How amazing is that $\frac{1}{\sqrt{\epsilon_0 \mu_0}} = 3 \times 10^8 \text{m/s}$?

A. OMGBBQPIZZA, so amazing!
B. It's pretty cool
C. Meh
D. Whatever

CORRECT ANSWER

OMGBBQPIZZA, so amazing!

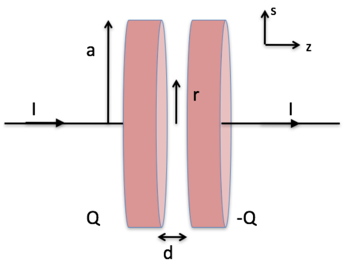
What do you want to do today?

A. Clickers and lecture
B. Tutorial

Either way, we are covering the same example.

Consider a large parallel plate capacitor as shown, charging so that $Q = Q_0 + \beta t$ on the positively charged plate. Assuming the edges of the capacitor and the wire connections to the plates can be ignored, what is the direction of the magnetic field $\mathbf{B}$ halfway between the plates, at a radius r?

A. $\pm\hat{\phi}$
B. 0
C. $\pm\hat{z}$
D. $\pm\hat{s}$
E. ???

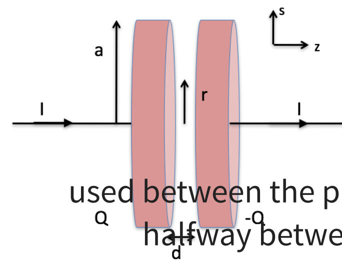


Same capacitor with $Q = Q_0 + \beta t$ on the positively charged plate. What is the direction of the magnetic field $\mathbf{B}$ halfway between the plates, at a radius r?

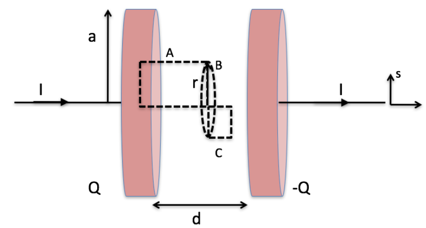
A. $+\hat{\phi}$

B. $-\hat{\phi}$

C. Not sure how to tell

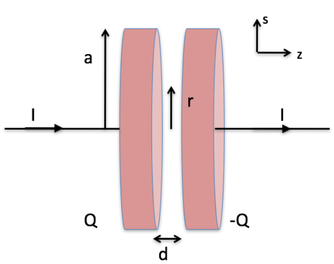


Same capacitor with $Q = Q_0 + \beta t$ on the positively charged plate. What kind of amperian loop can be used between the plates to find the magnetic field $\mathbf{B}$ halfway between the plates, at a radius r?



D) A different loop E) Not enough symmetry for a useful loop

Same capacitor with $Q = Q_0 + \beta t$ on the positively charged plate. What is the magnitude of the magnetic field $\mathbf{B}$ halfway between the plates, at a radius r?



A. $\frac{\mu_0 \beta}{2\pi r}$

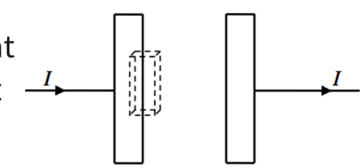
B. $\frac{\mu_0 \beta r}{2d^2}$

C. $\frac{\mu_0 \beta d}{2a^2}$

D. $\frac{\mu_0 \beta a}{2\pi r^2}$

E. None of the above

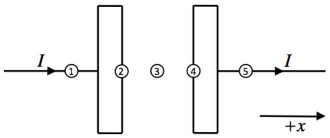
Consider the surface of an imaginary volume (dashed lines, at right) that partly encloses the left capacitor plate. For this closed surface, is the total flux of the current density, $\iint \mathbf{J} \cdot d\mathbf{A}$ positive, negative or zero?



A. Positive

B. Negative

C. Zero

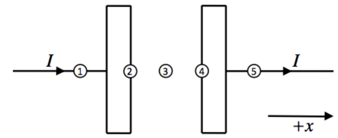


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

At location 3, the signs of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$ are:

A. both zero
B. both negative
C. both positive
D. $\partial\rho/\partial t$ is positive and $\nabla \cdot \mathbf{J}$ is negative
E. $\partial\rho/\partial t$ is negative and $\nabla \cdot \mathbf{J}$ is positive

Recall that charge is conserved locally!

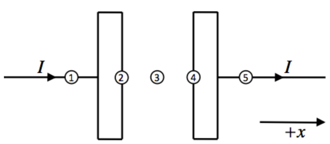


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

At location 2, the signs of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$ are:

A. both zero
B. both negative
C. both positive
D. $\partial\rho/\partial t$ is positive and $\nabla \cdot \mathbf{J}$ is negative
E. $\partial\rho/\partial t$ is negative and $\nabla \cdot \mathbf{J}$ is positive

Recall that charge is conserved locally!

