# Electricity and Magnetism II

## Griffiths Chapter 7 Maxwell's Equations

## Clicker Questions

# In the interior of a metal in static equilibrium the charge density ρ is:

A) zero always
B) never zero.
C) sometimes zero, sometime non-zero, depending on the conditions.

# Which of the following is a correct statement of charge conservation?

A) $$\frac{dQ_{enclosed}}{dt} = -\int \vec{\mathbf{J}} \bullet d\vec{\mathbf{l}}$$

B) $$\frac{dQ_{enclosed}}{dt} = -\iint \vec{\mathbf{J}} \bullet d\vec{\mathbf{A}}$$

C) $$\frac{dQ_{enclosed}}{dt} = -\iiint \nabla \cdot \vec{\mathbf{J}}\, d\tau$$

D) $$\frac{dQ_{enclosed}}{dt} = -\nabla \cdot \vec{\mathbf{J}}$$

E) None of these, or *more* than one.

For everyday currents in home electronics and wires, which answer is the order of magnitude of the instantaneous speed of the electrons in the wire?

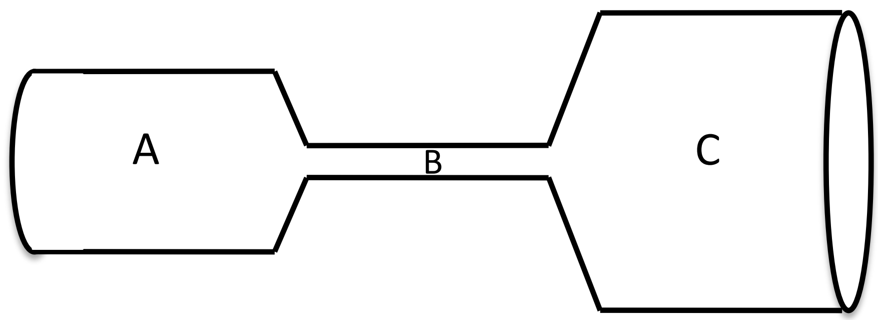
A. more than km/s
B. m/s
C. mm/s
D. μm/s
E. nm/s

An electric current *I* flows along a copper wire (low resistivity) into a resistor made of carbon (high resistivity) then back into another copper wire.

*In which material is the electric field largest?*


A. In the copper wire
B. In the carbon resistor
C. It's the same in both copper and carbon
D. It depends on the sizes of the copper and carbon

A copper cylinder is machined to have the following shape. The ends are connected to a battery so that a current flows through the copper.




Rank order (from greatest to smallest, e.g. A=C>B)

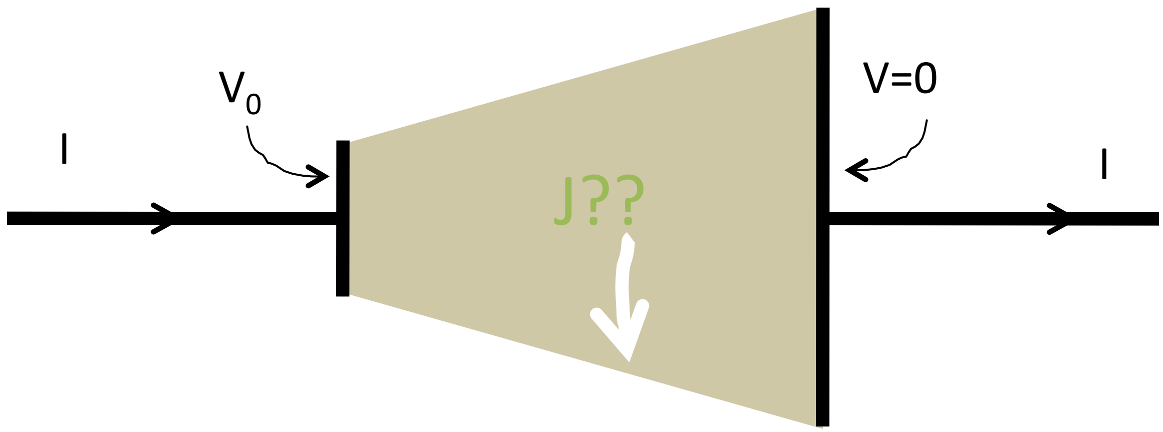
Magnitude of E field

Conductivity

Current

Current Density

Inside this resistor setup, what can you conclude about the current density **J** near the side walls?




A) Must be exactly parallel to the wall

B) Must be exactly perpendicular to the wall

C) Could have a mix of parallel and perp components

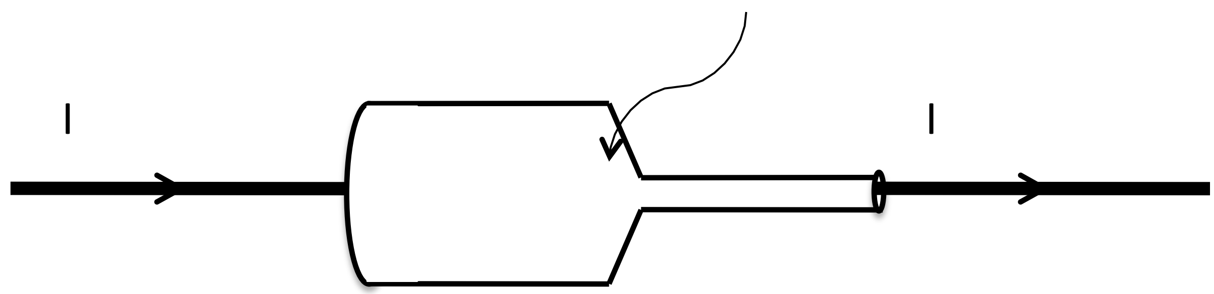
D) No obvious way to decide!?

Inside this resistor setup, (real world, finite sizes!)
what does the E field look like *inside* ?


A) Must be uniform and horizontal

B) Must have *some* nonuniformity, due to fringing effects!

Recall the machined copper from last class, with steady current flowing left to right through it

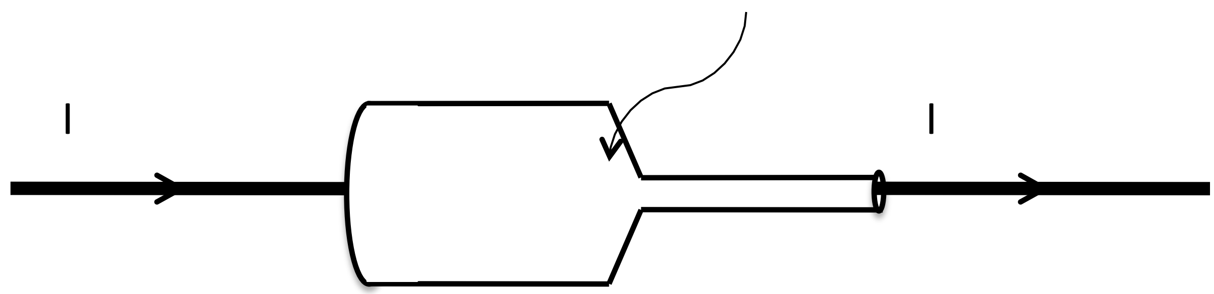



In the "necking down region" (somewhere in a small-ish region around the head of the arrow), do you think

A) $\nabla \cdot \mathbf{E} = 0$

B) $\nabla \cdot \mathbf{E} \neq 0$

Recall the machined copper from last class, with steady current flowing left to right through it




In steady state, do you expect there will be any surface charge accumulated anywhere on the walls of the conductor?

A) Yes

B) No

The resistivity, $\rho$, is the inverse of the conductivity, $\sigma$. The units of $\rho$ are:

A) Amps/volt
B) V/m
C) m/ohm
D) ohm*m
E) Joules/m

A steady electric current $I$ flows around a circuit containing a battery of voltage $V$ and a resistor $R$. Which of the following statements about $\oint \vec{E} \cdot d\vec{l}$ is true?

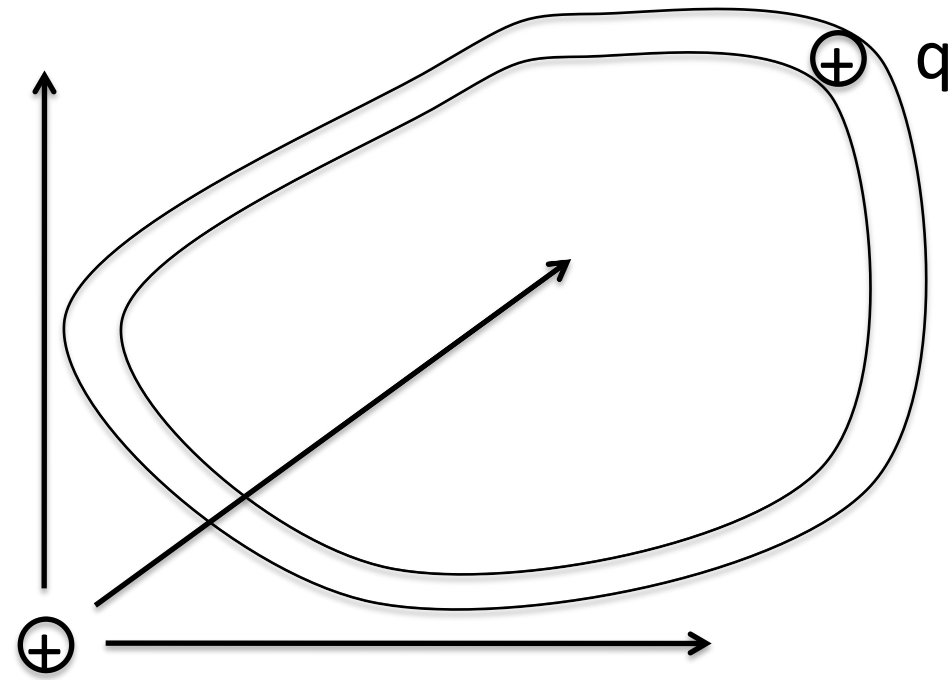
A. It is zero around the circuit because it's an electrostatic field
B. It is non-zero around the circuit because it's not an electrostatic field
C. It is zero around the circuit because there is no electric field in the battery, only in the rest of the circuit
D. It is non-zero around the circuit because there is no electric field in the battery, only in the rest of the circuit!
E. None of the above

$$EMF = \oint \vec{f} \cdot d\vec{l}$$

EMF is the line integral of the total force per unit charge around a closed loop.
The units of EMF are:

A) Farads
B) Joules.
C) Amps, (that’s why current flows.)
D) Newtons, (that’s why it’s called emf)
E) Volts

Imagine a charge q able to move around a tube which makes a closed loop. If we want to drive the charge around the loop, we **cannot** do this with E-field from a single stationary charge.




