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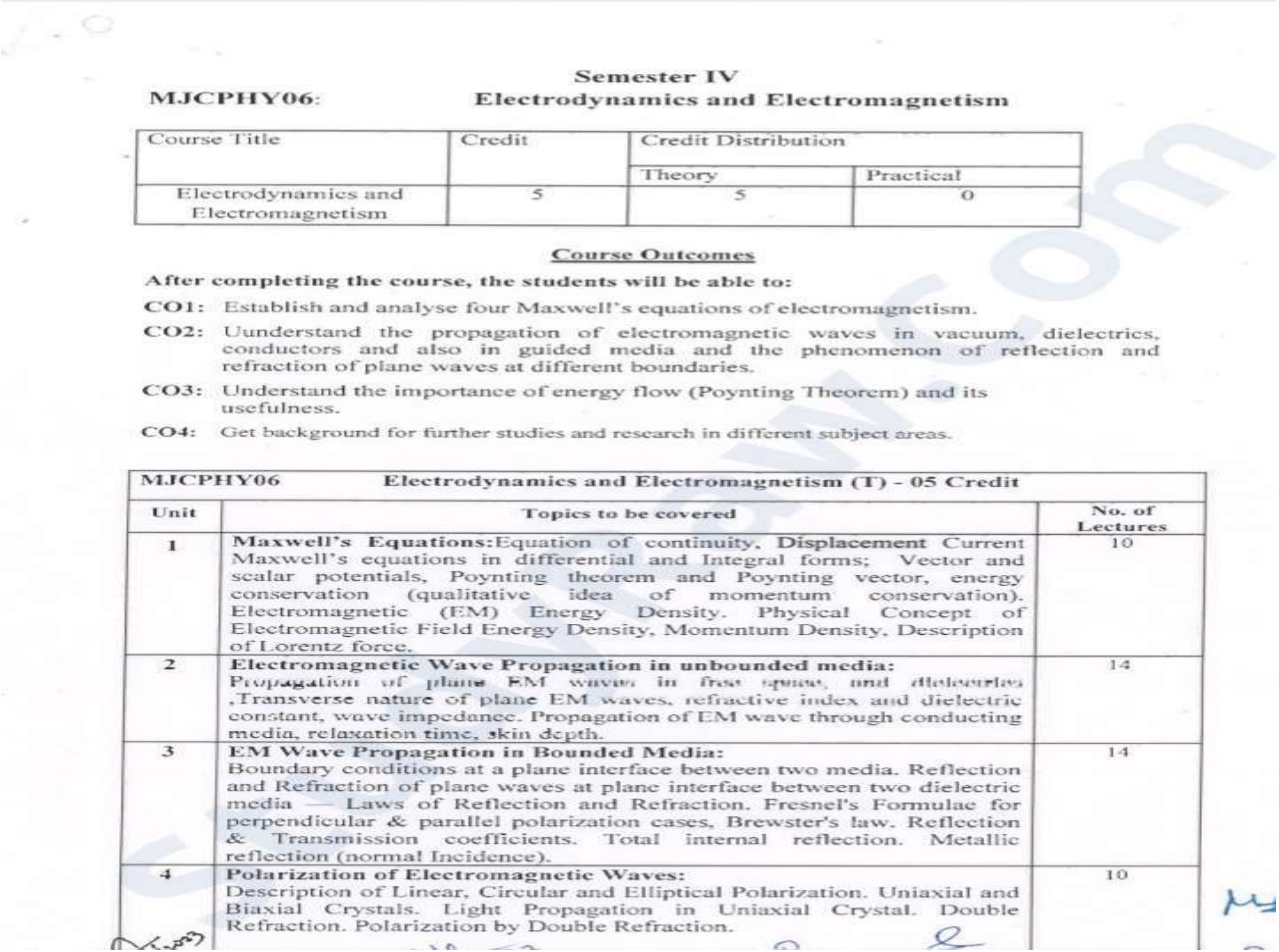
MJCPHY06
Electrodynamics and Electromagnetism



Semester IV

MJCPHY06: **Electrodynamics and Electromagnetism**

Course Title	Credit	Credit Distribution	
		Theory	Practical
Electrodynamics and Electromagnetism	5	5	0

Course Outcomes

After completing the course, the students will be able to:

CO1: Establish and analyse four Maxwell's equations of electromagnetism.

