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

A. OMGBBQPIZZA, so amazing!

B. It's pretty cool

C. Meh

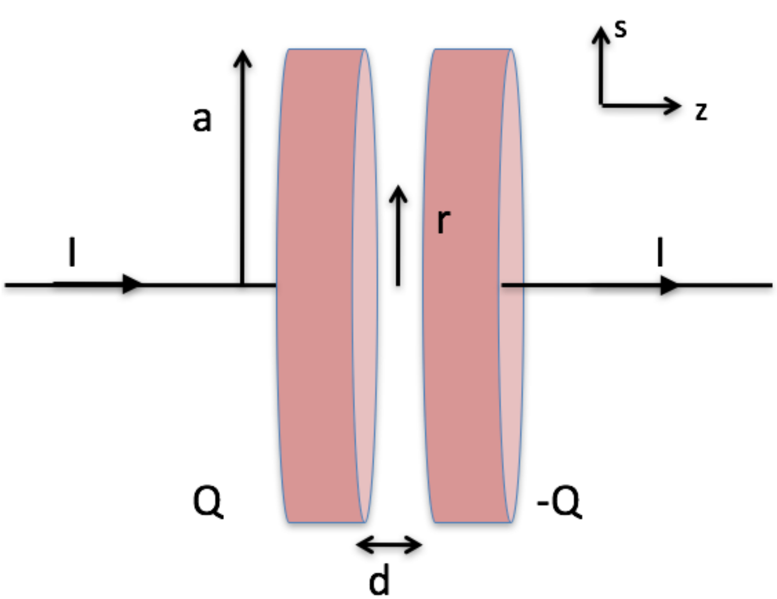
D. Whatever

CORRECT ANSWER

OMGBBQPIZZA, so amazing!

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 B halfway between the plates, at a radius r?



A. $\pm\hat{\phi}$

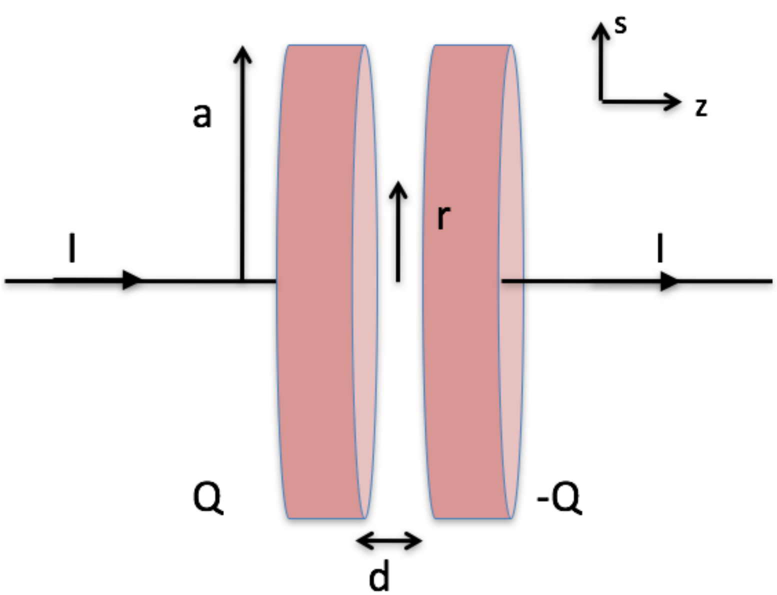
B. 0

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 B halfway between the plates, at a radius r?