Can we drive the charge around the loop with some *combination* of stationary + and – charges?

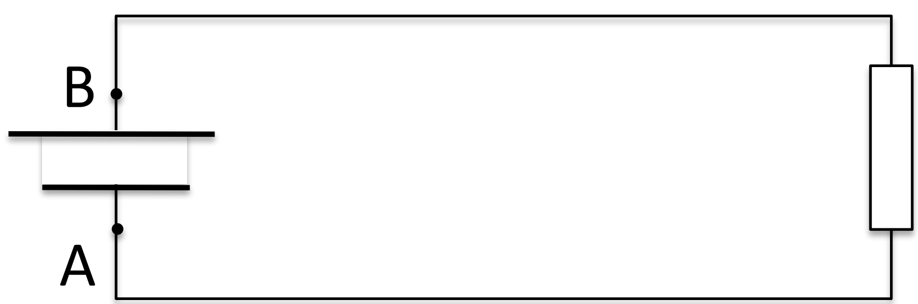
A) Yes
B) No

A circuit with a battery with voltage difference $\Delta V$ is attached to a resistor. The force per charge due to the charges is **E**. The force per charge inside the battery is $\mathbf{f} = \mathbf{f}_{bat} + \mathbf{E}$

How many of the following statements are true?

$$\text{emf} = \oint \vec{f} \cdot d\vec{l} \qquad \text{emf} = \oint \vec{f}_{bat} \cdot d\vec{l}$$

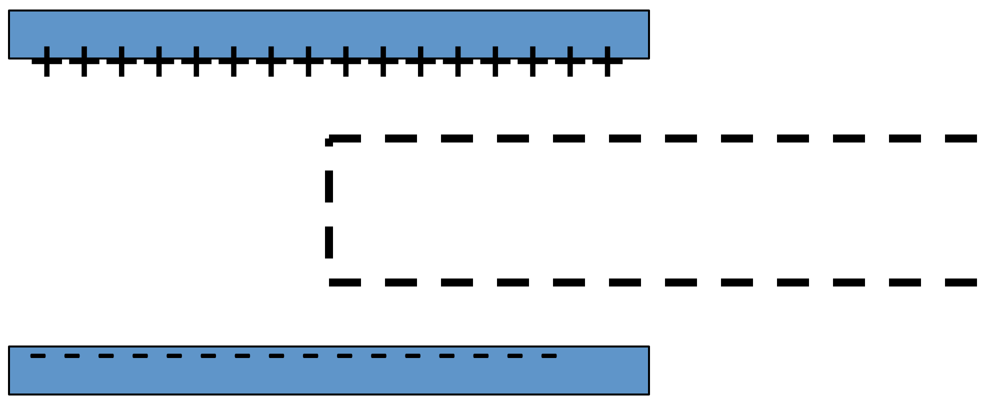
$$\text{emf} = \int_{A\,(\text{inside bat})}^{B} \vec{f}_{bat} \cdot d\vec{l} \qquad \text{emf} = \int_{B}^{A} \vec{E} \cdot d\vec{l}$$




A) 0
B) 1
C) 2
D) 3
E) 4

$$EMF = \oint \vec{f} \cdot d\vec{l}$$

Is there a nonzero EMF around the (dashed) closed loop, which is partway inserted between two charged isolated capacitor plates.

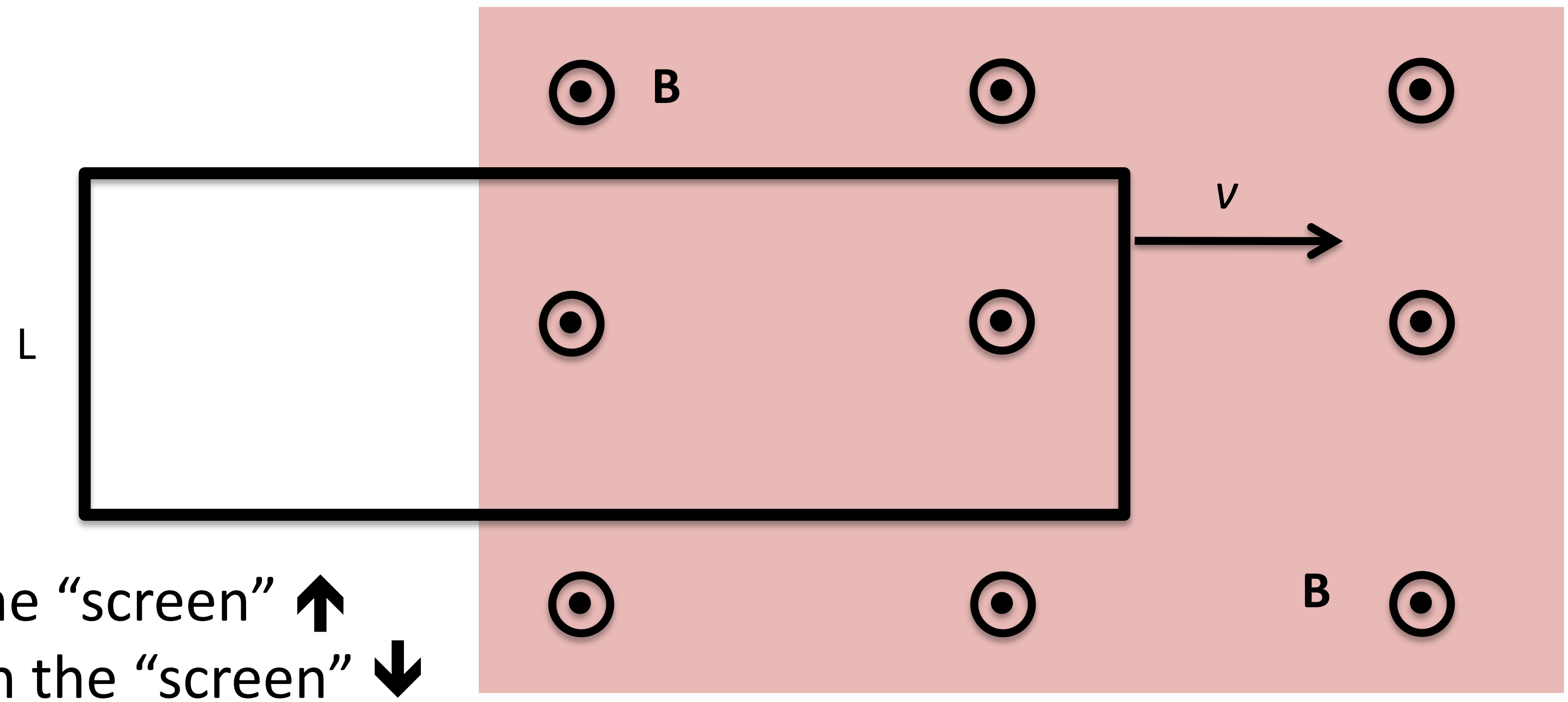


A) EMF=0 here

B) EMF≠0 here

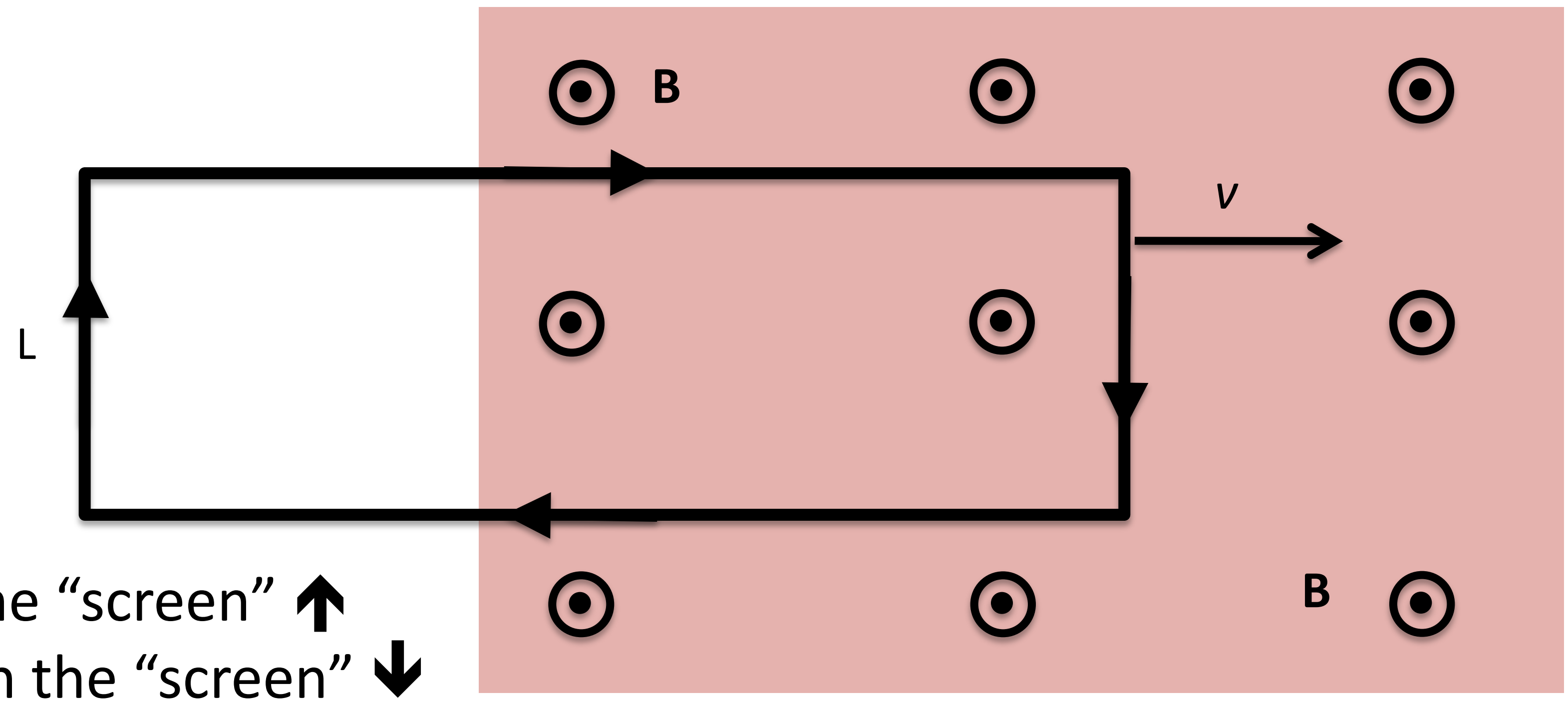
C) ? I would need to do a nontrivial calculation to decide

