PHY-112 | Principles of Physics-2

Akiful Islam (AZW)
Summer 2024 | Class #6

Department of Mathematics & Natural Sciences

Measure Electric Flux

Electric Flux

Measure field lines through a loop

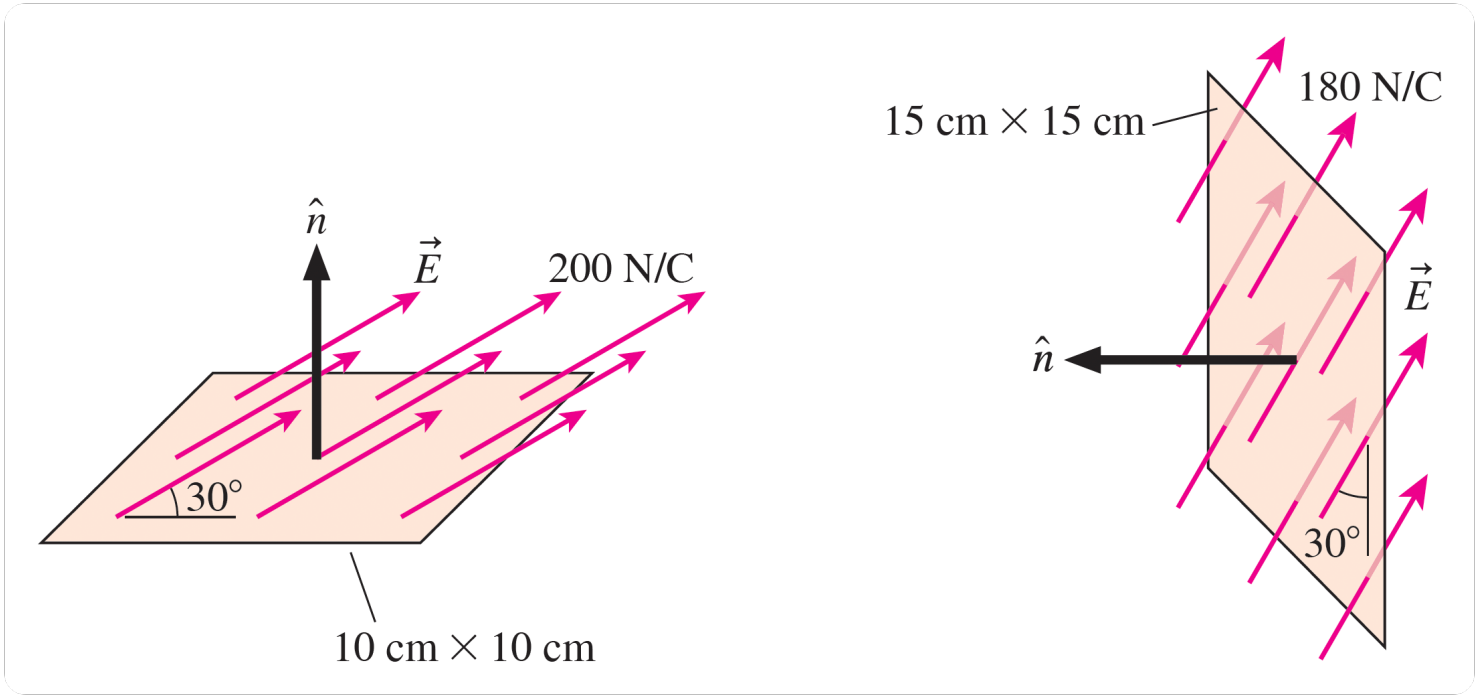
$$\Phi_E = \vec{E} \cdot \vec{A} = \vec{E} \cdot \hat{n}\,(A) = EA\cos\phi \quad \text{(Uniform field)}$$

$$\Phi_E = \int \vec{E} \cdot \hat{n}\,(dA) = EdA\cos\phi \quad \text{(Non-Uniform field)}$$

Incepting Ideas (1)

Hint: The key is to find the angle

Q: Calculate electric flux through the surface shown.



Incepting Ideas (2)

Hint: The key is to dot multiply

Q: A 1.0 cm $\times$ 5.0 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 $\vec{E} = (2000\hat{i} - 4000\hat{k})$?

Similar problem to look at for Additional Practice at home

Exercises 1, 2, 3, p-679 (Resnick-Halliday)

Example 22.1 (p-751), Exercises 22.1, 22.2 (p-769) (Young-Freedman)

Gauss's Law and Electric fields

How much field through an area?