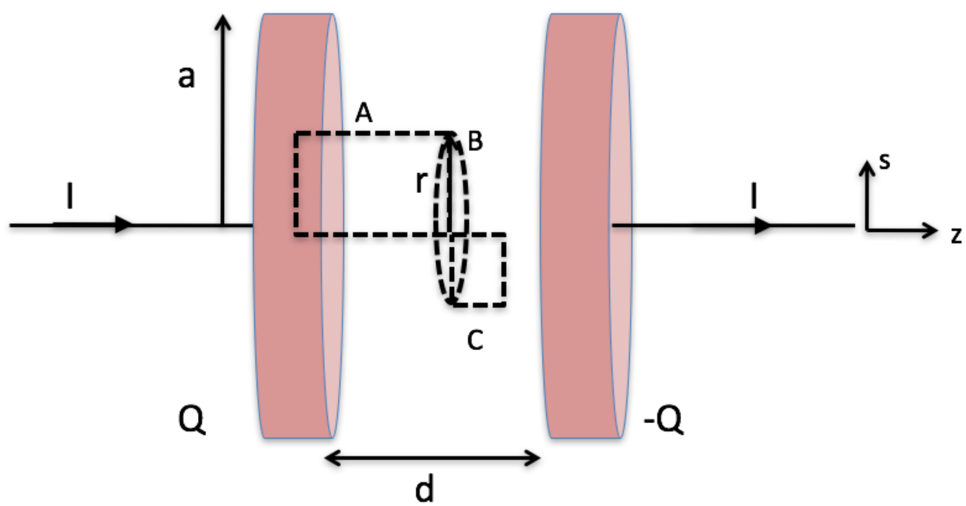


A. $+\hat{\phi}$

B. $-\hat{\phi}$

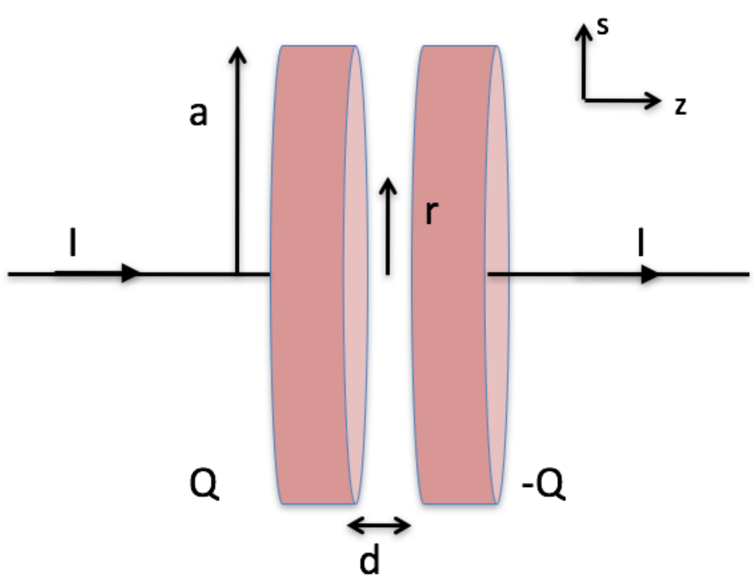
C. Not sure how to tell

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 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 B halfway between the plates, at a radius r?