One end of rectangular metal loop enters a region of constant uniform magnetic field **B**, with initial constant speed *v*, as shown. What direction is the *magnetic* force on the loop?




A. Up the "screen" ↑
B. Down the "screen" ↓
C. To the right →
D. To the left ←
E. The net force is zero

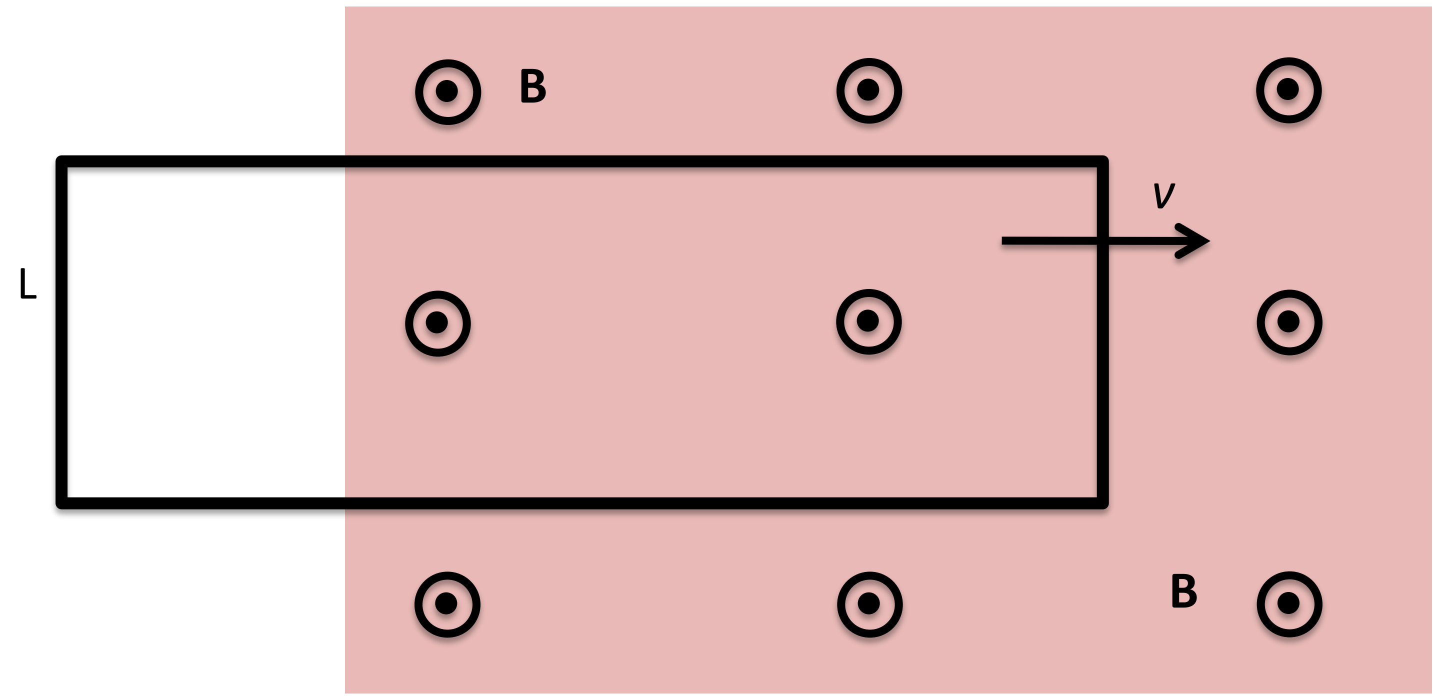
One end of rectangular metal loop enters a region of constant uniform magnetic field **B,** with initial constant speed *v,* as shown. What direction is the *magnetic* force on the loop?




A. Up the "screen" ↑
B. Down the "screen" ↓
C. To the right →
D. To the left ←
E. The net force is zero

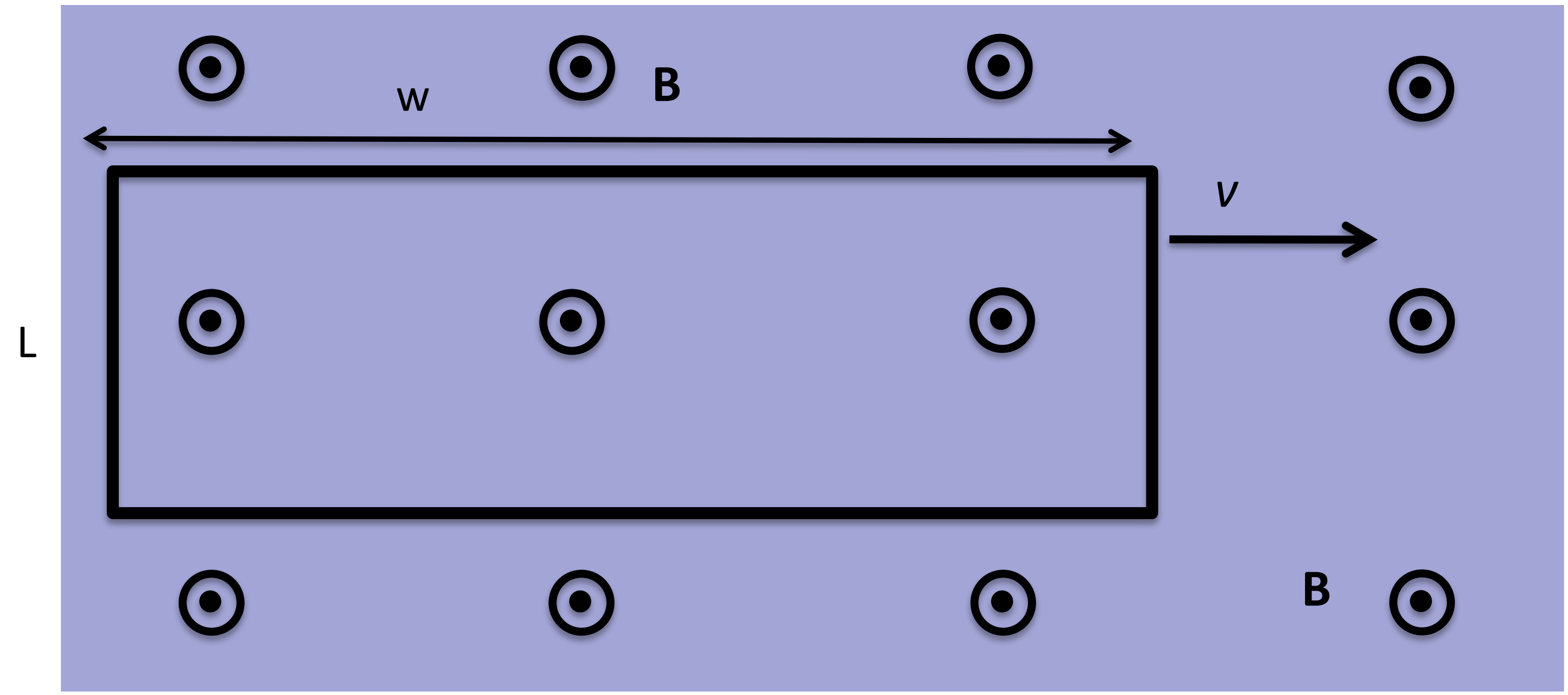
7.19

One end of rectangular metal loop enters a region of constant uniform magnetic field **B**, out of page**,** with constant speed *v,* as shown. As the loop enters the field is there a non-zero emf around the loop?




A. Yes, current will flow CW
B. Yes, current will flow CCW
C. No

A rectangular metal loop moves through a region of constant uniform magnetic field **B,** with speed *v* at *t* = *0,* as shown. What is the magnetic force on the loop at the instant shown? Assume the loop has resistance R.




