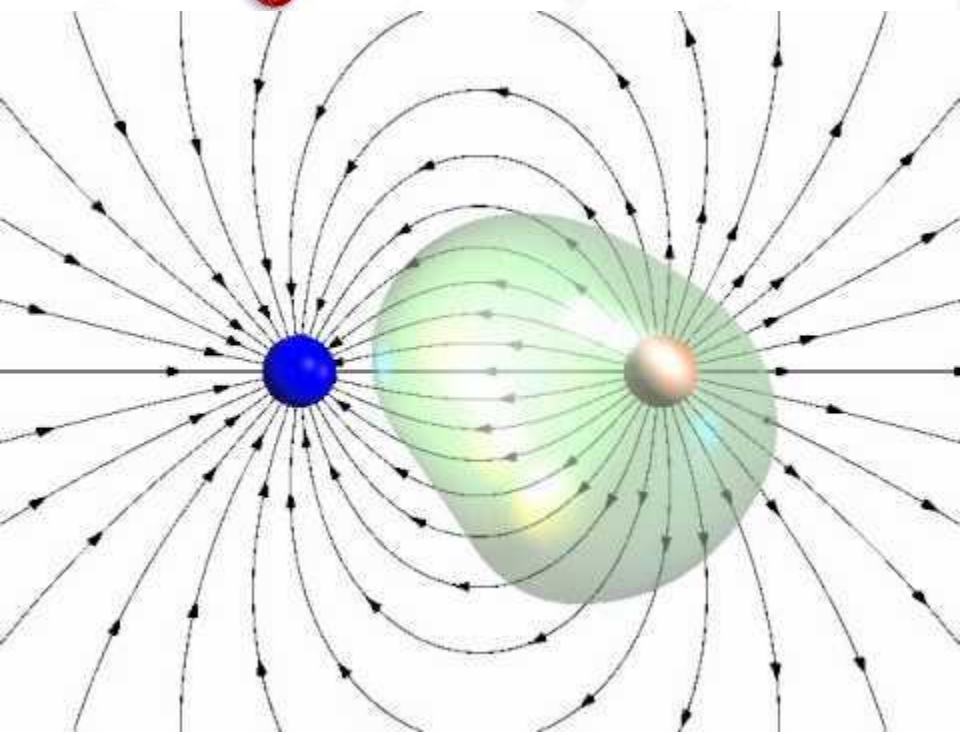


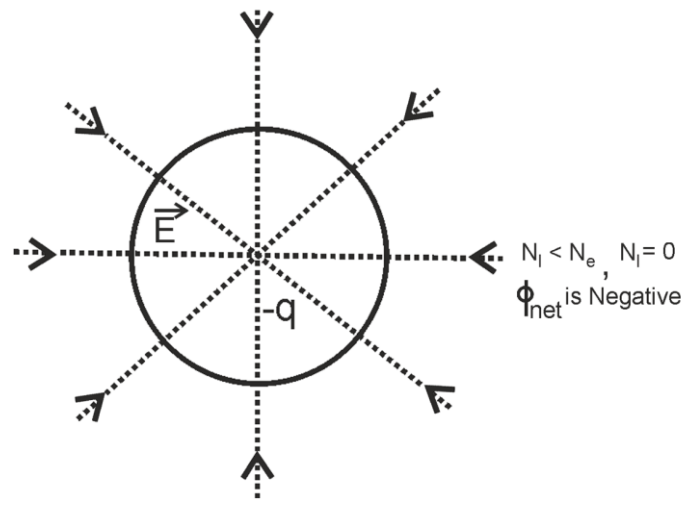


today's topics

**Applications of Gauss Law**  
**Electric Field calculations due to line, surface, Spherical volume charge**



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**Q:25**  
The directional derivative of  $f(x, y, z) = x(x^2 - y^2) - z$  at  $A(1, -1, 0)$  in the direction of  $\vec{p} = (2\hat{i} - 3\hat{j} + 6\hat{k})$  is:

- 8/49
- 8/7
- 8/7
- 0

$\nabla f = (x^2 - y^2)\hat{i} - 2xy\hat{j} - \hat{k}$   
 $\nabla f|_A = (1 - 1)\hat{i} + 2\hat{j} - \hat{k} = 2\hat{j} - \hat{k}$   
 $\vec{p} = 2\hat{i} - 3\hat{j} + 6\hat{k}$   
 $|\vec{p}| = \sqrt{4 + 9 + 36} = \sqrt{49} = 7$   
 $\vec{p} = \frac{2\hat{i} - 3\hat{j} + 6\hat{k}}{7}$   
 $\text{Directional Derivative} = \nabla f \cdot \vec{p} = (2\hat{j} - \hat{k}) \cdot \frac{2\hat{i} - 3\hat{j} + 6\hat{k}}{7} = \frac{0 - 6 - 6}{7} = -\frac{12}{7}$

**Q:21**  
Evaluate  $\int_C \vec{F} \cdot d\vec{r}$  where  $\vec{F} = \frac{y\hat{i} - x\hat{j}}{x^2 + y^2}$

(i) Circular path  $x^2 + y^2 = 1$  described clockwise.