CO2: Uunderstand the propagation of electromagnetic waves in vacuum, dielectrics, conductors and also in guided media and the phenomenon of reflection and refraction of plane waves at different boundaries.

CO3: Understand the importance of energy flow (Poynting Theorem) and its usefulness.

CO4: Get background for further studies and research in different subject areas.

MJCPHY06	**Electrodynamics and Electromagnetism (T) - 05 Credit**	
Unit	**Topics to be covered**	**No. of Lectures**
1	**Maxwell's Equations:** Equation of continuity, **Displacement** Current Maxwell's equations in differential and Integral forms; Vector and scalar potentials, Poynting theorem and Poynting vector, energy conservation (qualitative idea of momentum conservation). Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density, Description of Lorentz force.	10
2	**Electromagnetic Wave Propagation in unbounded media:** Propagation of plane EM waves in free space, and dielectrics ,Transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation of EM wave through conducting media, relaxation time, skin depth.	14
3	**EM Wave Propagation in Bounded Media:** Boundary conditions at a plane interface between two media. Reflection and Refraction of plane waves at plane interface between two dielectric media — Laws of Reflection and Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection. Metallic reflection (normal Incidence).	14
4	**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction.	10

5	**Transmission Line:** Propagation of e.m. wave through transmission line, reflection coefficient, standing wave, characteristic impedance, propagation constant. **Wave Guides:** Fundamentals of wave guides, Condition of continuity at the interface. Expressions for field components, TE and TM modes. Propagation properties, cutoff frequency,. Field energy and Power transmission. **Optical Fibres:** Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).	12
	Total	**60**

Suggested Books:

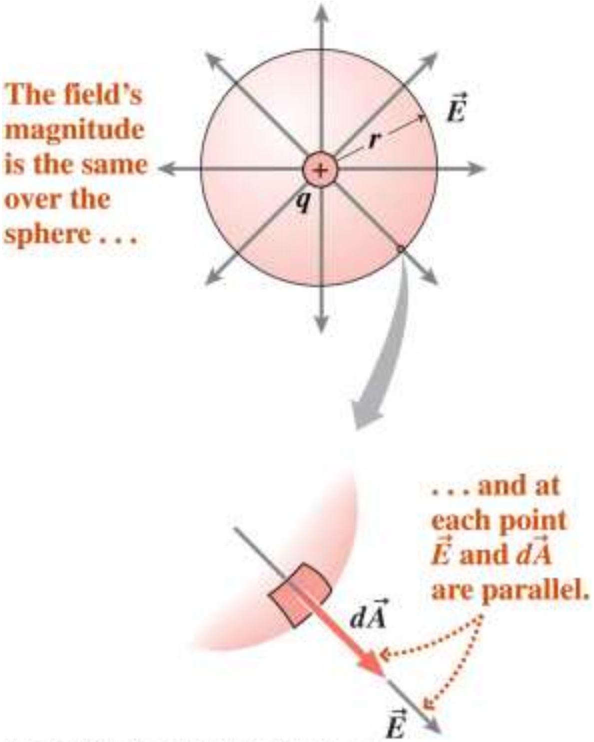
1. Introduction to Electrodynamics, D.J. Griffiths, Benjamin Cummings. ,
2. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner,Springer
3. Electromagnetic Fields & Waves, P. Lorrain & D. Corson, W.H. Freeman& Co.
4. Electromagnetics, J. A. Edminster, Schaum Series, Tata McGraw Hill.
5. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, Cambridge University Press.
6. Electrodynamics and Plasma Physics S.L.Kakan ,C. Herajan, CBS publisher
7. Electrodynamics :K.K Chopra &G.C Aggrawal
8. Classical Electrodynamics J D Jakson Wiley