The total Φ_E passing through a closed surface is proportional to the total electric charge Q_{enc} enclosed within that surface.

$$\oint_S \Phi_E = \oint_S \vec{E} \cdot d\vec{a} = \frac{Q_{\text{enclosed}}}{\epsilon_0}. \qquad \text{(Integral Form)}$$

$$\text{where} \quad \epsilon_0 = 8.854 \times 10^{-12}\,\text{F}\,\text{m}^{-1}$$

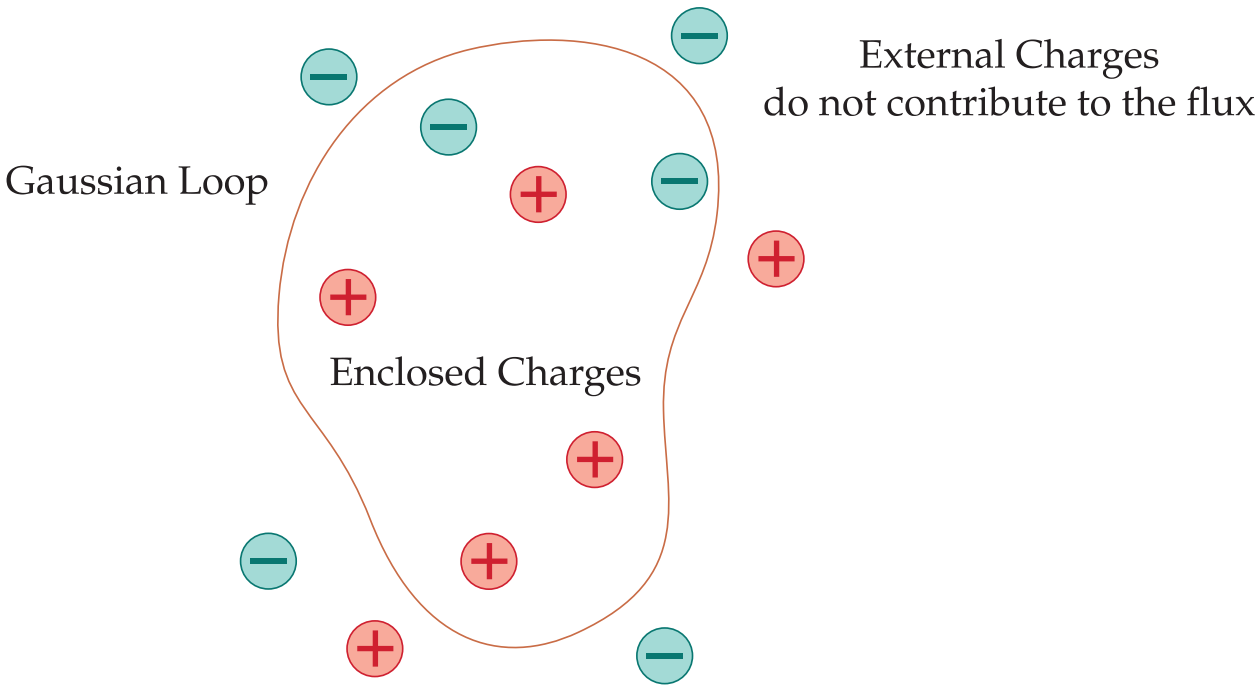
$$\rightarrow \text{Permittivity of free space}$$

It relates the behavior of the electric field to the distribution of electric charge. **One demands the presence of the other**.

Note: Q_{enc} is the net charge calculated by taking the algebraic sum of all charges enclosed by the Gaussian surface.

Gauss's Law and Enclosed Charges

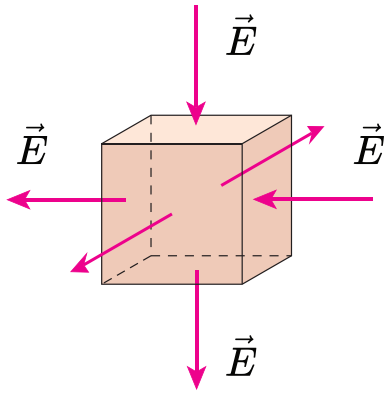
Outsiders do not count



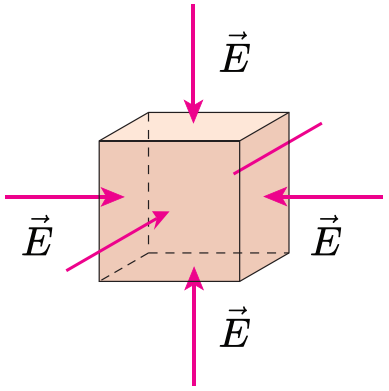
Incepting Ideas (3)

Count the Field Lines

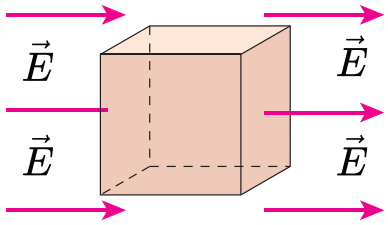
Q: Comment on the type of charges enclosed within the cube.