A. $2L^2 vB^2/R$ (right) B) $2L^2 vB^2/R$ (left) C) 0
B. D. Something else/not sure...

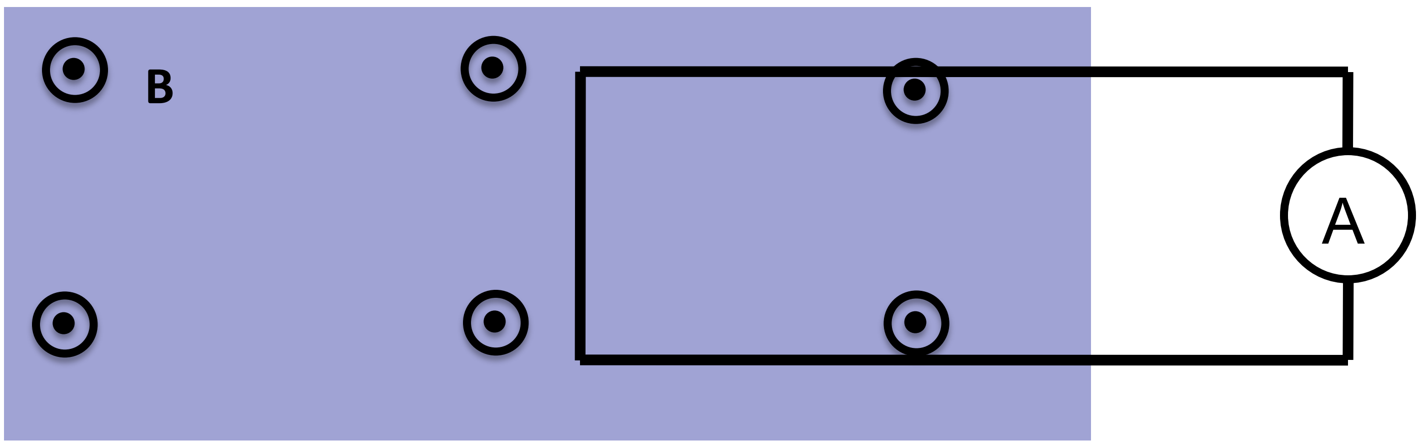
Consider two situations:

1) Loop moves to right with speed |v|

2) Magnet moves to left with (same) speed |v|

What will the ammeter read in each case?

(Assume that CCW current => positive ammeter reading)




A) $I_1 > 0, I_2 = 0$  B) $I_1 = I_2 > 0$  C) $I_1 = -I_2 > 0$

D) $I_1 = I_2 = 0$  E) Something different/not sure

7.22

Faraday found that EMF is proportional to the negative time rate of change of B. EMF is also the line integral of a force/charge. The force is

$$\text{EMF} = \oint \vec{f}_q \cdot d\vec{l}$$

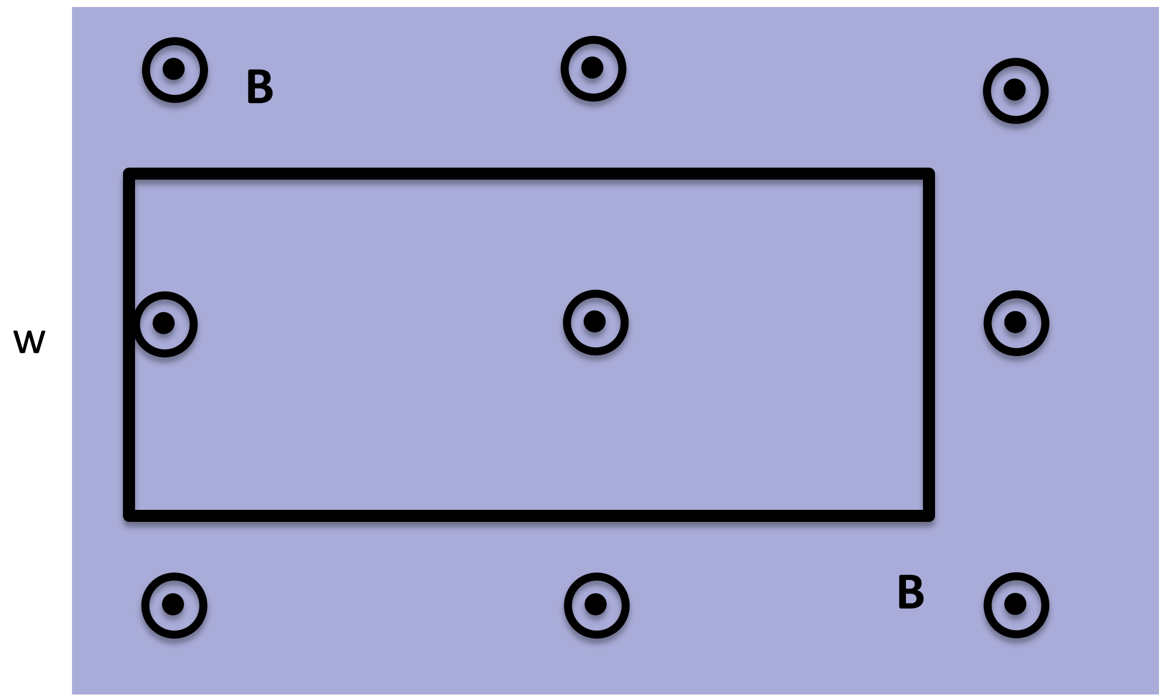
A) The magnetic Lorentz force.
B) an electric force.
C) the strong nuclear force.
D) the gravitational force.
E) an entirely new force.

A time changing B creates an electric field via Faraday's Law:

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_{mag}}{dt} \qquad \nabla \times \vec{E} = -\frac{\partial \vec{B}}{dt}$$

A) Now I have no idea how to find E.
B) This law suggests a familiar way to find E in all situations.
C) This law suggests a familiar way to find E in sufficiently symmetrical situations.
D) I see a path to finding E, but it bears no relation to anything we have previously seen.

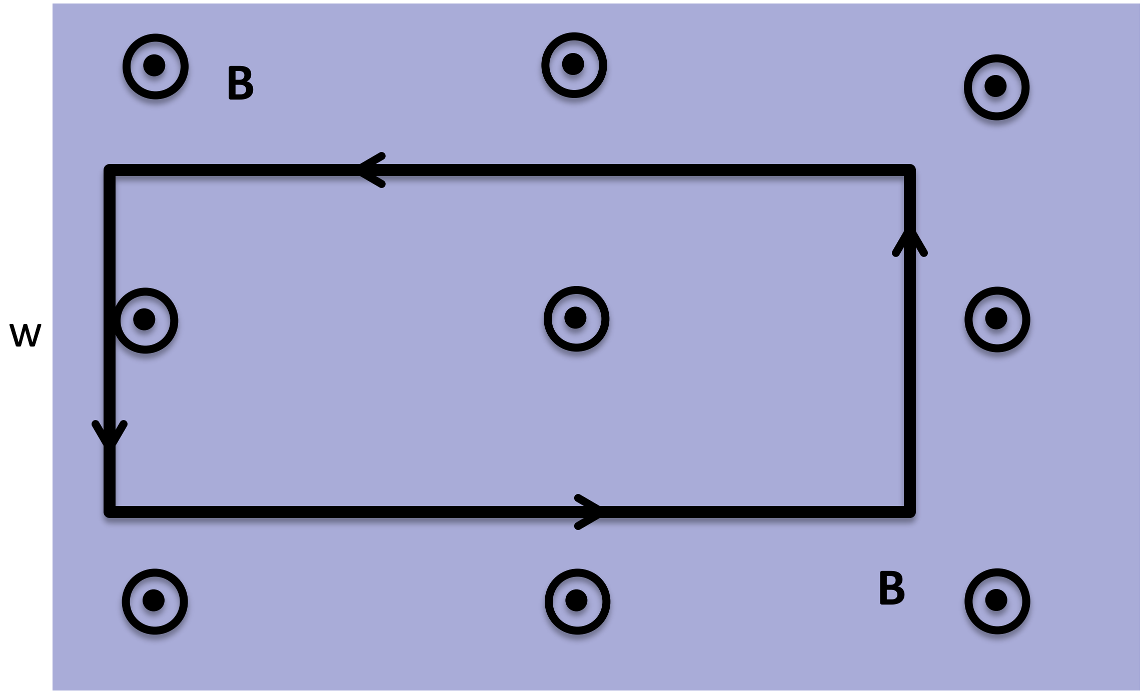
A stationary rectangular metal loop is in a region of uniform magnetic field **B**, which has magnitude B *decreasing* with time as $B=B_0-kt$. What is the direction of the field $\mathbf{B}_{ind}$ created by the induced current in the loop, in the plane region inside the loop?




A) Into the screen B) Out of the screen

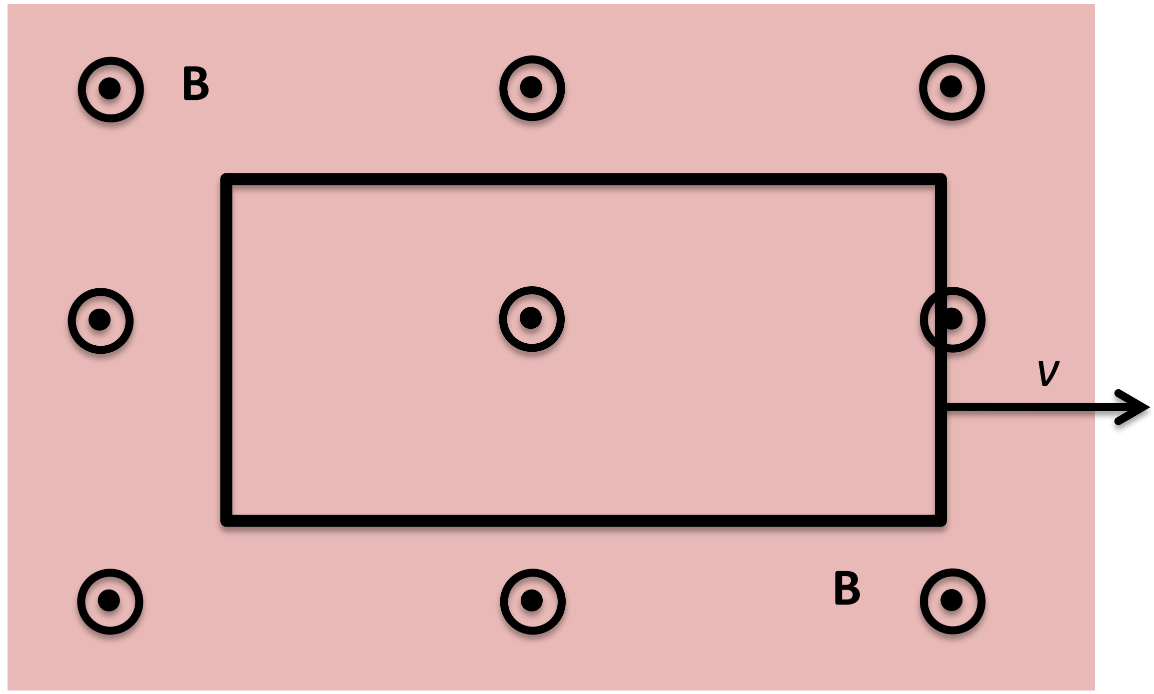
C) To the left D) To the right E) other/??

