Application of Gauss's Law (Field due to infinitely long st. wire, due to uniformly charged infinite plane sheet)

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 01
CHAPTER NAME : ELECTRIC CHARGES AND FIELDS

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LEARNING OUTCOME

- Students can understand electric flux and its application in the open and closed surface.
- Students should understand the physical information contained in Gauss's law and they should be able to apply this law to the calculation of field distributions in systems with specified symmetry.
- Students can calculate the electric field due to various configurations including point charge, line of charge, the sheet of charge.
- Students apply knowledge of electrostatics to explain natural physical processes and related technological advances.

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QUICK REVIEW

1. Define electric flux?
2. Write S.I unit of electric flux?
3. What is a Gaussian surface?
4. State Gauss theorem in electrostatics?
5. How is electric flux expressed in terms of surface integral of electric field?

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INTRODUCTION

Video to be played:

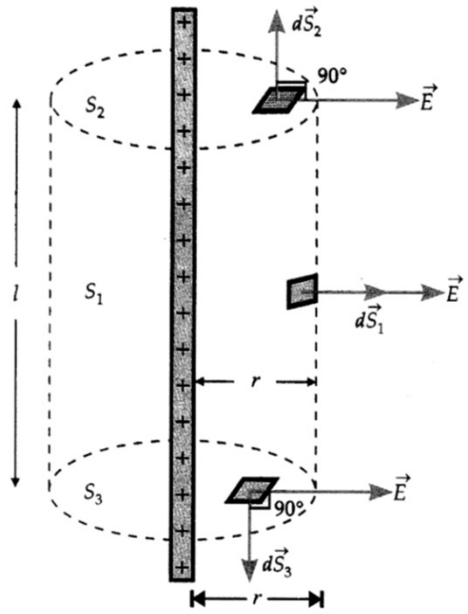
https://www.youtube.com/watch?v=GWBXW1vpZQI

Electric field due to an infinitely long straight uniformly charged wire.

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

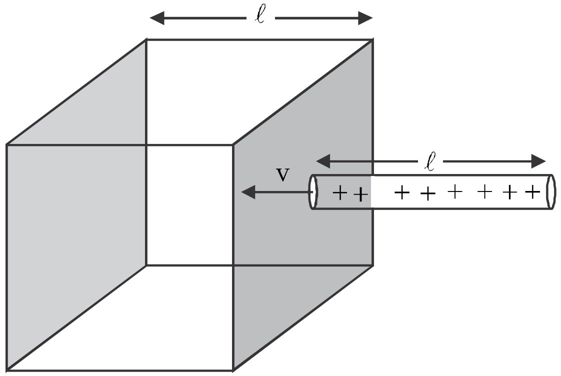
In vector form

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

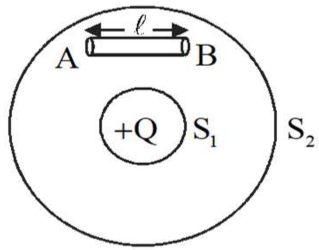


NUMERICAL

1. A uniformly charged rod with a linear charge density λCm^{-1} of length ℓ is inserted in the cube with constant velocity v and moves out of the opposite face. Draw the graph showing the variation of electric flux with time.

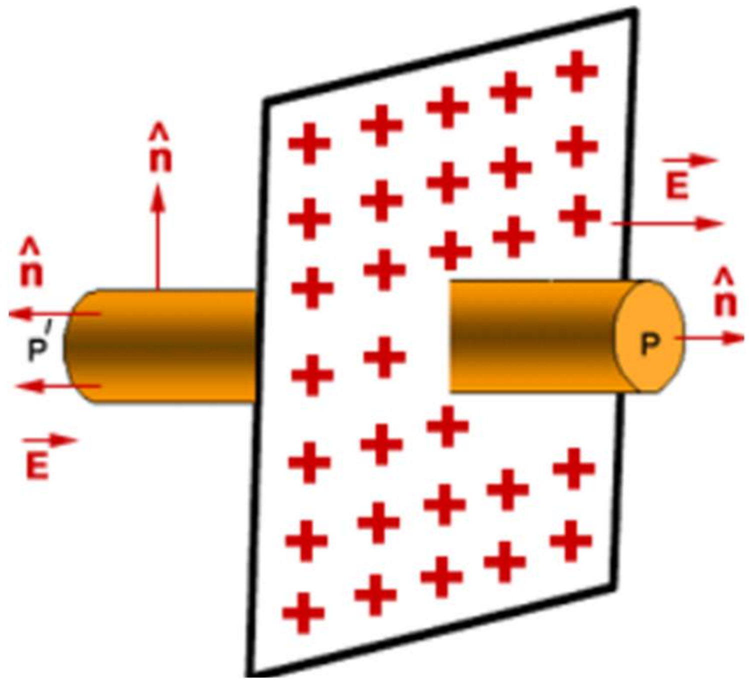


2. In the figure shown, calculate the total flux of the electrostatic field through the surface S_1 and S_2. The wire AB shown has a linear charge density λ given $\lambda = kx$ where x is the distance measured along the wire from end A

