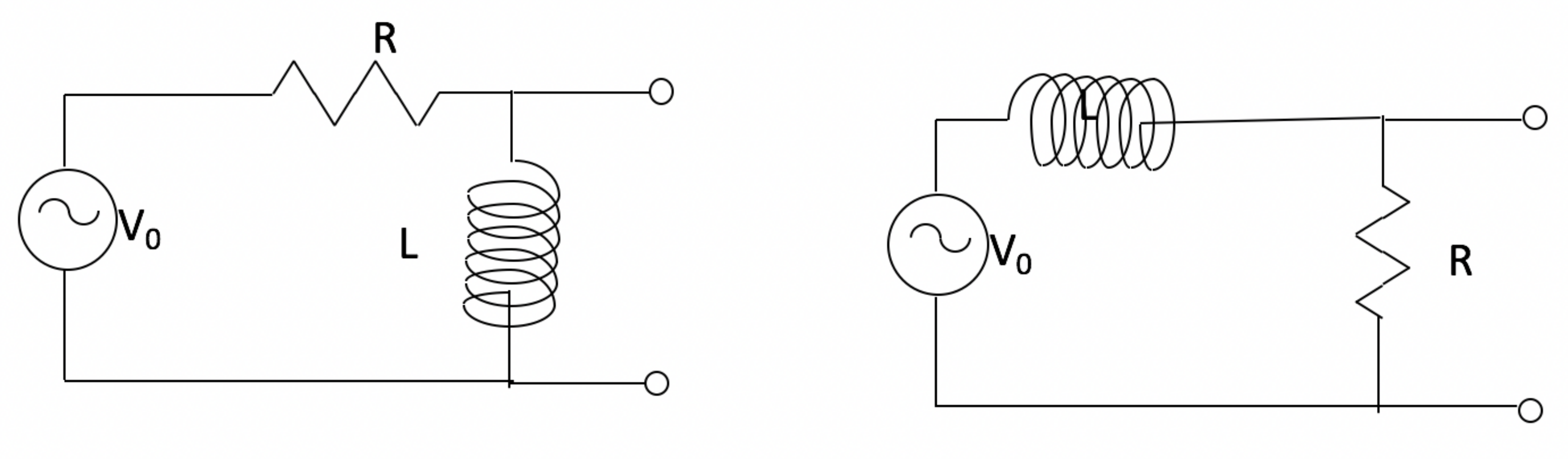
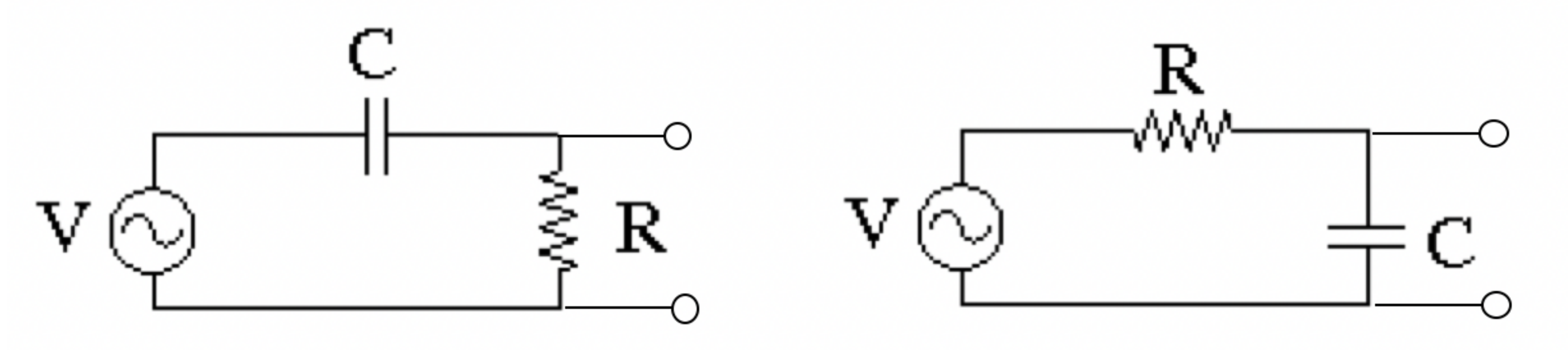
Two LR circuits driven by an AC power supply are shown below.