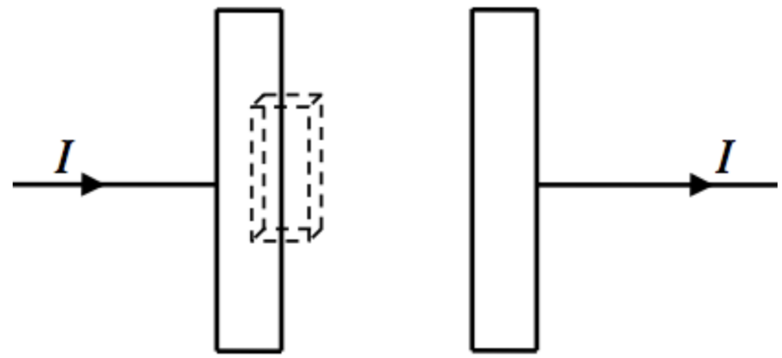
A. $\frac{\mu_0 \beta}{2\pi r}$

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

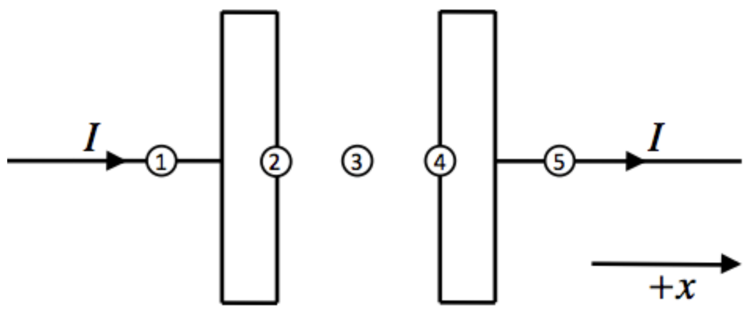
C. $\frac{\mu_0 \beta d}{2a^2}$

$\mu_0 \beta a$

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

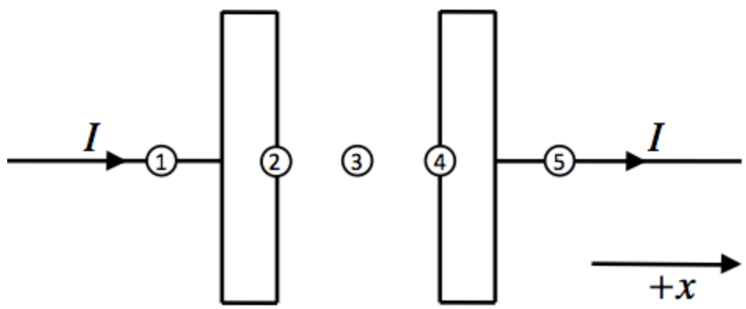


At each location, we will evaluate the sign of $\partial \rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!

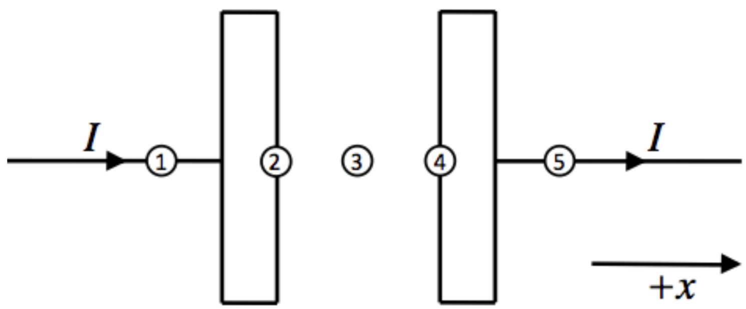


At each location, we will evaluate the sign of \partial \rho/\partial t and \nabla \cdot \mathbf{J}.

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!

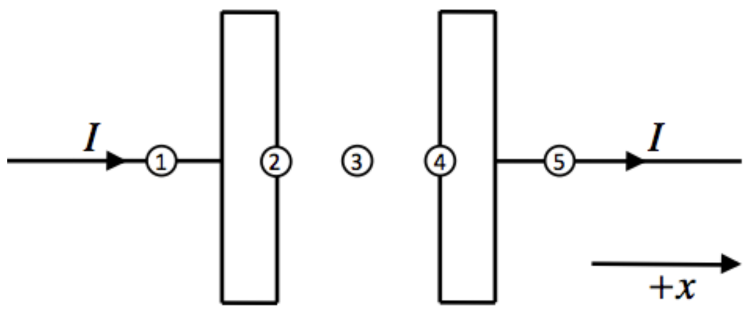


At each location, we will evaluate the sign of $\partial \rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!

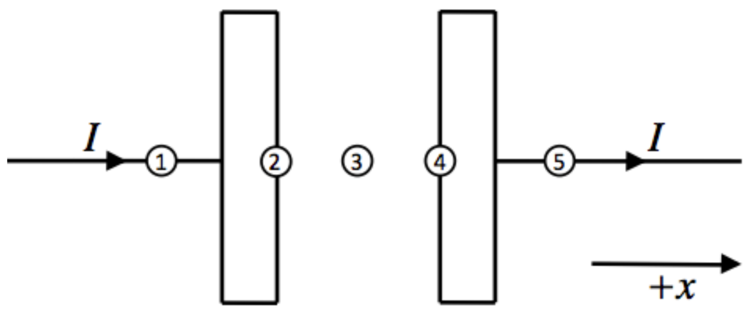


At each location, we will evaluate the sign of $\partial \rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!