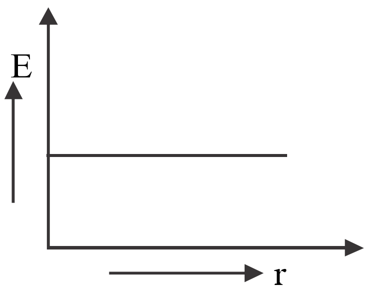


Electric field due to a uniformly charged infinite, non conducting, plane sheet

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

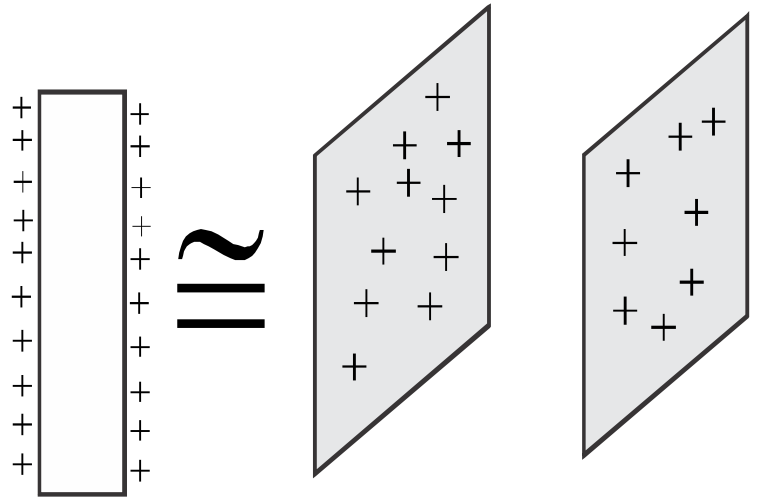


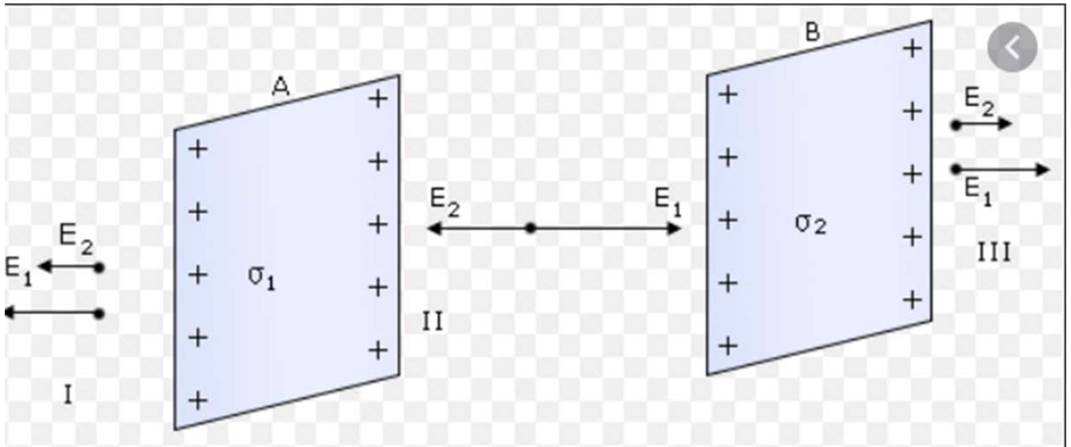
In vector form $$\boxed{\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}}$$



Electric field due to a uniformly charged infinite, conducting plane sheet

In conducting sheet, charges reside on the entire outside surface. So a charged conducting sheet is equivalent to two sheets with equal charges.





Field due to two infinite plane sheets of charge

Electric field due to a uniformly charged infinite, conducting plane sheet

Field on the right of plates

$$(a)E_{net} = E_1 + E_2 = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

Field in between the plates

- Electric field $E_{net} = E_1 - E_2 = \dfrac{\sigma}{2\varepsilon_0} - \dfrac{\sigma}{2\varepsilon_0} = 0$

Field on the left of plates

(a)Electric field = $E_{net} = E_1 + E_2 = \dfrac{\sigma}{2\varepsilon_0} + \dfrac{\sigma}{2\varepsilon_0} = \dfrac{\sigma}{\varepsilon_0}$

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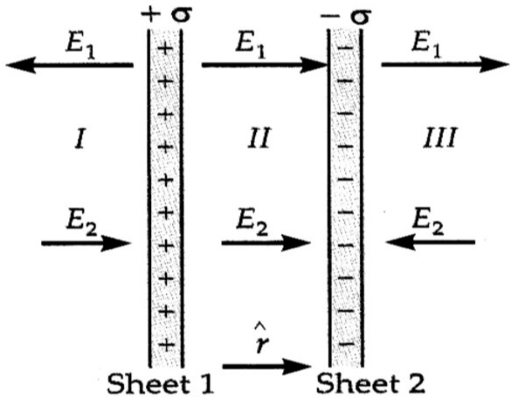
POINTS TO REMEMBER

1. When the equal and same sign of charges are given to parallel plates, the charges will appear on the far faces of the plates.

2. When two parallel plates are given equal and opposite charges, the charge will appear on near faces of plates.

NUMERICAL

1. Find the electric field in between and outside of two infinite parallel plates of surface charge densities $+\sigma and -\sigma$



HOME ASSIGNMENT

1. An infinite line charge produces a field of 9 x 104 N/C at a distance of 2cm. Calculate the linear charge density.
2. Derive an electric field due to an infinitely long straight uniformly charged wire of linear charge density. Using Gauss law.
3. Use Gauss's law to derive an expression for the electric field between two uniformly charge parallel sheets with surface charge density σ and - σ respectively.
4. Two large thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and magnitudes 17.0 x 10-12 cm-2. What is E?
   a) To the left of the plates.
   b) To the right of the plates
   c) In between the plates.

THANKING YOU

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