Which circuit is a low pass filter?

A. The left circuit
B. The right circuit
C. Both circuits
D. Neither circuit

Two RC circuits driven by an AC power supply are shown below.



Which circuit is a high pass filter?

A. The left circuit
B. The right circuit
C. Both circuits
D. Neither circuit

Ampere's Law relates the line integral of B around some closed path, to a current flowing through a surface bounded by the chosen closed path.

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$$

By calling it a "Law", we expect that:

A. It is neither correct nor useful.
B. It is sometimes correct and sometimes easy to use.
C. It is correct and sometimes easy to use.
D. It is correct and always easy to use.
E. None of the above.

ANNOUNCEMENTS

- Quiz 3 (Friday 2/12) - RLC circuits
  - Solve a circuit problem using the phasor method
  - Discuss limits on the response and how it might act as a filter

Take the divergence of the curl of any (well-behaved) vector function $\mathbf{F}$, what do you get?

$$\nabla \cdot (\nabla \times \mathbf{F}) = ???$$

A. Always 0

B. A complicated partial differential of $\mathbf{F}$

C. The Laplacian: $\nabla^2 \mathbf{F}$

D. Wait, this vector operation is ill-defined!

Take the divergence of both sides of Faraday's law:

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

What do you get?

A. 0 = 0 (is this interesting?)
B. A complicated partial differential equation (perhaps a wave equation of some sort ?!) for $\mathbf{B}$
C. Gauss' law!
D. ???

Take the divergence of both sides of Ampere's law:

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$$

According to this, the divergence of $\mathbf{J}$ is:

A. $-\partial\rho/\partial t$

B. A complicated partial differential of $\mathbf{B}$

C. Always 0

D. ???

Ampere's Law relates the line integral of $\mathbf{B}$ around some closed path, to a current flowing through a surface bounded by the chosen closed path.

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$$

The **path** can be:

A. Any closed path
B. Only circular paths
C. Only sufficiently symmetrical paths
D. Paths that are parallel to the B-field direction.
E. None of the above.

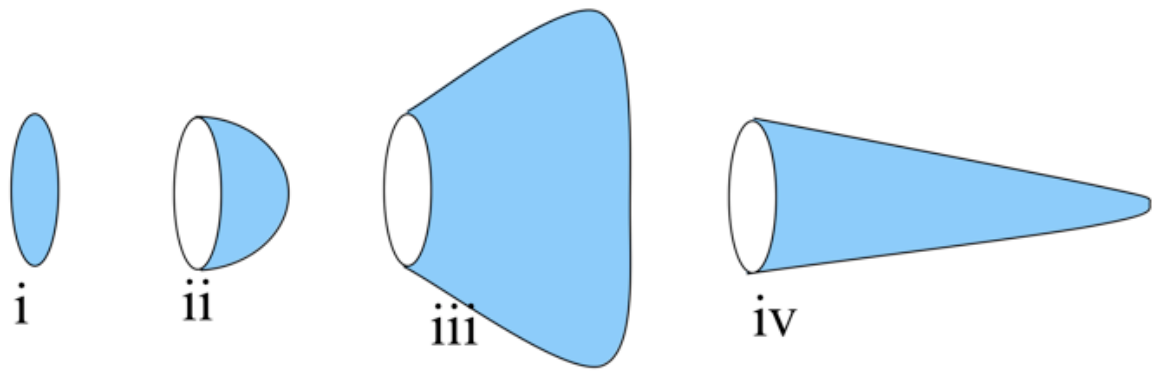
Ampere's Law relates the line integral of $\mathbf{B}$ around some closed path, to a current flowing through a surface bounded by the chosen closed path.