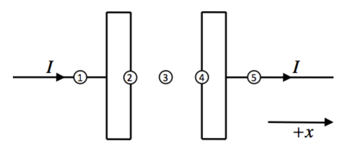


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

At location 4, the signs of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$ are:

A. both zero
B. both negative
C. both positive
D. $\partial\rho/\partial t$ is positive and $\nabla \cdot \mathbf{J}$ is negative
E. $\partial\rho/\partial t$ is negative and $\nabla \cdot \mathbf{J}$ is positive

Recall that charge is conserved locally!

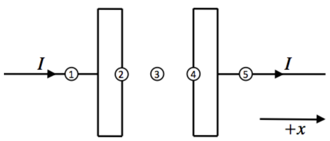


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

At location 1, the signs of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$ are:

A. both zero
B. both negative
C. both positive
D. $\partial\rho/\partial t$ is positive and $\nabla \cdot \mathbf{J}$ is negative
E. $\partial\rho/\partial t$ is negative and $\nabla \cdot \mathbf{J}$ is positive

Recall that charge is conserved locally!

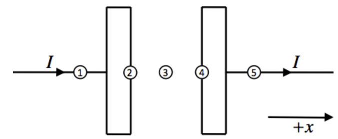


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

At location 5, the signs of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$ are:

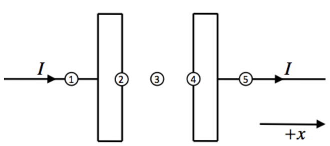
A. both zero
B. both negative
C. both positive
D. $\partial\rho/\partial t$ is positive and $\nabla \cdot \mathbf{J}$ is negative
E. $\partial\rho/\partial t$ is negative and $\nabla \cdot \mathbf{J}$ is positive

Recall that charge is conserved locally!



Suppose the original Ampere's law $\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$ were correct without any correction from Maxwell (it's not, but suppose for a moment that it is). What would this imply about $\nabla \cdot \mathbf{J}$ at points 2 and 4 in the diagram?

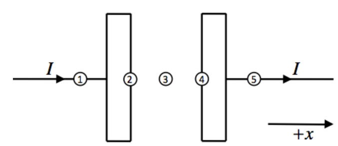
A. The remain unchanged
B. They swap signs
C. They become zero
D. ???



Let's continue with the (incomplete) definition of Ampere's Law: $\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$.

What does this form tell you about the signs of $(\nabla \times \mathbf{B})_x$ at locations 1, 3, and 5?

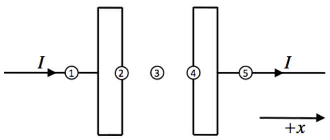
A. All positive
B. All negative
C. Positive at 1 and 5, zero at 3
D. Negative at 1 and 5, zero at 3
E. Something else



Let's return to the complete definition of Ampere's Law: $\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \varepsilon_0 \mu_0 \frac{d\mathbf{E}}{dt}$.

At location 1, what are the signs of J_x, dE_x/dt, and $(\nabla \times \mathbf{B})_x$?

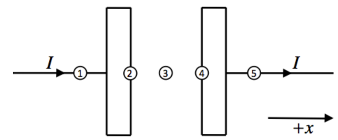
A. $J_x < 0, dE_x/dt < 0, (\nabla \times \mathbf{B})_x < 0$
B. $J_x = 0, dE_x/dt > 0, (\nabla \times \mathbf{B})_x > 0$
C. $J_x > 0, dE_x/dt = 0, (\nabla \times \mathbf{B})_x > 0$
D. $J_x > 0, dE_x/dt > 0, (\nabla \times \mathbf{B})_x > 0$
E. Something else



Let's return to the complete definition of Ampere's Law:
$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \varepsilon_0 \mu_0 \frac{d\mathbf{E}}{dt}$.

At location 3, what are the signs of J_x, dE_x/dt, and $(\nabla \times \mathbf{B})_x$?

A. $J_x < 0, dE_x/dt < 0, (\nabla \times \mathbf{B})_x < 0$
B. $J_x = 0, dE_x/dt > 0, (\nabla \times \mathbf{B})_x > 0$
C. $J_x > 0, dE_x/dt = 0, (\nabla \times \mathbf{B})_x > 0$
D. $J_x > 0, dE_x/dt > 0, (\nabla \times \mathbf{B})_x > 0$
E. Something else



Let's return to the complete definition of Ampere's Law:
$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \varepsilon_0 \mu_0 \frac{d\mathbf{E}}{dt}$.

At location 5, what are the signs of J_x, dE_x/dt, and $(\nabla \times \mathbf{B})_x$?

A. $J_x < 0, dE_x/dt < 0, (\nabla \times \mathbf{B})_x < 0$
B. $J_x = 0, dE_x/dt > 0, (\nabla \times \mathbf{B})_x > 0$
C. $J_x > 0, dE_x/dt = 0, (\nabla \times \mathbf{B})_x > 0$
D. $J_x > 0, dE_x/dt > 0, (\nabla \times \mathbf{B})_x > 0$
E. Something else