(ii) The square formed by the lines  $x = \pm 1, y = \pm 1$ , counter clockwise.

(i)  $\oint_C \frac{y dx - x dy}{x^2 + y^2}$   
 $= \int_0^{2\pi} \frac{-\sin^2 \theta - \cos^2 \theta}{1} d\theta = \int_0^{2\pi} -1 d\theta = -2\pi$

(ii)  $\oint_C \frac{y dx - x dy}{x^2 + y^2}$   
 $= \int_0^{2\pi} \frac{\cos^2 \theta - \sin^2 \theta}{1} d\theta = \int_0^{2\pi} \cos 2\theta d\theta = 0$

## Number of Questions covered-56

**Q:54** Which one of the following describes the relationship among the three vectors,  $\vec{i} + \vec{j} + \vec{k}$ ,  $2\vec{i} + 3\vec{j} + \vec{k}$  and  $5\vec{i} + 6\vec{j} + 4\vec{k}$

(a) The vectors are mutually perpendicular

(b) The vectors are linearly independent

(c) The vectors are linearly independent

(d) The vectors are unit vectors

$\vec{A} \cdot \vec{B} = 2 + 3 + 4 = 9$

$\begin{bmatrix} 1 & 1 & 1 \\ 2 & 3 & 1 \\ 5 & 6 & 4 \end{bmatrix}$   
 $R_3 = 3R_1 + R_2$

**Q:56** If two charges of  $10\mu\text{C}$  &  $-10\mu\text{C}$  are located at  $(-1, 1, 0)$  &  $(2, 2, 0)$  then find force on a charge  $2\mu\text{C}$  placed at  $(0, 0, 2)$ .

**Sol.**

$\vec{F}_3 = \vec{F}_{13} + \vec{F}_{23}$   
 $= \frac{20 \times 10^{-12}}{4\pi \times 10^{-9} \times 12} (\hat{i} + \hat{j} + 2\hat{k}) + \frac{20 \times 10^{-12}}{4\pi \times 10^{-9} \times 12} (-2\hat{i} - 2\hat{j} + 2\hat{k})$   
 $= \frac{20 \times 10^{-12}}{4\pi \times 10^{-9} \times 12} (\hat{i} + \hat{j} + 2\hat{k} - 2\hat{i} - 2\hat{j} + 2\hat{k})$   
 $= \frac{20 \times 10^{-12}}{4\pi \times 10^{-9} \times 12} (-\hat{i} - \hat{j} + 4\hat{k})$