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$$

The **surface** can be:

A. Any closed bounded surface
B. Any open bounded surface
C. Only surfaces perpendicular to $\mathbf{J}$.
D. Only surfaces tangential to the B-field direction.
E. None of the above.

Rank order $\int \mathbf{J} \cdot d\mathbf{A}$ (over blue surfaces) where $\mathbf{J}$ is uniform, going left to right:



A. iii > iv > ii > i

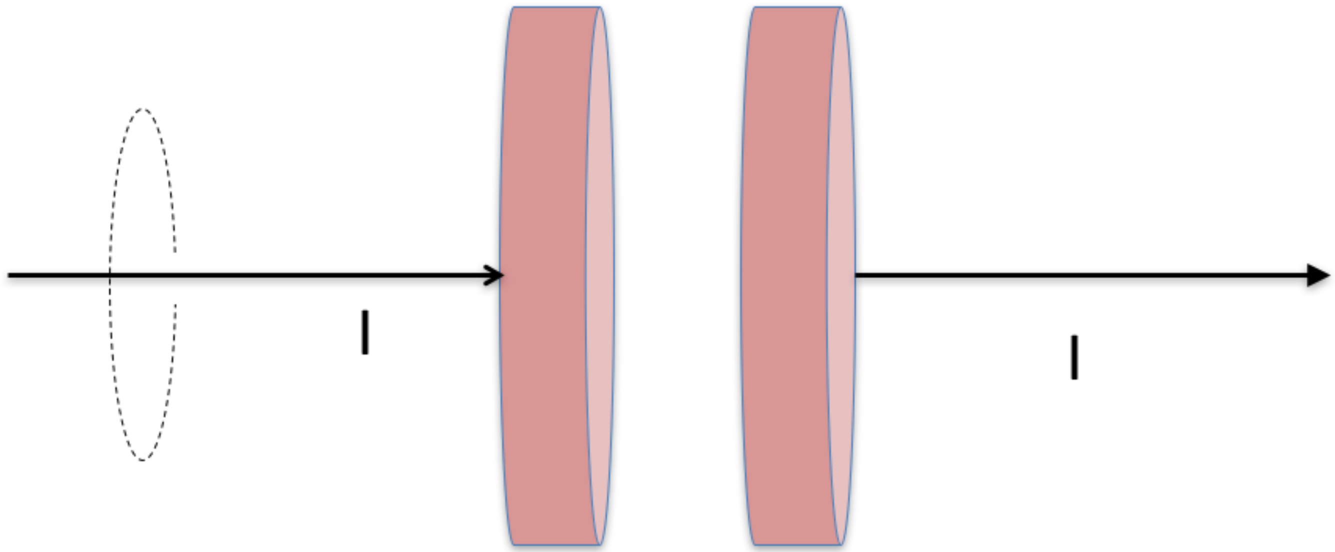
B. iii > i > ii > iv

C. i > ii > iii > iv

D. Something else!!

E. Not enough info given!!