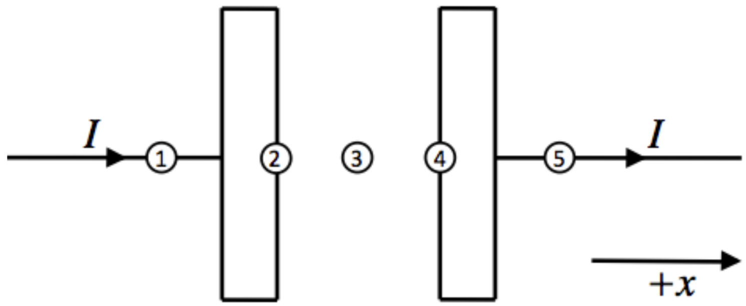


At each location, we will evaluate the sign of $\partial \rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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

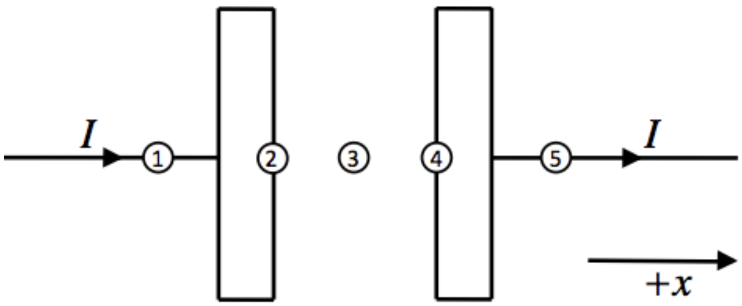
A. both zero
B. both negative
C. both positive
D. $\partial \rho/\partial t$ is positive and $\nabla \cdot \mathbf{J}$ is negative
E. $\partial \rho/\partial t$ is negative and $\nabla \cdot \mathbf{J}$ is positive

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?

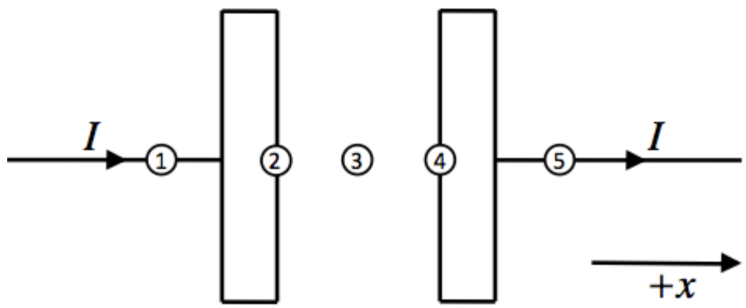
A. The remain unchanged
B. They swap signs
C. They become zero
D. ???



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?

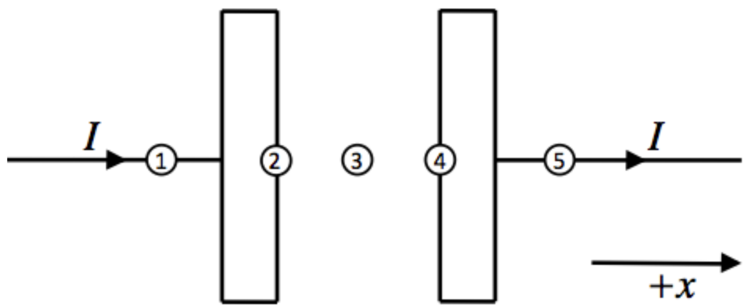
A. All positive
B. All negative
C. Positive at 1 and 5, zero at 3
D. Negative at 1 and 5, zero at 3
E. Something else



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 $(\nabla \times \mathbf{B})_x$?

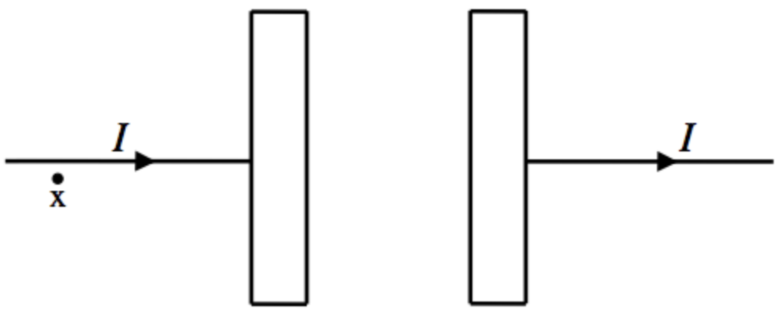
A. $J_x<0$, $dE_x/dt<0$, $(\nabla \times \mathbf{B})_x<0$
B. $J_x=0$, $dE_x/dt>0$, $(\nabla \times \mathbf{B})_x>0$
C. $J_x>0$, $dE_x/dt=0$, $(\nabla \times \mathbf{B})_x>0$
D. $J_x>0$, $dE_x/dt>0$, $(\nabla \times \mathbf{B})_x>0$
E. Something else



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}.