Gauss's law

We have shown that the number of field lines emerging from a closed surface is proportional to the net charge enclosed

or

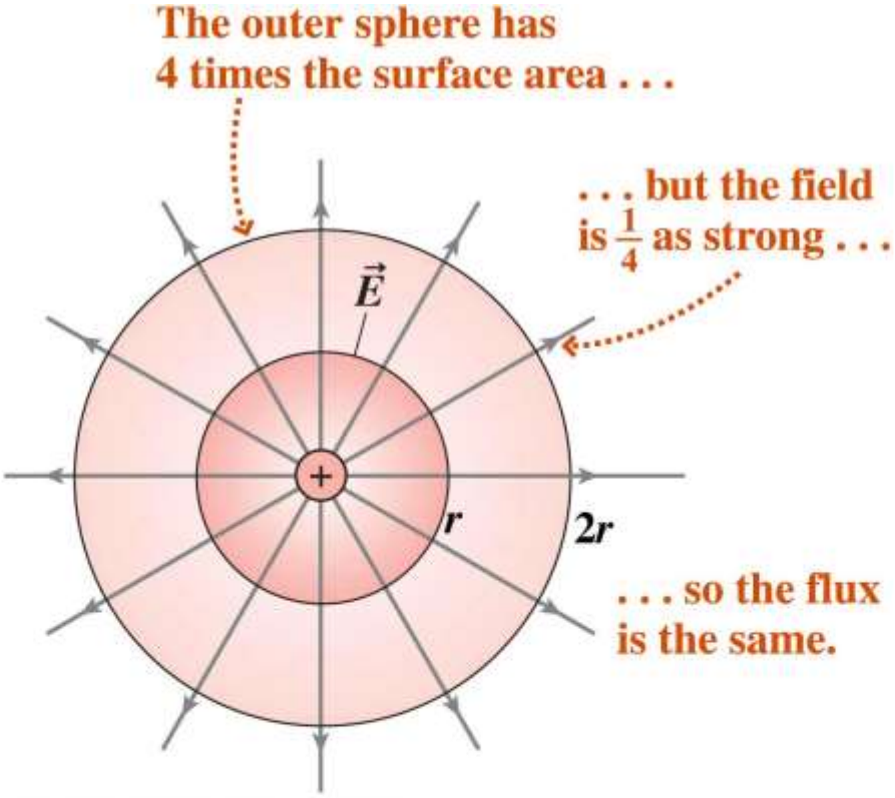
The electric flux through any closed surface is proportional to the charge enclosed



The field's magnitude is the same over the sphere . . .

. . . and at each point $\vec{E}$ and $d\vec{A}$ are parallel.

Gauss's law follows from the inverse square aspect of Coulomb's law



The outer sphere has 4 times the surface area . . .

. . . but the field is $\frac{1}{4}$ as strong . . .

. . . so the flux is the same.

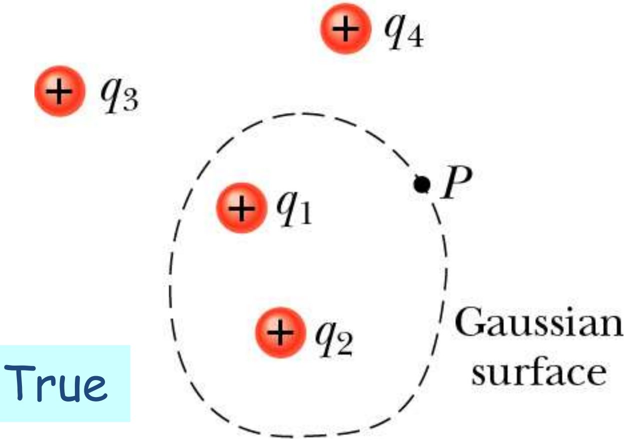
TRUE or FALSE?

A F

All particles contribute to the electric field at point P on the surface.

The net flux of electric field through the surface due to q_3 and q_4 is zero.

The net flux of electric field through the surface due to q_1 and q_2 is proportional to $(q_1 + q_2)$.