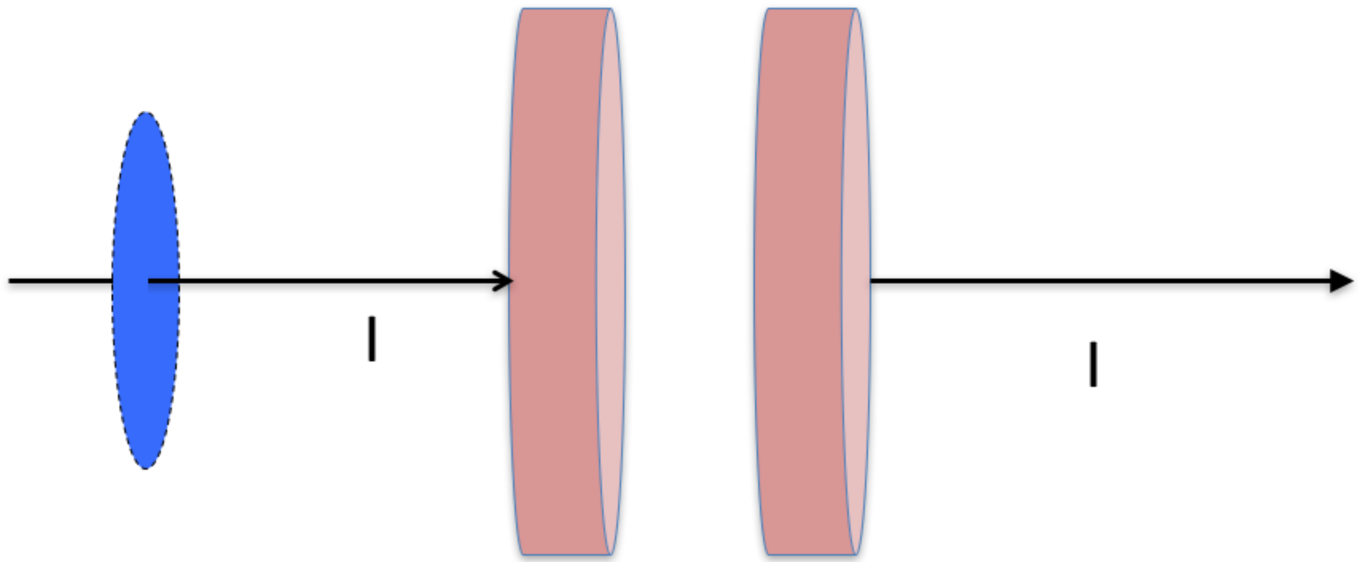
We are interested in $\mathbf{B}$ on the dashed "Amperian loop", and plan to use $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_t$ to figure it out. What is I_t here?



A. I
B. $I/2$
C. 0
D. Something else

We are interested in $\mathbf{B}$ on the dashed "Amperian loop", and plan to use $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_t$ to figure it out. What is I_t here?

The surface over which we integrate $\boldsymbol{J} \cdot d\mathbf{A}$ *is shown in blue.*



