PHY-112

Principles of Physics-II

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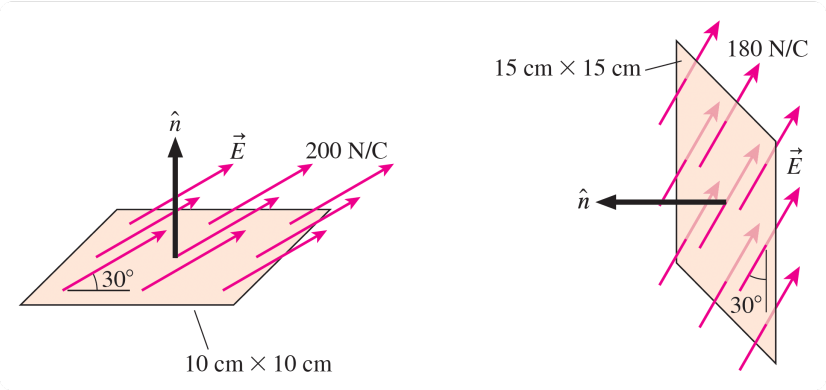
Spring-24 | Class-7

$\vec{E}$ Field for 3 Model Sources Using Gauss's Law

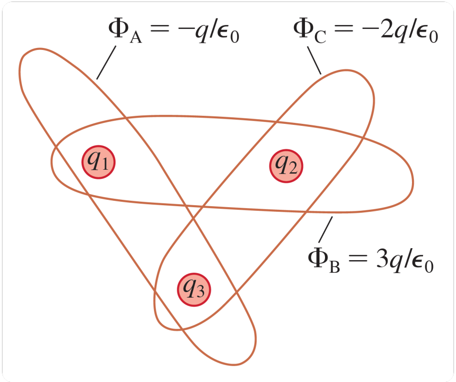
- Line Charge $\longrightarrow \vec{E} = \left(\dfrac{\lambda}{2\pi\epsilon_0 r}\right)\hat{r}$
- Surface Charge $\longrightarrow \vec{E} = \left(\dfrac{\sigma}{2\epsilon_0}\right)\hat{n}$
- Volume Charge $\longrightarrow \vec{E} = \left(\dfrac{r\rho}{3\epsilon_0}\right)\hat{r}$

Q: Calculate electric flux through the surface shown.



Q: A $1.0\,\text{cm} \times 5.0\,\text{cm}$ rectangle lies in the xy-plane with unit vector $\hat{n}$ pointing in the $+z$-direction. What is the electric flux through the rectangle if the electric field is $\vec{E} = (2000\hat{\imath} - 4000\hat{k})$?

Q: Three Gaussian surfaces and the electric flux through each are shown. What are the three charges q_1, q_2, and q_3?

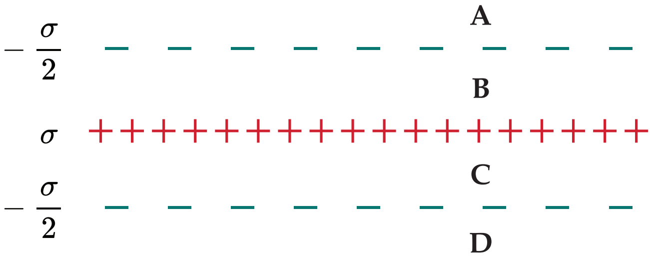


Q: A thin, horizontal ($y = 0$), 50 m-long copper wire is charged to $+3.5$ nC. The charge is uniformly distributed on the wire.

- Find $\vec{E}$ at $y = 3$ cm.
- Find $\vec{E}$ at $y = -4$ cm.
- Find $\vec{E}$ at $(x = 3, y = 3)$ cm.
- Find $\vec{E}$ at $(x = 3, y = 6)$ cm.

Testing Concepts (5)

Q: The three parallel planes of charge shown, having surface charge densities $\dfrac{-\sigma}{2}, \sigma, \dfrac{-\sigma}{2}$. Find the electric fields $\vec{E}_A$ to $\vec{E}_D$ in regions A to D. The upward direction is the +y-direction.



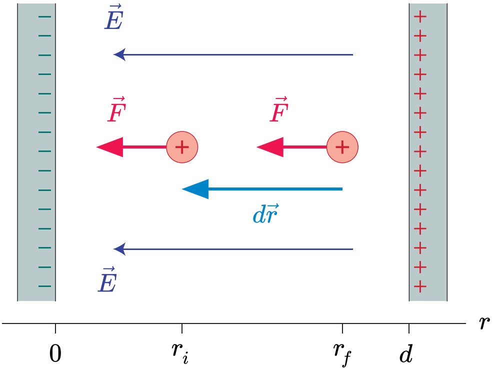
Testing Concepts (6)

Q: A spherically symmetric (uniform) charge distribution ($R = 40\,\mathrm{cm}$) produces the electric field $\vec{E} = (5000r^2)\hat{r}\ \mathrm{N\,C^{-1}}$, where r is in meters.

- What is the electric field strength at $r = 20\,\mathrm{cm},\ 40\,\mathrm{cm},\ 70\,\mathrm{cm}$?
- What is the electric flux through a $40\,\mathrm{cm}$-diameter spherical surface that is concentric with the charge distribution?
- How much charge is inside this $40\,\mathrm{cm}$-diameter spherical surface?
- Find the spherical charge density of this distribution.

Electric Potential Energy and Potential

Work Done due to Electrostatic Force



Work Done due to Electrostatic Force

When a charge moves or is moved in the electric field, work is done by or against the Coulomb force to accelerate it, thus displacing it. This work done is stored as potential energy in the system.

$$
\begin{aligned}
W &= \int dW \\
&= \int \vec{F} \cdot d\vec{r} \\
&= q_0 \int_{\text{start}}^{\text{final}} \vec{E} \cdot d\vec{r}.
\end{aligned}
$$

Types of Work Done due to Electrostatic Force

- Charges **moves** on its own due to Coulomb Force $\vec{F}_E \longrightarrow$ Positive Work (By the System)
- Charges are **moved** using external force $\vec{F}_{\text{ext}} \longrightarrow$ Negative Work (On the System)