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# GATE 2024



**प्रचण्ड** Batch

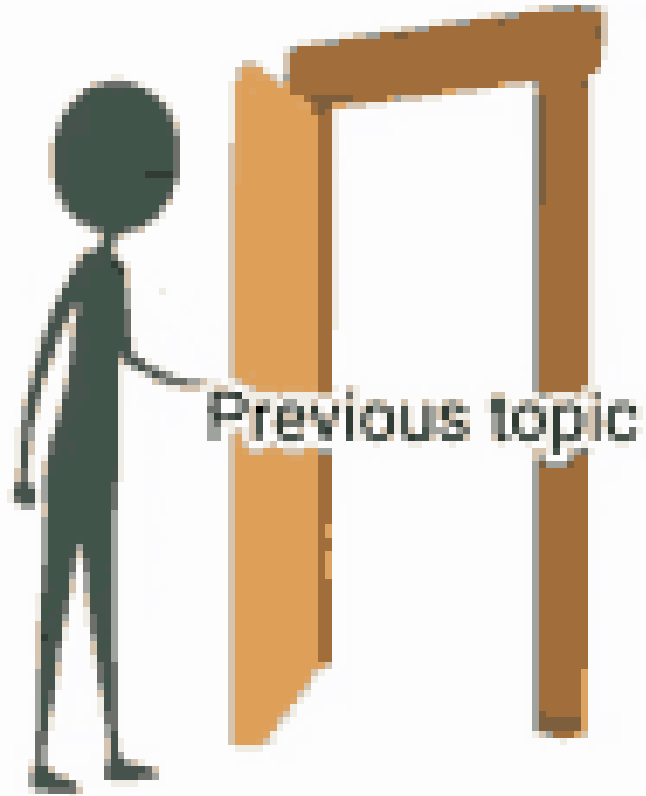
**Electromagnetic Field Theory**

**FIELDS DUE TO LINE, SURFACE  
AND SPHERICAL VOLUME CHARGES**

**LEC-11**

**EE & ECE**





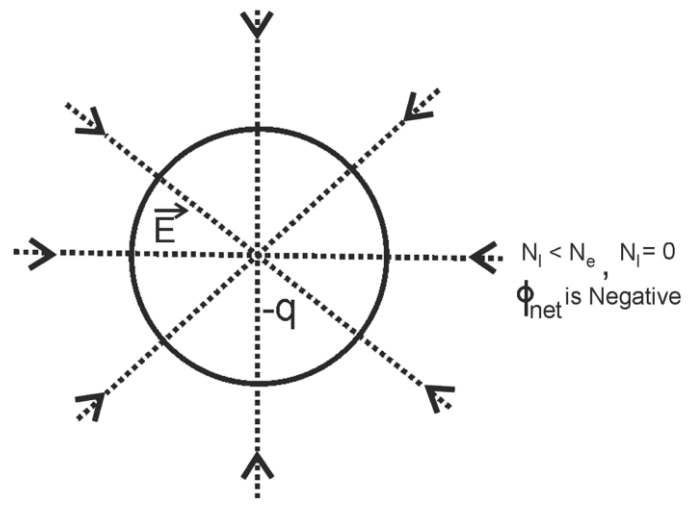
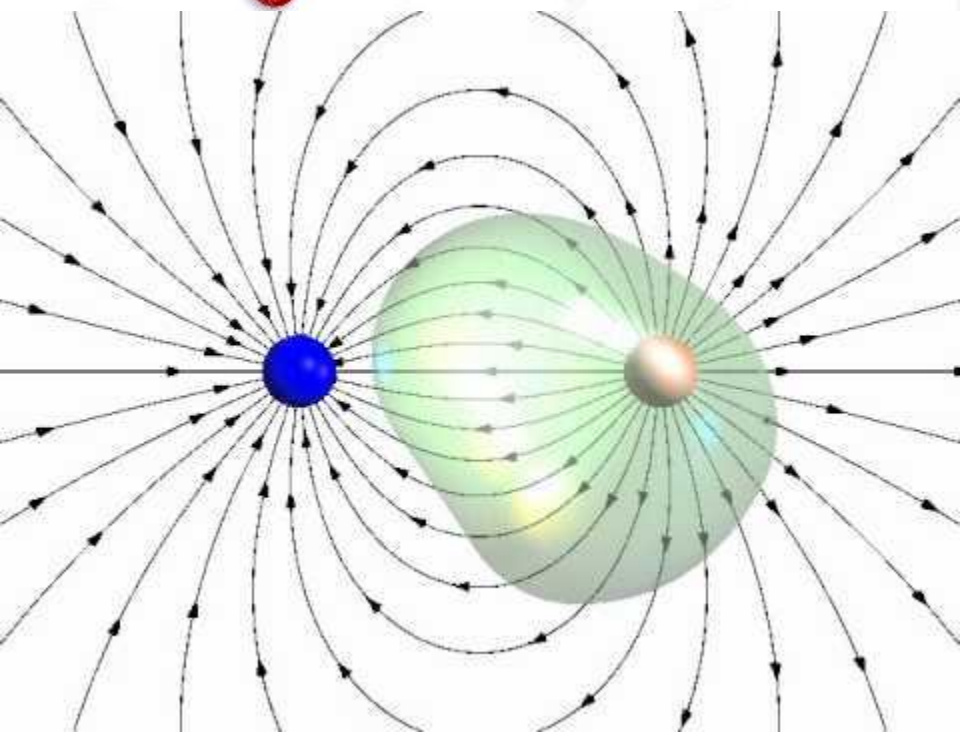
- 1. Basic introduction of Fields**
- 2. Basics of Vectors**
- 3. Coordinate Systems**
- 4. Vector Integrals**
- 5. Vector differentials**
- 6. Coulomb's law and Gauss law**





today's topics

**Applications of Gauss Law**  
**Electric Field calculations due to line, surface, Spherical volume charge**



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## Electric Field calculations due to point Charge



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## Gauss Law





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## **Electric Field Calculations due to uniformly charged line Charge**



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## **Electric Field Calculations due to uniformly charged line Charge**



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## **Electric Field Calculations due to uniformly charged Surface Charge**

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## **Electric Field Calculations due to uniformly charged Surface Charge**

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## **Electric Field Calculations due to uniformly charged Surface Charge**

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## **Electric Field Calculations due to uniformly charged Spherical volume Charge**



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## **Electric Field Calculations due to uniformly charged Spherical volume Charge**



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