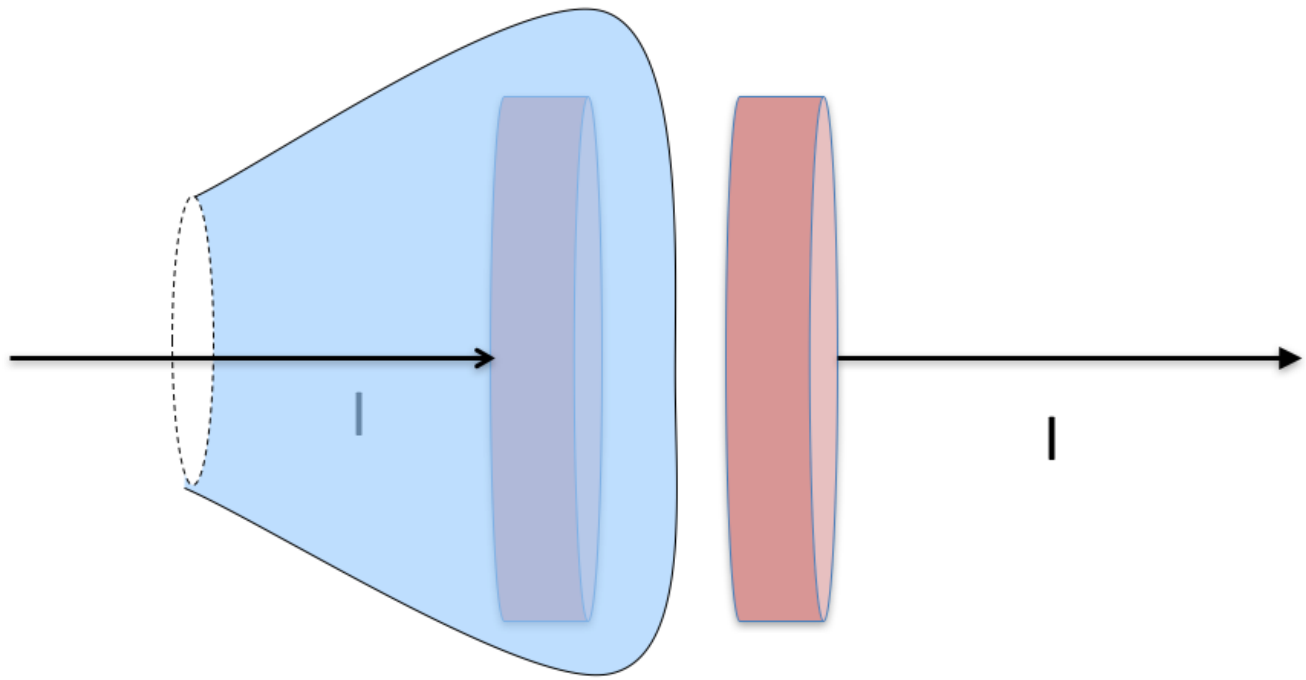
A. I

B. $I/2$

C. 0

D. Something else

We are interested in $\mathbf{B}$ on the dashed "Amperian loop", and plan to use $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_t$ to figure it out. What is I_t here? *The surface over which we integrate* $\boldsymbol{J} \cdot d\mathbf{A}$ *is shown in blue.*



A. I

B. $I/2$

C. 0

D. Something else

The complete differential form of Ampere's Law is now argued to be:

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

The integral form of this equation is:

A. $\iint \mathbf{B} \cdot d\mathbf{A} = \mu_0 I + \mu_0 \epsilon_0 \frac{d}{dt} \oint \mathbf{E} \cdot d\mathbf{l}$

B. $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I + \mu_0 \epsilon_0 \frac{d}{dt} \oint \mathbf{E} \cdot d\mathbf{l}$

C. $\iint \mathbf{B} \cdot d\mathbf{A} = \mu_0 I + \mu_0 \epsilon_0 \frac{d}{dt} \iint \mathbf{E} \cdot d\mathbf{A}$

D. $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I + \mu_0 \epsilon_0 \frac{d}{dt} \iint \mathbf{E} \cdot d\mathbf{A}$

E. Something else/???

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

A. OMGBBQPIZZA, so amazing!

B. It's pretty cool

C. Meh

D. Whatever

CORRECT ANSWER

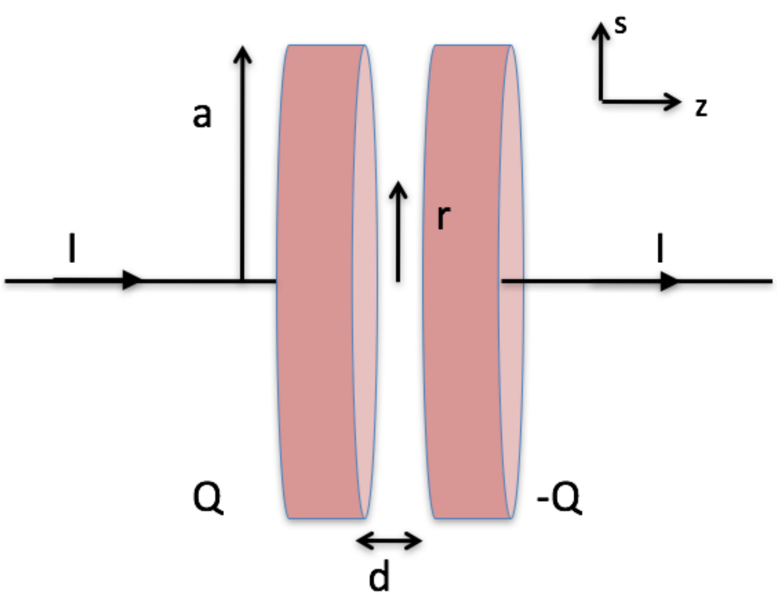
OMGBBQPIZZA, so amazing!