A stationary rectangular metal loop is in a region of uniform magnetic field **B**, which has magnitude B *decreasing* with time as $B=B_0-kt$. What is the direction of the field $\mathbf{B_{ind}}$ created by the induced current in the loop, in the plane region inside the loop?




A) Into the screen  B) Out of the screen
C) To the left  D) To the right  E) other/??

A rectangular metal loop is moving thru a region of constant uniform magnetic field **B,** out of page, with constant speed *v,* as shown. Is there a non-zero emf around the loop?

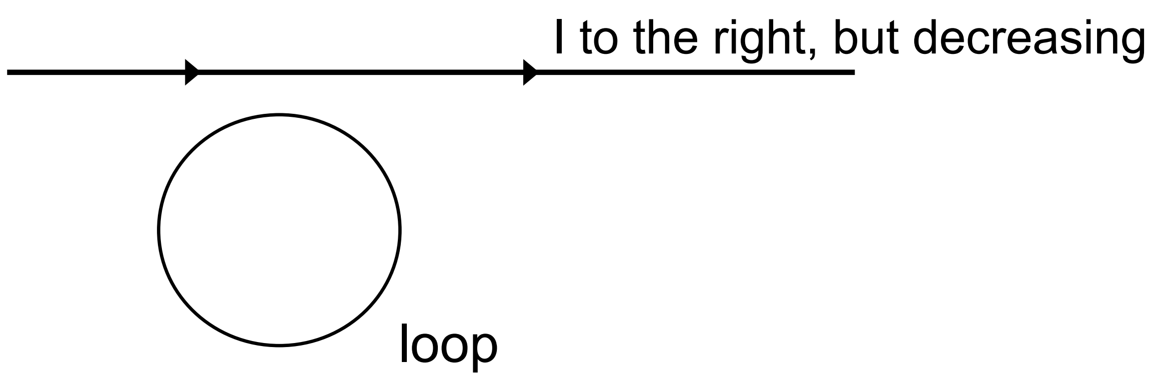



A. Yes, current will flow CW
B. Yes, current will flow CCW
C. No

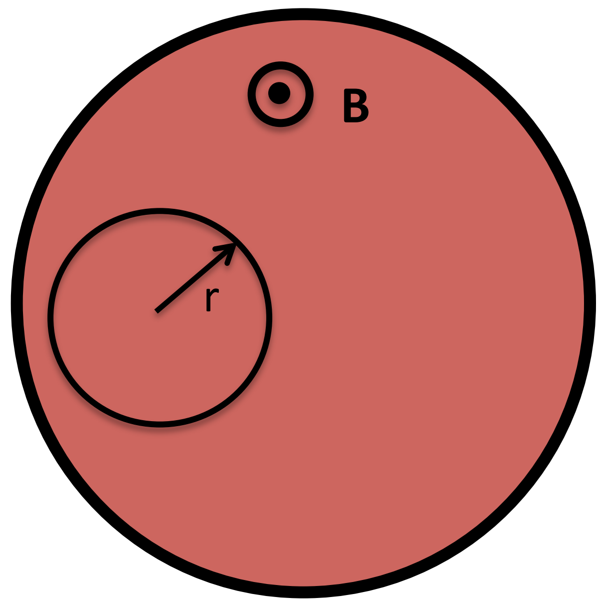
On a piece of paper, please write down your name, Stokes' theorem, and the Divergence Theorem…

A loop of wire is near a long straight wire which is carrying a large current I, which is ***decreasing***. The loop and the straight wire are in the same plane and are positioned as shown. The current induced in the loop is

A) counter-clockwise B) clockwise C) zero.

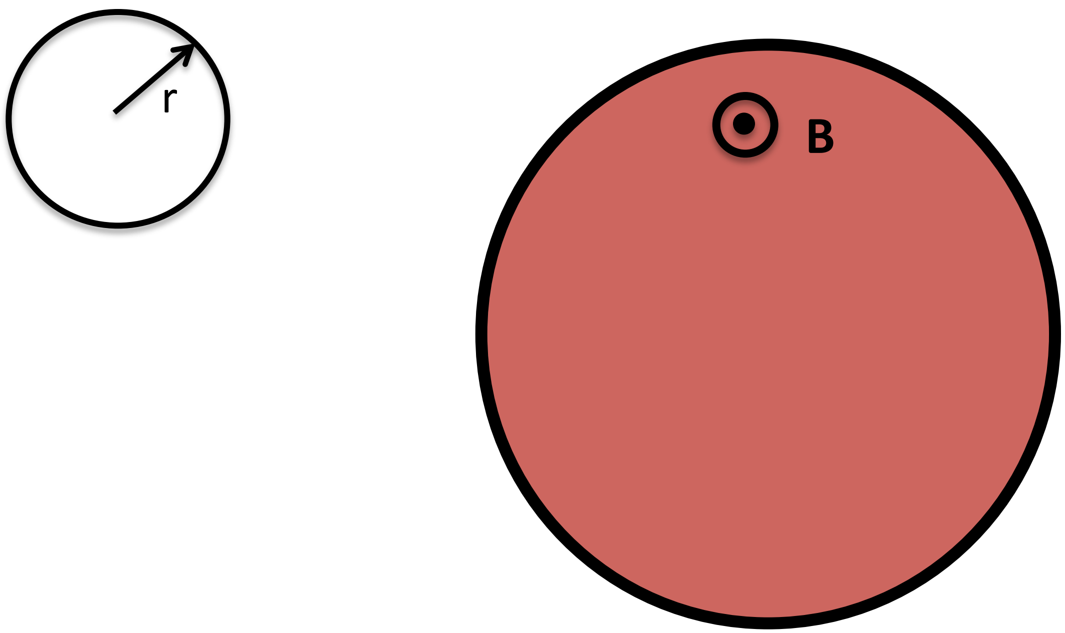


The current in an infinite solenoid with uniform magnetic field **B** inside is increasing so that the magnitude B in increasing with time as $B=B_0+kt$. A small circular loop of radius r is placed NON-coaxially inside the solenoid as shown. What is the emf around the small loop?
(Assume CW is the direction of d**l** in the EMF loop integration)




A. $k\pi r^2$
B. $-k\pi r^2$
C. Zero
D. Nonzero, but need more information for value
E. Not enough information to tell if zero or non-zero

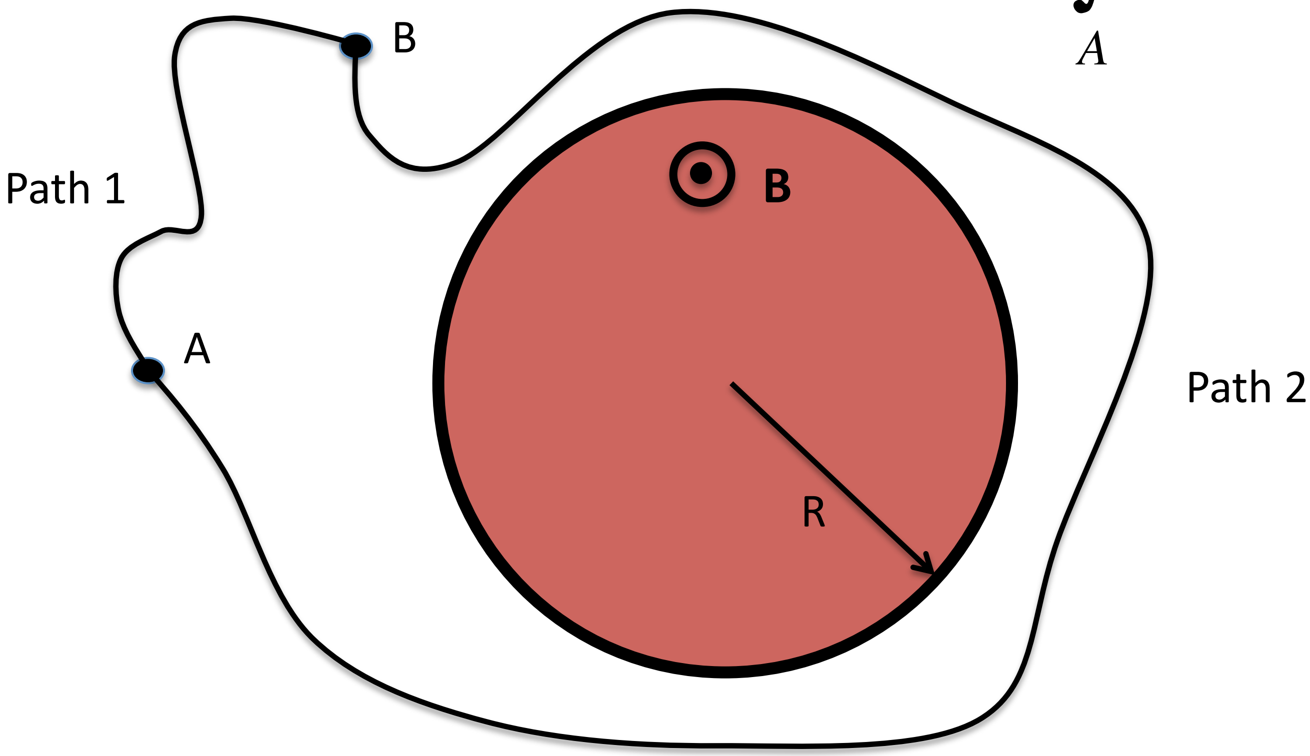
The current in an infinite solenoid with uniform magnetic field **B** inside is increasing so that the magnitude B in increasing with time as $B=B_0+kt$. A small circular loop of radius r is placed outside the solenoid as shown. What is the emf around the small loop? (Assume CW is the positive direction of current flow).