All True

$$\oint \underline{E} \cdot d\,\underline{A} = \frac{q_{enc}}{\varepsilon_0}$$ Gauss' Law

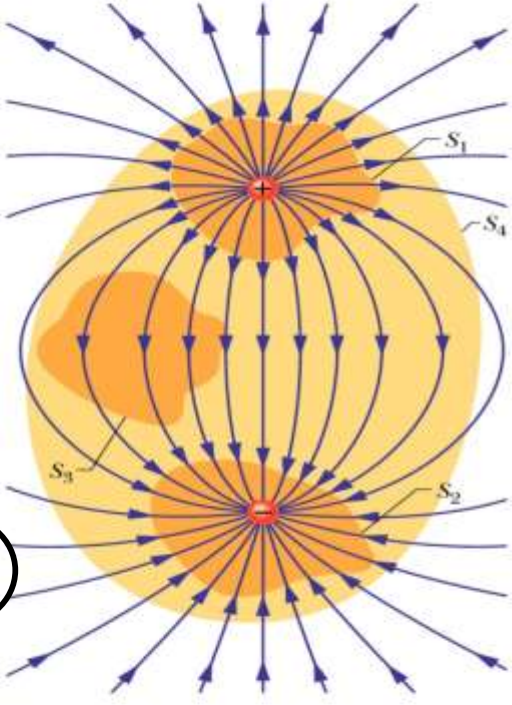
Gauss's Law

Gauss' Law relates the net flux Φ of an electric field through a closed surface to the net charge q_{enc} that is enclosed by that surface

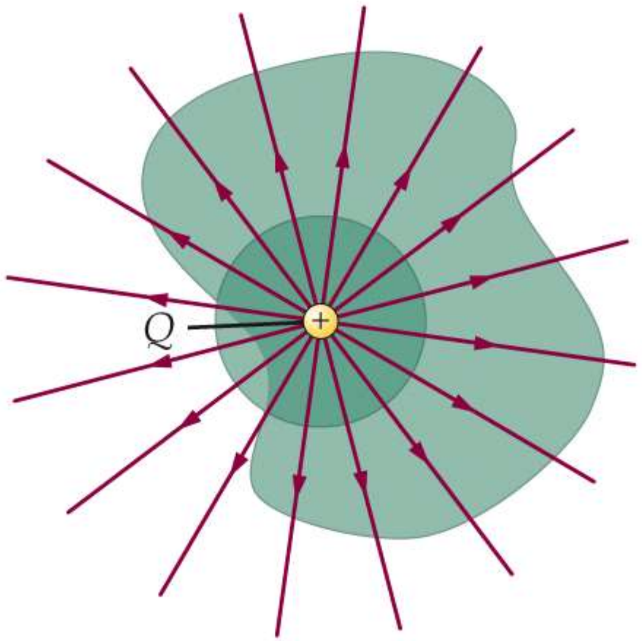
$$\Phi = \frac{q_{enc}}{\varepsilon_0}$$

$$\boxed{\oint \underline{E} \cdot d\,\underline{A} = \frac{q_{enc}}{\varepsilon_0} \qquad \text{Gauss' Law}}$$

- in vacuum (or air)