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. $\pm\hat{\phi}$

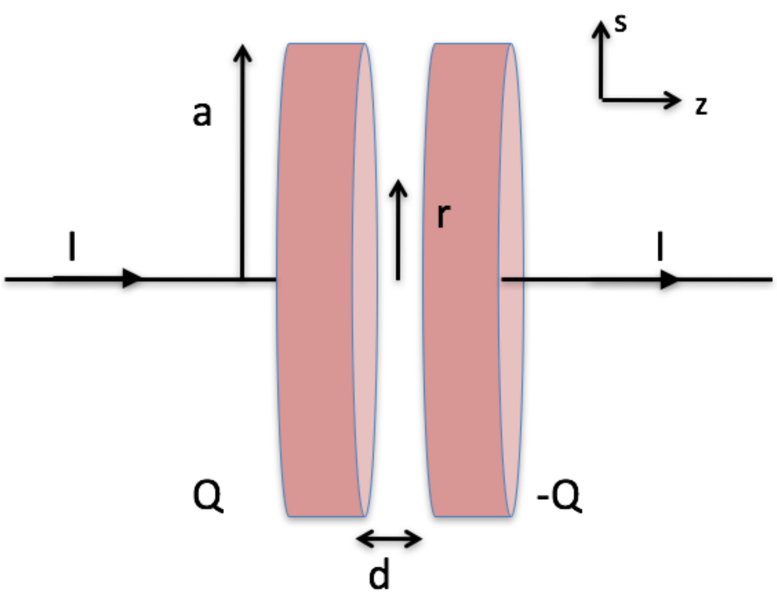
B. 0

C. $\pm\hat{z}$

D. $\pm\hat{s}$

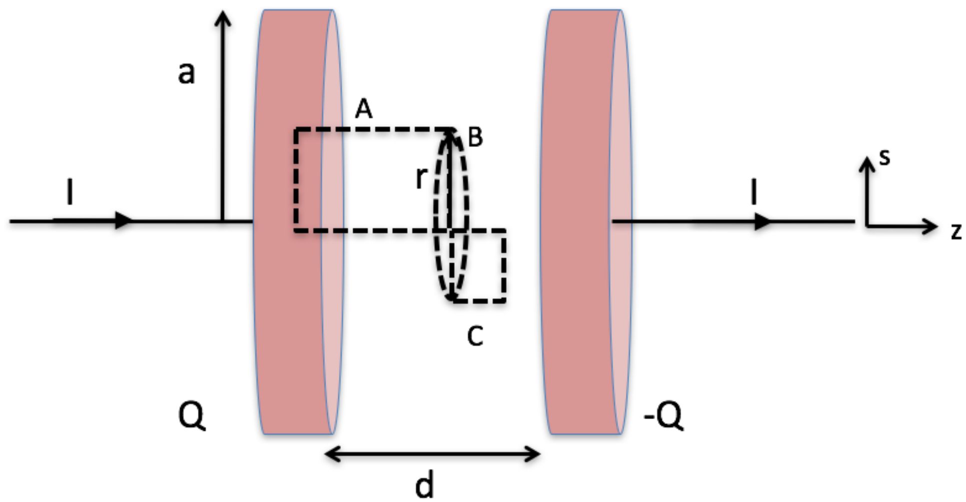
E. ???

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?