A. $k\pi r^2$
B. $-k\pi r^2$
C. Zero
D. Nonzero, but need more information for value
E. Not enough information to tell if zero or non-zero

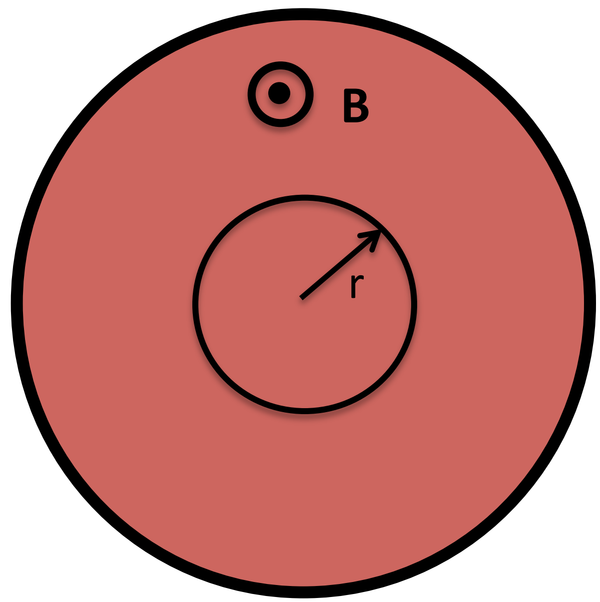
The current in an infinite solenoid of radius R with uniform magnetic field **B** inside is increasing so that the magnitude B in increasing with time as $B=B_0+kt$. If I calculate V along path 1 and path 2 between points A and B, do I get the same answer?

$$V = -\int_A^B E \cdot dl$$




A. Yes
B. No
C. Need more information

The current in an infinite solenoid with uniform magnetic field **B** inside is increasing so that the magnitude B in increasing with time as $B=B_0+kt$. A small circular loop of radius r is placed coaxially inside the solenoid as shown. Without calculating anything, determine the direction of the field $\mathbf{B_{ind}}$ created by the induced current in the loop, in the plane region inside the loop?



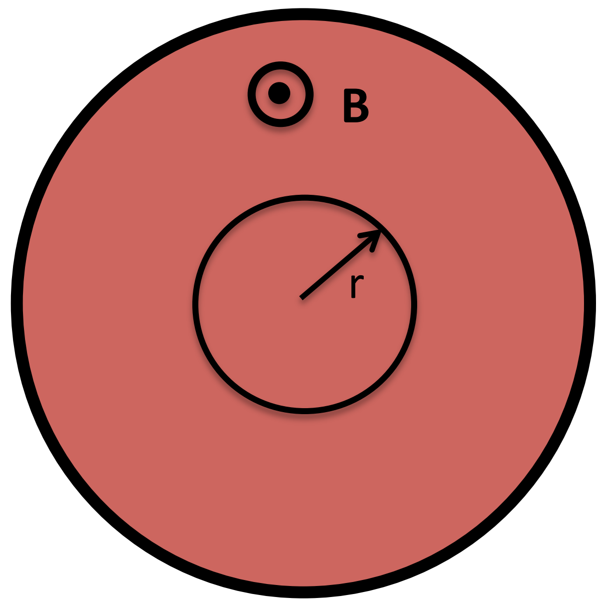

A. Into the screen
B. Out of the screen
C. CW
D. CCW
E. Not enough information

Faraday found that EMF is proportional to the negative time rate of change of B. To make an equality, the proportionality factor has units of:

$$EMF = \alpha\left(\frac{-dB}{dt}\right)$$

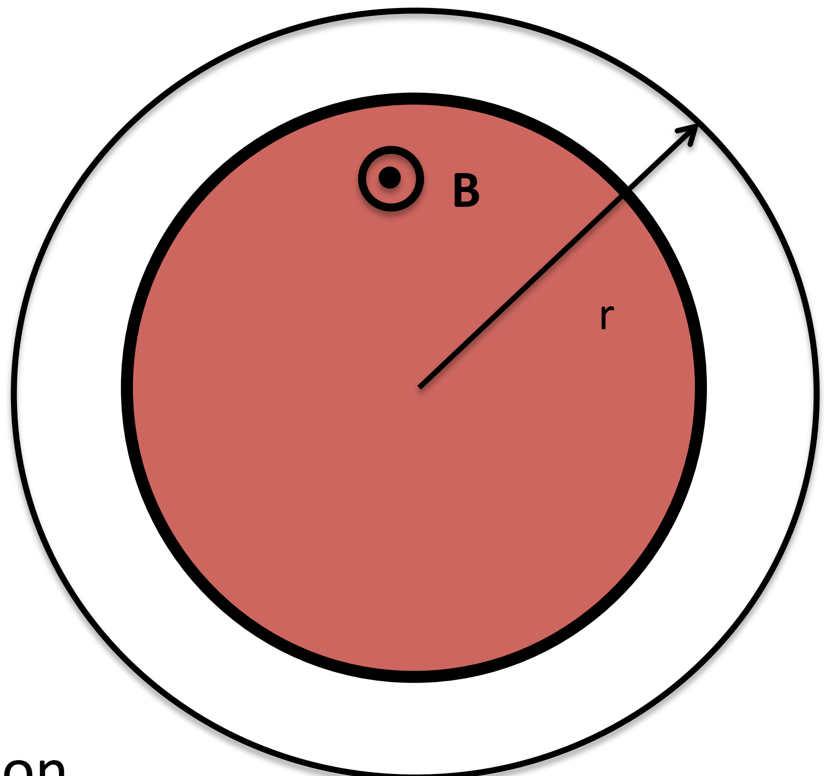
A) meters
B) m/sec
C) sec/m$^2$
D) m$^2$
E) Volts

The current in an infinite solenoid with uniform magnetic field **B** inside is increasing so that the magnitude B in increasing with time as $B=B_0+kt$. A small circular loop of radius r is placed coaxially inside the solenoid as shown. What is the emf around the small loop? (Assume CW is the positive direction of around the loop).




A. $k\pi r^2$
B. $-k\pi r^2$
C. Zero
D. Nonzero, but need more information for value
E. Not enough information to tell if zero or non-zero

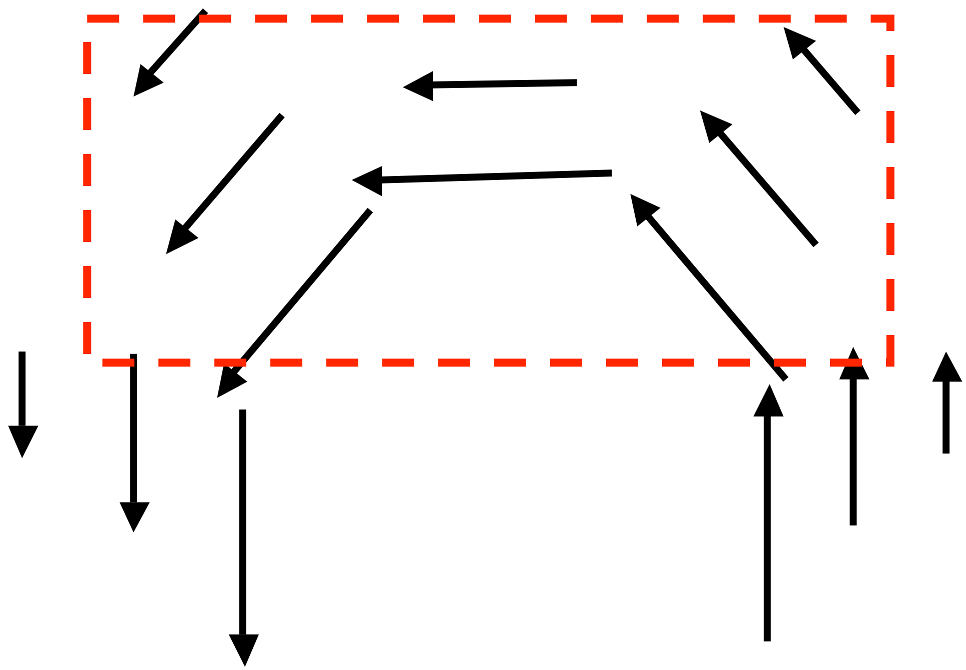
The current in an infinite solenoid with uniform magnetic field **B** inside is increasing so that the magnitude B is increasing with time as $B=B_0+kt$. A circular loop of radius r is placed coaxially outside the solenoid as shown. In what direction is the induced **E** field around the loop?




A. CW
B. CCW
C. The induced E is zero
D. Not enough information

If the arrows represent an E field, is the **rate of change in magnetic flux** (perpendicular to the page) through the dashed region zero or nonzero?