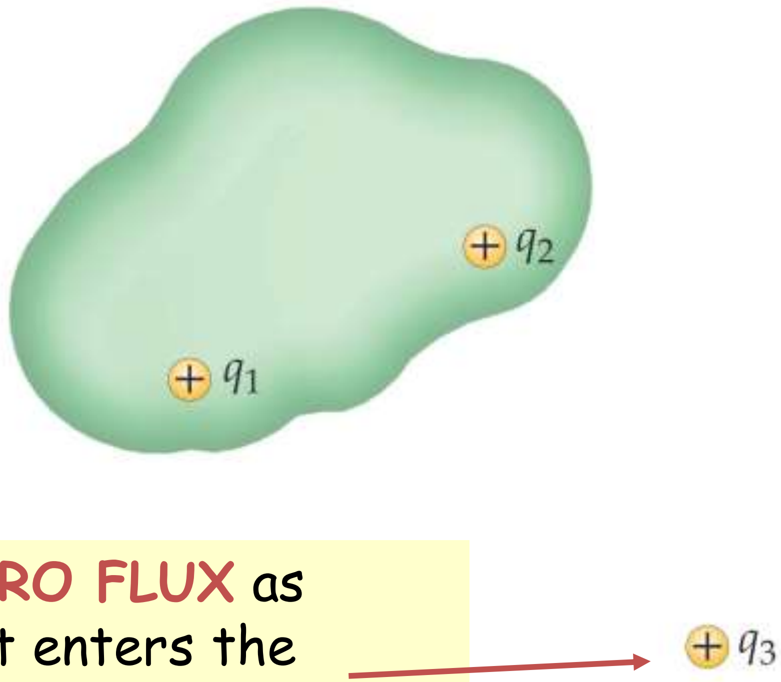
Q



The net number of electric field lines out of each surface is the same

SHAPE OF SURFACE DOESN'T MATTER

$$\Phi = \oint \underline{E} \cdot d\,\underline{A}$$

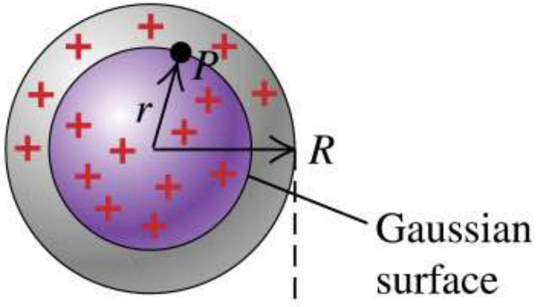


Flux through the surface due to **ALL** the charges

this charge contributes **ZERO FLUX** as every field line from it that enters the surface at one point, leaves at another