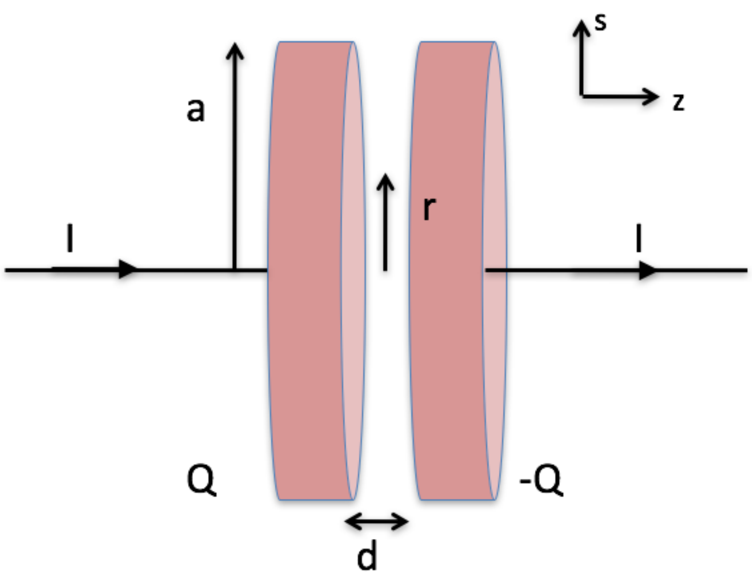
A. $+\hat{\phi}$
B. $-\hat{\phi}$
C. Not sure how to tell

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

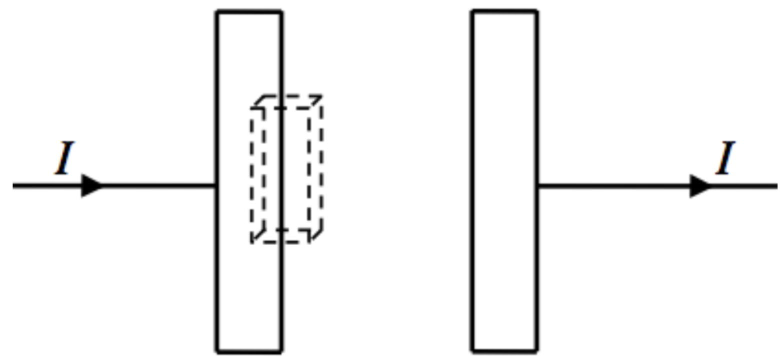
B. $\frac{\mu_0 \beta r}{2d^2}$

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

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

E. None of the above

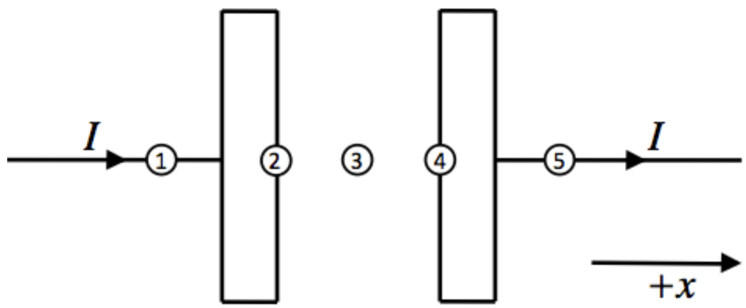
Consider the surface of an imaginary volume (dashed lines, at right) that partly encloses the left capacitor plate. For this closed surface, is the total flux of the current density, $\iint \mathbf{J} \cdot d\mathbf{A}$ positive, negative or zero?



A. Positive

B. Negative

C. Zero

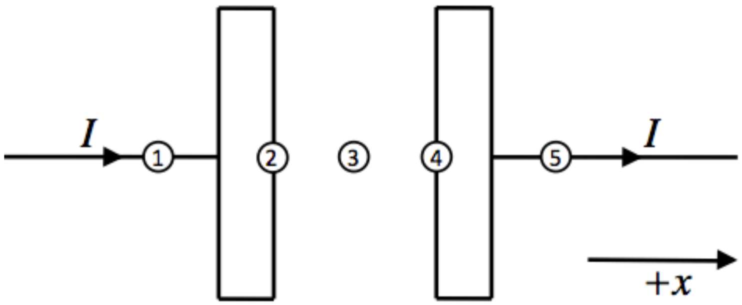


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!