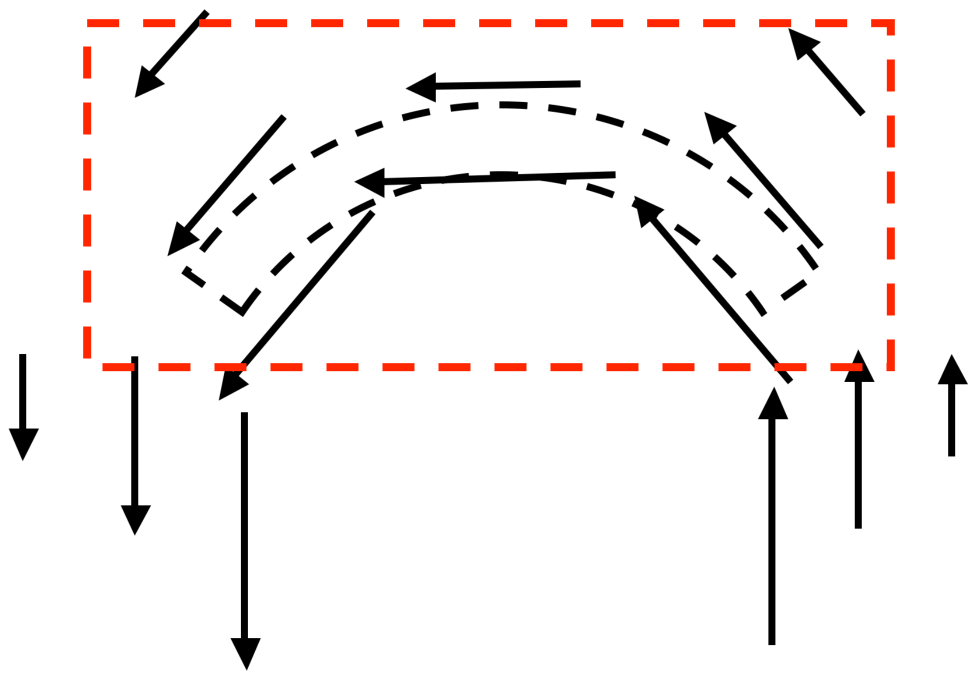
$$\vec{\mathbf{E}}(s,\varphi,z) = \frac{c}{s}\,\hat{\varphi}$$



A. $d\Phi/dt=0$ B) $d\Phi/dt \neq 0$ C) ???

If the arrows represent an E field, is the **rate of change in magnetic flux** (perpendicular to the page) through the dashed region zero or nonzero?

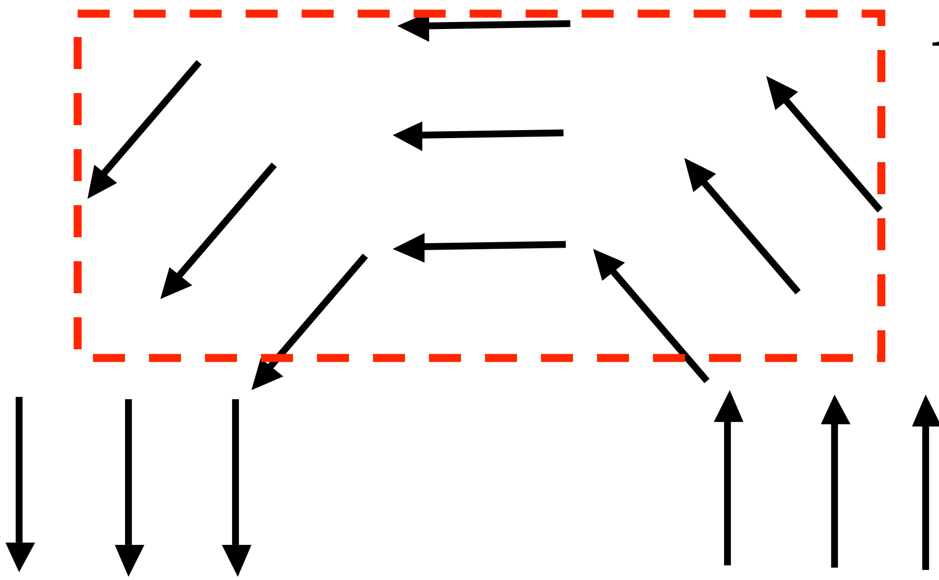
$$\vec{\mathbf{E}}(s,\varphi,z) = \frac{c}{s}\,\hat{\varphi}$$



A. $d\Phi/dt=0$ B) $d\Phi/dt \neq 0$ C) ???

If the arrows represent an E field (note that |E| is the same everywhere), is the **rate of change in magnetic flux** (perpendicular to the page) in the dashed region zero or nonzero?

$$\vec{\mathbf{E}} = E_0\,\hat{\varphi}$$



A) $d\Phi/dt = 0$ B) $d\Phi/dt$ is non-zero

C) Need more info...

Regarding Faraday's Law and the idea that a time-changing magnetic field creates an electric field:

A) Yeah, I'm feeling pretty good about it. I remember all that Lenz stuff.
B) Pretty new to me. Only have some vague memory of Lenz and Faraday.
C) What's Lenz's Law? Completely new.
D) Other.

A long solenoid of cross sectional area, $A$, creates a magnetic field, $B_0$(t) that is spatially uniform inside and zero outside the solenoid.


$$\oint \vec{E} \bullet d\vec{l} = -\frac{d\Phi_B}{dt}$$

$$\oint \vec{B} \bullet d\vec{l} = \mu_0 I_{through}$$

A) Yes, yes. I already get it.
B) Ah! Now I'm pretty sure I can find E.
C) Still not certain how to proceed.

A long solenoid of cross sectional area, $A$, creates a magnetic field, $B_0$(t) that is spatially uniform inside and zero outside the solenoid. SO:


$$\oint \vec{E} \bullet d\vec{l} = -\frac{d\Phi_B}{dt}$$

A) $E = \dfrac{\mu_0 I_{solenoid}}{2\pi r}$

B) $E = -A 2\pi r \dfrac{\partial B}{\partial t}$

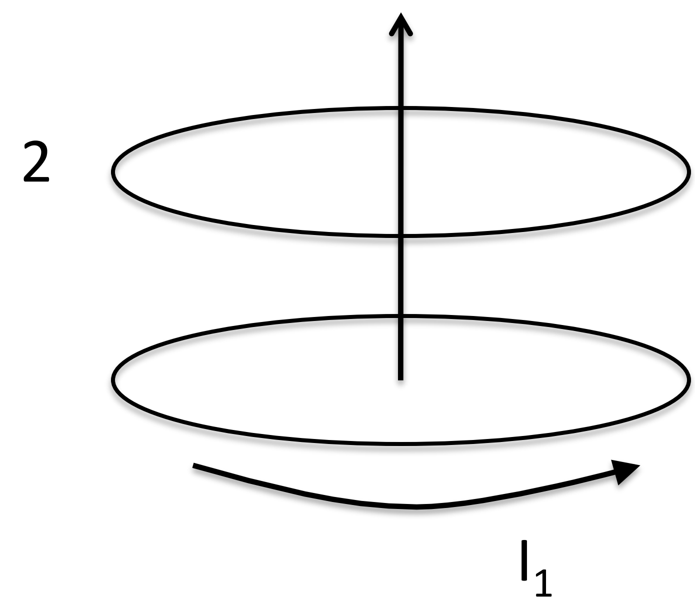
C) $E = -A \dfrac{\partial B}{\partial t} \dfrac{1}{\pi r^2}$

D) $E = -A \dfrac{\partial B}{\partial t} \dfrac{1}{2\pi r}$

A current, $I_1$, in Coil 1, creates a total magnetic flux, $\Phi_2$, threading Coil 2.
If instead, you put the same current around Coil 2, then the resulting flux threading Coil 1 is:

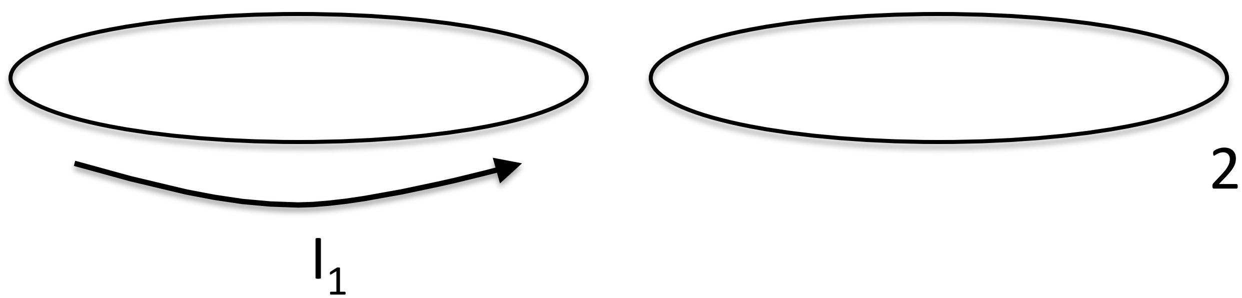
A) Something that you need to calculate for the particular geometry.
B) Is equal to the flux through Coil 2 if the geometry is symmetrical.
C) Is always equal to the flux that $I_1$ caused in Coil 2.
D) Causes no net flux in Coil 1.

The current $I_1$ in loop 1 is increasing. What is the direction of the induced current in loop 2, which is co-axial with loop 1?