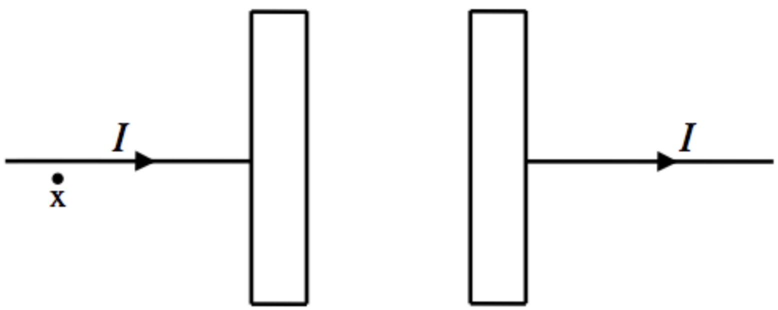
At location 3, what are the signs of J_x, dE_x/dt, and (\nabla \times \mathbf{B})_x?

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



A pair of capacitor plates are charging up due to a current I. The plates have an area $A=\pi R^2$. Use the Maxwell-Ampere Law to find the magnetic field at the point "x" in the diagram as distance r from the wire.

A. $B = \frac{\mu_0 I}{4 \pi r}$
B. $B = \frac{\mu_0 I}{2 \pi r}$
C. $B = \frac{\mu_0 I}{4 \pi r^2}$
D. $B = \frac{\mu_0 I}{2 \pi r^2}$
E. Something much more complicated



The plates have an area $A=\pi R^2$. Use the Gauss' Law to find the electric field between the plates, answer in terms of σ the charge density on the plates.

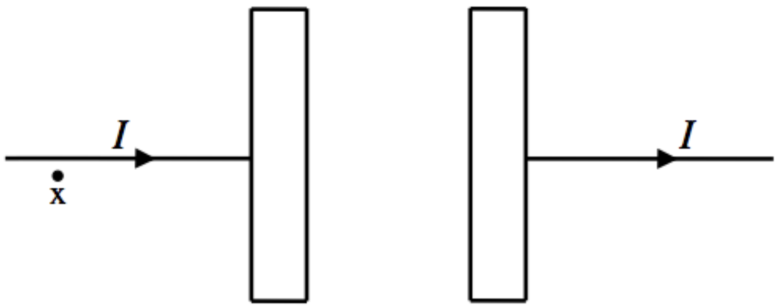
A. $E = \sigma/\varepsilon_0$

B. $E = -\sigma/\varepsilon_0$

C. $E = \sigma/(\varepsilon_0 \pi R^2)$

D. $E = \sigma \pi R^2 / \varepsilon_0$

E. Something much more complicated



The plates have an area $A=\pi R^2$. Determine the relationship between the current flowing in the wires and the rate of change of the charge density on the plates.

A. $d\sigma/dt = I$
B. $\pi R^2\, d\sigma/dt = I$
C. $d\sigma/dt = \pi R^2 I$
D. Something else

We found the relationship between the current and the change of the charge density was: $\pi R^2 d\sigma/dt = I$. Determine the rate of change of the electric field between the plates, $d\mathbf{E}/dt$.