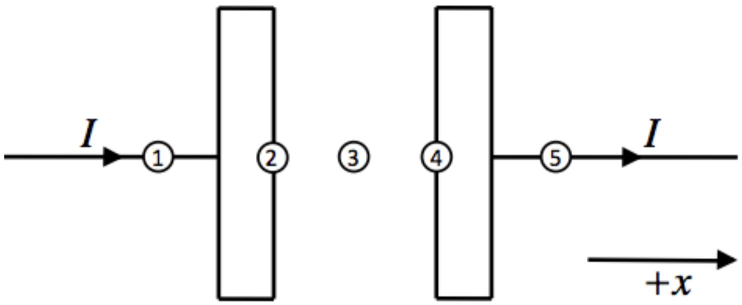


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!

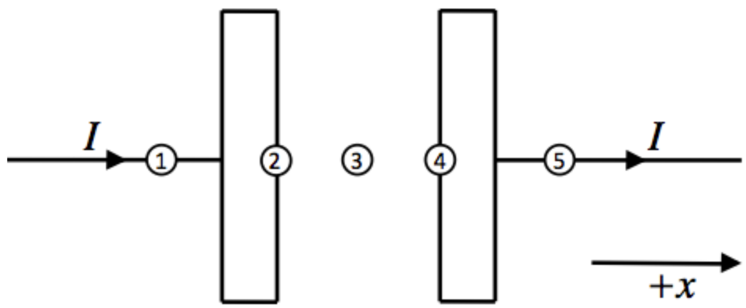


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!

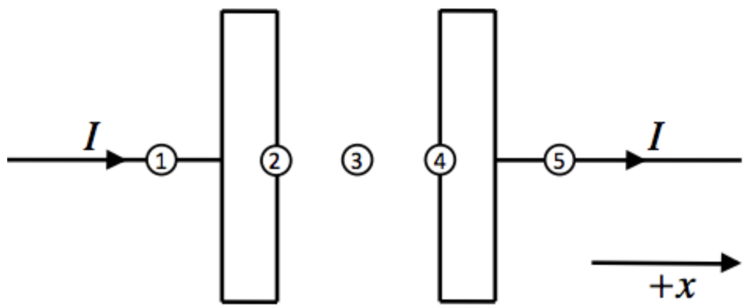


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!

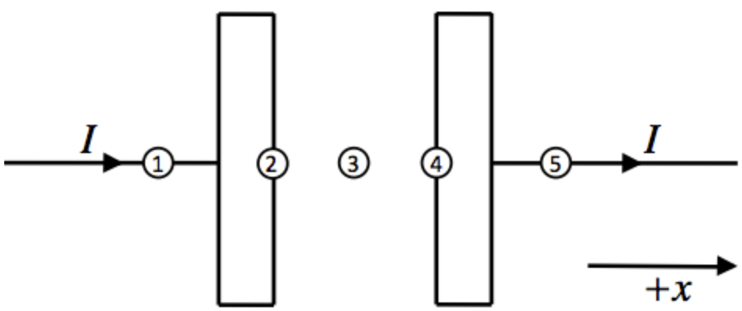


At each location, we will evaluate the sign of $\partial\rho/\partial t$ and $\nabla \cdot \mathbf{J}$.

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!



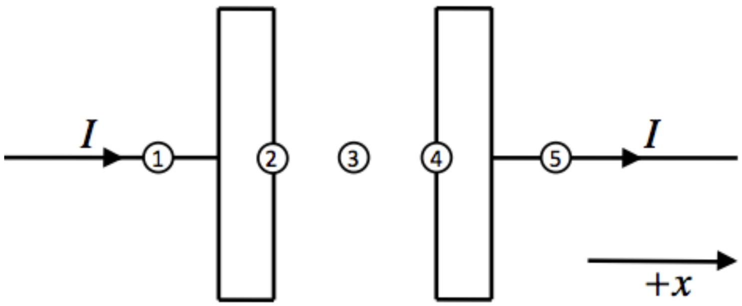
Suppose the original Ampere's law $\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$ were correct without any correction from Maxwell (it’s not, but suppose for a moment that it is). What would this imply about $\nabla \cdot \mathbf{J}$ at points 2 and 4 in the diagram?

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