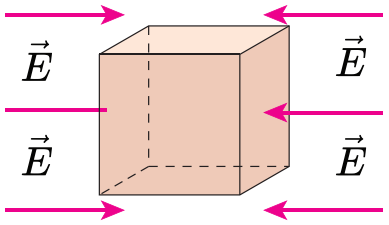
A



B



C

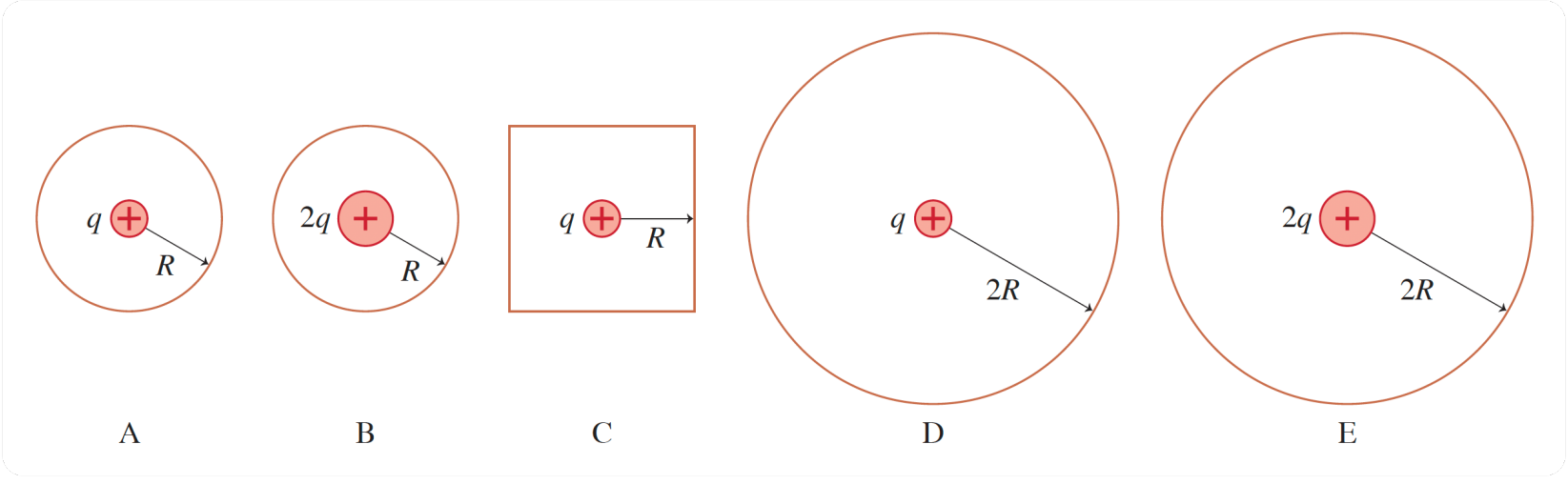


D

Incepting Ideas (4)

Count the Field Lines through each face

Q: These are two-dimensional cross-sections through three-dimensional closed spheres and a cube. Rank in order, from largest to smallest, the electric fluxes Φ_A to Φ_E through surfaces A to E.

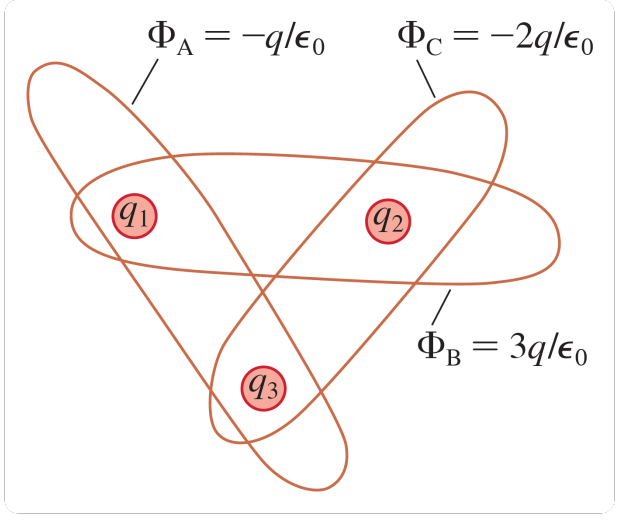


Incepting Ideas (5)

Sum the charges within the same loop

Homework Practice Problem: Try it Yourself

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



Hint: Find Q_{enc} for each surface (A, B, and C) and set it to the value given in question. This forms 3 equations. Solve the equations. The solutions are the three charges q_1, q_2, and q_3.

That is it for today!