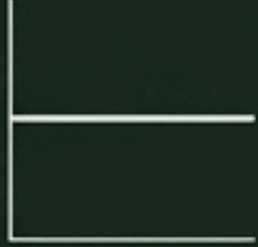
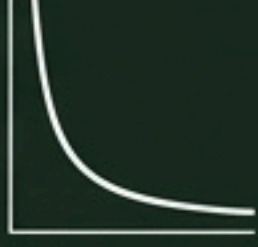
(Enclosed charge is zero)



All three symmetries lead to distinct scaling laws. Let's compare them...

Key Takeaways: The Scaling Laws Matrix



Geometry	Density Variable	Gaussian Shape	Scaling Law
Infinite Wire (1D)	λ	Cylinder	$E \propto \frac{1}{r}$ 
Infinite Sheet (2D)	σ	Pillbox	$E = \text{Constant}$ 
Spherical Shell (3D, Outside)	q	Sphere	$E \propto 1/r^2$ 

Check Your Understanding

Match the following continuous charge distributions to their correct **Electric Field (E) vs. Distance (r)** dependency graphs.

A. Infinite Plane Sheet

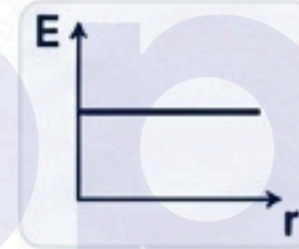
B. Infinite Straight Wire

C. Point Charge / Outside Shell

1.



2.



3.



Solution: **A** → **2** ($E \propto r^0$), **B** → **3** ($E \propto 1/r$), **C** → **1** ($E \propto 1/r^2$). Mastering these 3 scaling laws is essential for NEET/JEE electrostatics.



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