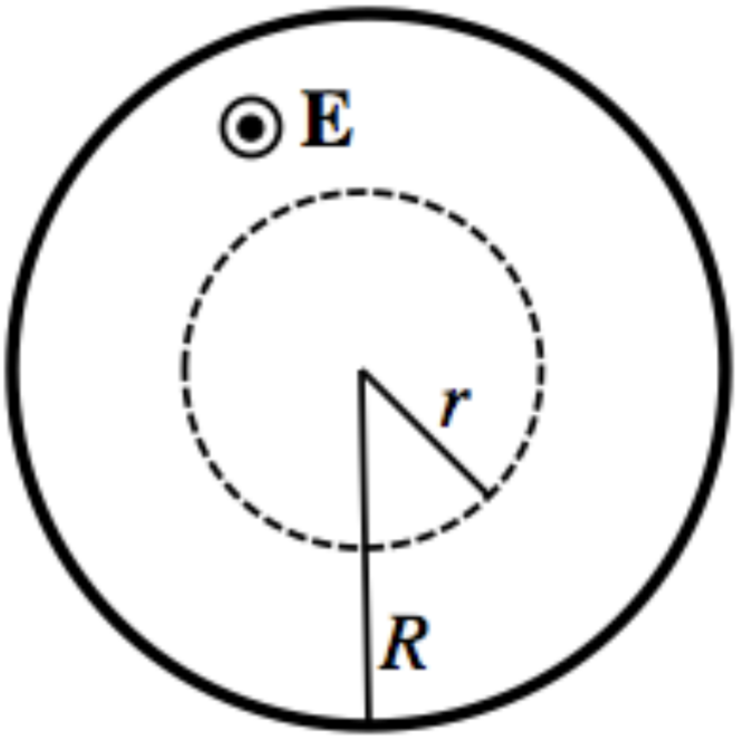
A. $\sigma/\varepsilon_0 \hat{x}$

B. $I/(\pi R^2 \varepsilon_0) \hat{x}$

C. $-I/(\pi R^2 \varepsilon_0) \hat{x}$

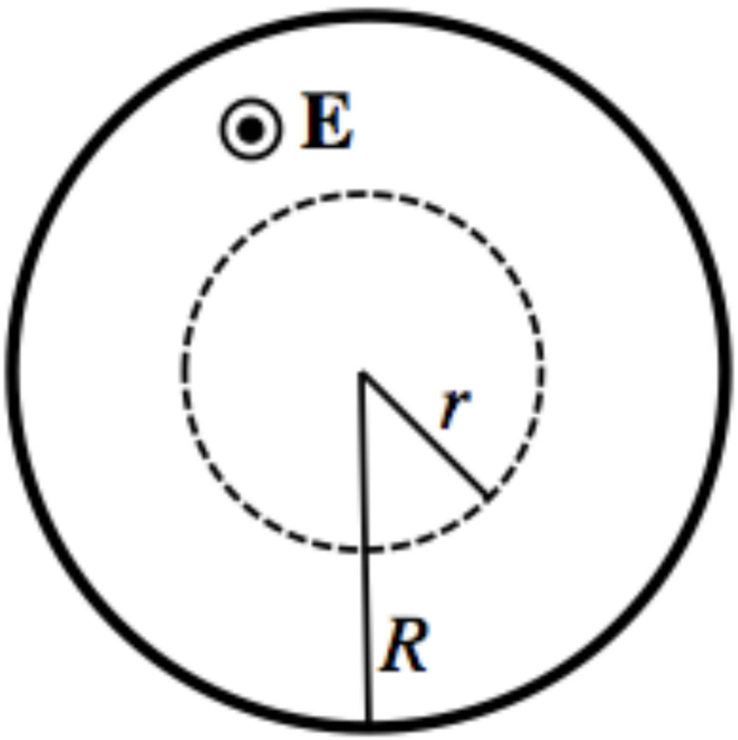
D. $I/(2 \pi R \varepsilon_0) \hat{x}$

E. $-I/(2 \pi R \varepsilon_0) \hat{x}$



Use the Maxwell-Ampere Law to derive a formula for the manetic at a distance $r<R$ from the center of the plate in terms of the current, I.

A. $B=\frac{\mu_0 I}{2\pi r}$
B. $B=\frac{\mu_0 I r}{2\pi R^2}$
C. $B=\frac{\mu_0 I}{4\pi r}$
D. $B=\frac{\mu_0 I r}{4\pi R^2}$
E. Something else entirely



Use the Maxwell-Ampere Law to derive a formula for the manetic at a distance $r>R$ from the center of the plate in terms of the current, I.

A. $B=\frac{\mu_0 I}{2\pi r}$
B. $B=\frac{\mu_0 I r}{2\pi R^2}$
C. 0
D. Something else entirely