Example 21.1 Field of a uniformly charged sphere

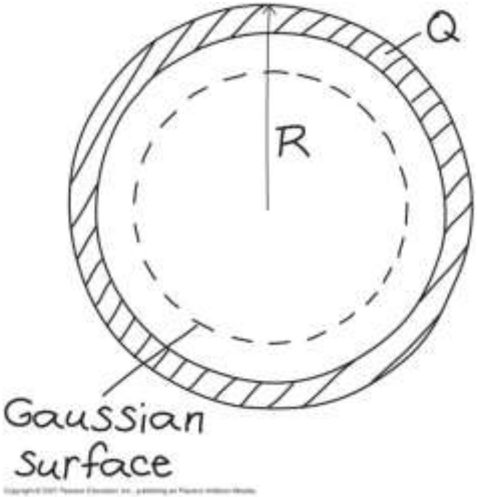
Total charge Q
Radius R

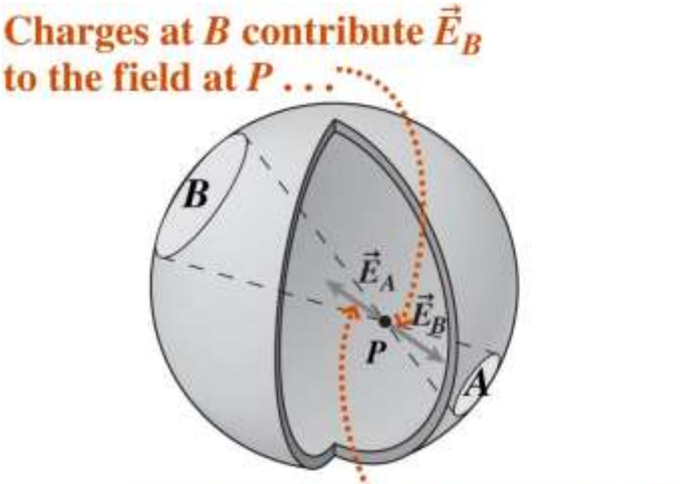


Done on board in lecture

Example 21.2
Field of a hollow spherical sphere

From Gauss's law, E = 0 inside shell

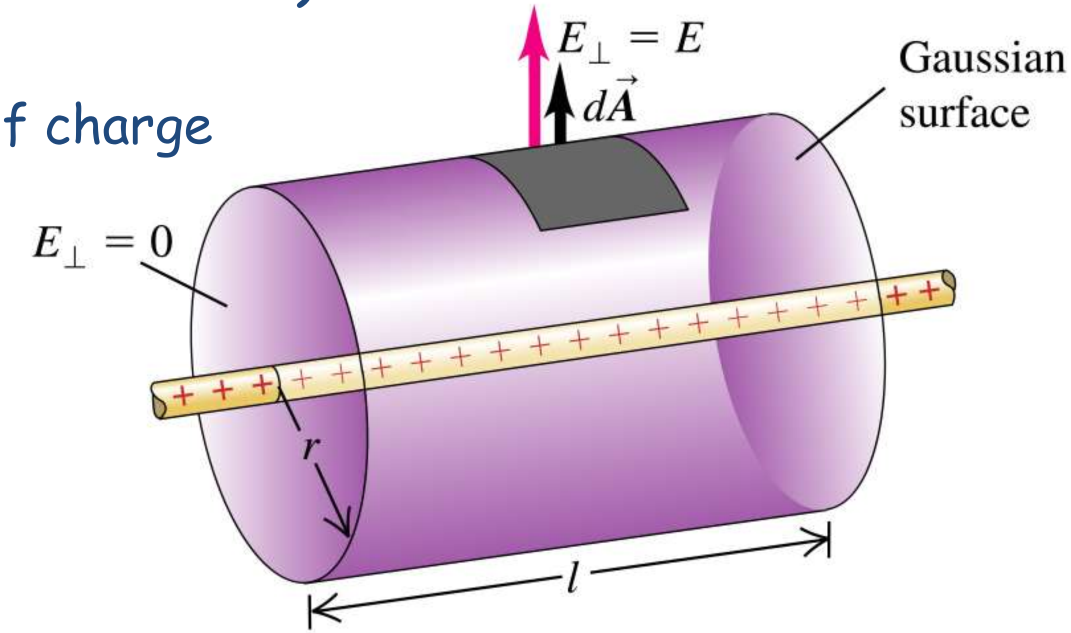




Read Example 21.3
Field of a point charge within a shell

and TIP: SYMMETRY MATTERS!

Line symmetry (Next lecture)

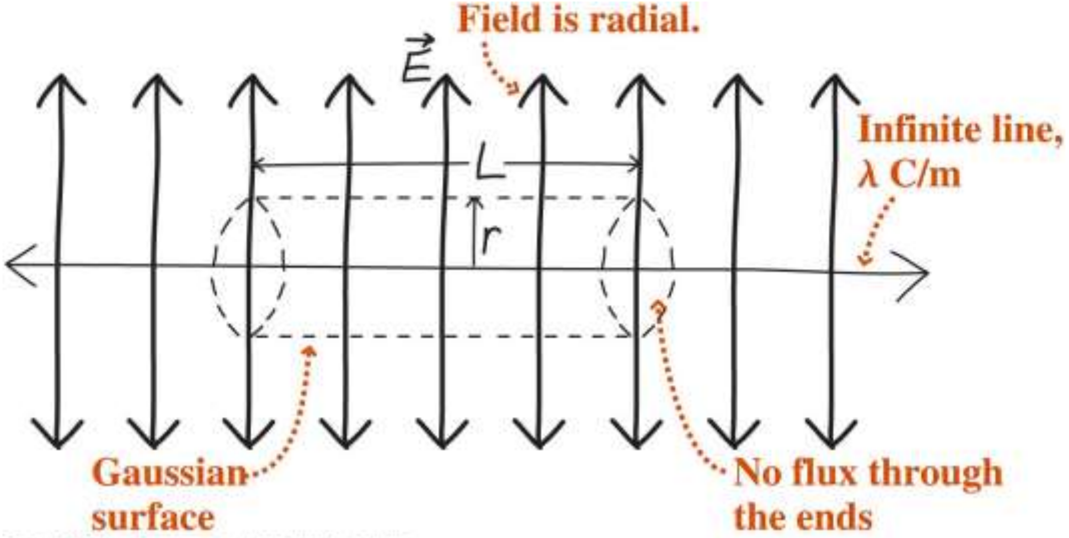


Example 21.4 Field of a line of charge

A section of an infinitely long wire with a uniform linear charge density, λ.

Find an expression for E at distance r from axis of wire.

$$E = \frac{\lambda}{2\pi\varepsilon_0 r} \qquad \text{(line of charge)}$$



Applying Gauss' Law: cylindrical symmetry

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$ (line of charge)

(Compare this result with that obtained using Coulomb's law in Example 20.7, when wire is infinitely long.)

Applies outside any cylindrical charge distribution

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