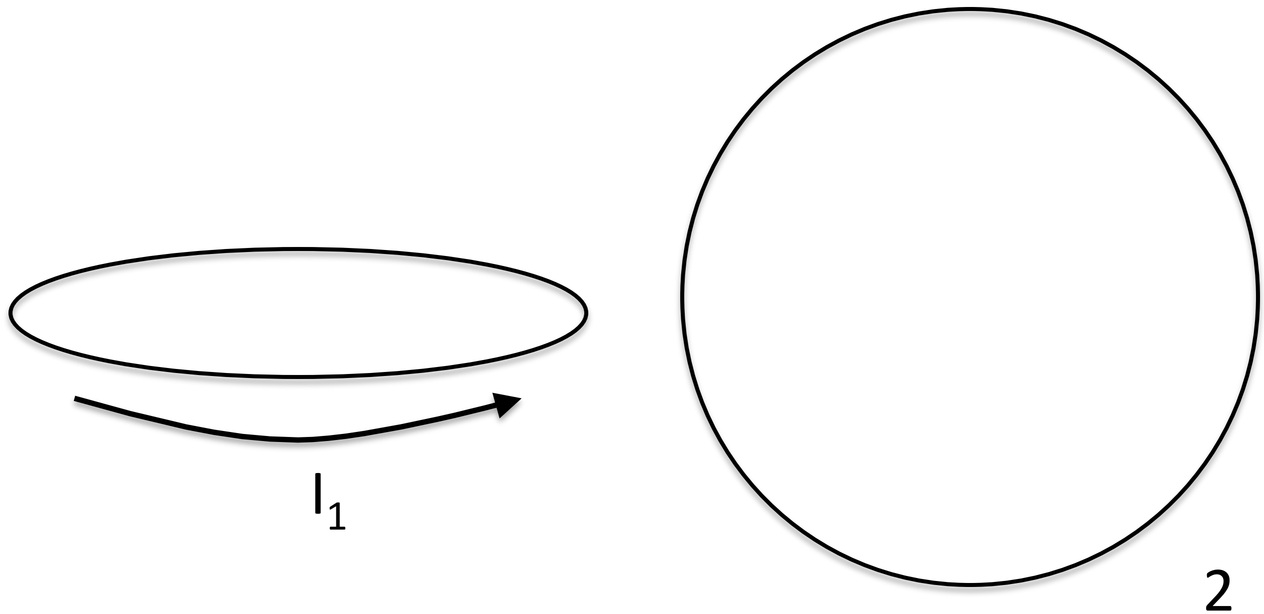

A. The same direction as $I_1$
B. The opposite direction as $I_1$
C. There is no induced current
D. Need more information

The current $I_1$ in loop 1 is increasing. What is the direction of the induced current in loop 2, which lies in the same plane as loop 1?



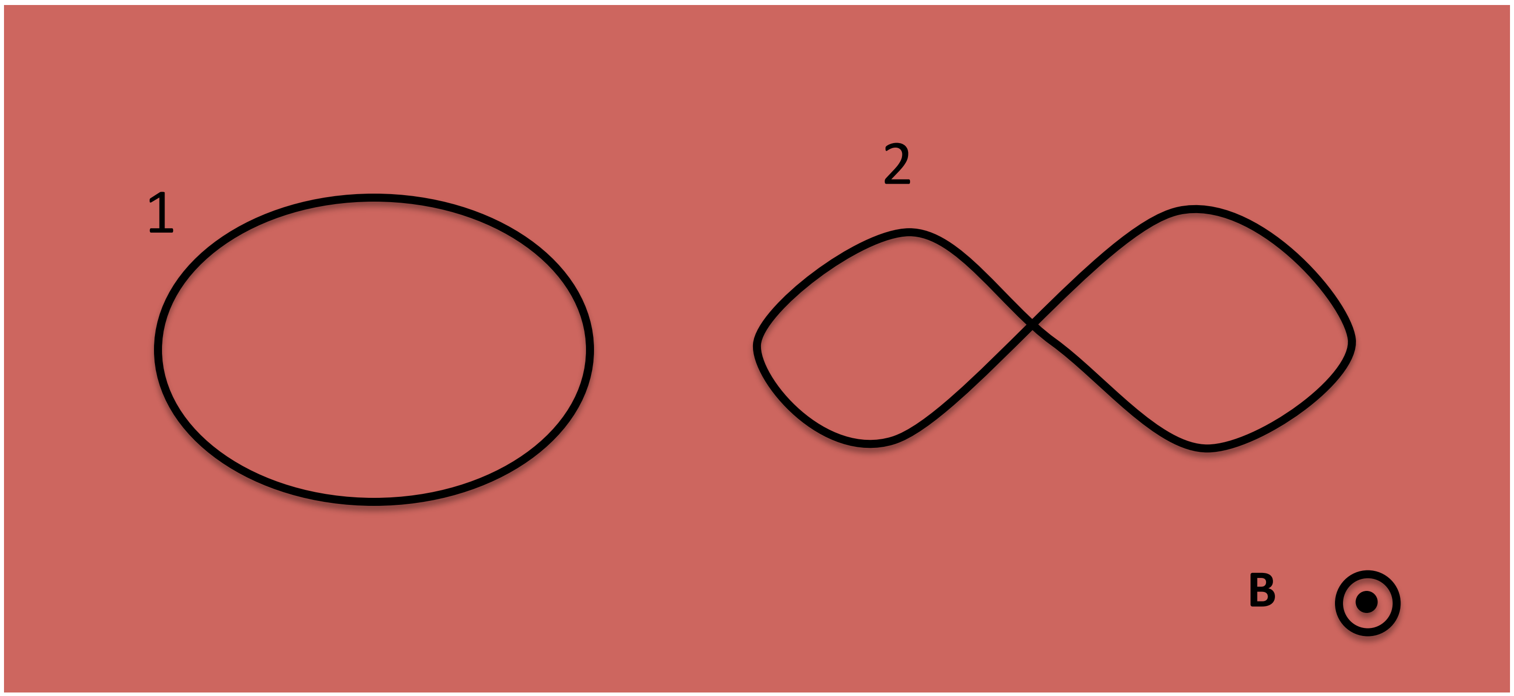

A. The same direction as $I_1$
B. The opposite direction as $I_1$
C. There is no induced current
D. Need more information

The current $I_1$ in loop 1 is decreasing. What is the direction of the induced current in loop 2, which lies in a plane perpendicular to loop 1 and contains the center of loop 1?




A. CW
B. CCW
C. There is no induced current
D. Need more information

Two flat loops of equal area sit in a uniform field **B** which is increasing in magnitude. In which loop is the induced current the largest? (The two wires are insulated from each other at the crossover point in loop 2.)

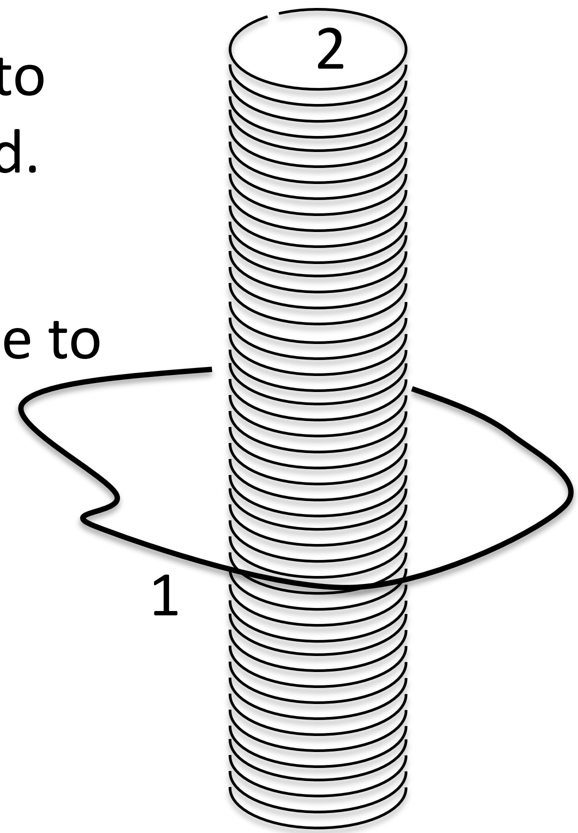



A. 1
B. 2
C. They are both the same.
D. Not enough information given.

A loop of wire 1 is around a very long solenoid 2.

$$\Phi_1 = M_{12} I_2$$ = the flux thru loop 1 due to the current in the solenoid.

$$\Phi_2 = M_{21} I_1$$ = the flux thru solenoid due to the current in the loop 1




Which is easier to compute?

A) $M_{12}$ B) $M_{21}$

C) equally difficult to compute

A current, $I_1$, in Coil 1, creates a total magnetic flux, $F_2$, threading Coil 2: $\Phi_2 = M_{21} I_1$

If instead, you put the same current around Coil 2, then the resulting flux threading Coil 1 is:

A) Something that you need to calculate for the particular geometry.

B) Is equal to the flux through Coil 2 only if the geometry is symmetrical.

C) Is always equal to the flux that $I_1$ caused in Coil 2.

D) Is nearly certain to differ from flux that was in Coil 2.

A long solenoid of cross sectional area, $A$, length, $l$, and number of turns, $N$, carrying current, $I$, creates a magnetic field, $B$, that is spatially uniform inside and zero outside the solenoid. It is given by:


$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{thru}$$

A) $B = \mu_0 \dfrac{N^2}{l}$

B) $B = \mu_0 \dfrac{N^2}{l} I$

C) $B = \mu_0 \dfrac{N}{l} I$

D) $B = \mu_0 \dfrac{N}{l} AI$

A long solenoid of cross sectional area, *A*, length, *l*, and number of turns, *N*, carrying current, *I*, creates a magnetic field, *B*, that is spatially uniform inside and zero outside the solenoid. The self inductance is:

$$B = \mu_0 \frac{N}{l} I$$

A) $L = \mu_0 \frac{N^2}{lA}$

B) $L = \mu_0 \frac{N}{l} A$

C) $L = \mu_0 \frac{N^2}{l^2} A$

D) $L = \mu_0 \frac{N^2}{l} A$

Consider a cubic meter box of uniform magnetic field of 1 Tesla and a cubic meter box of uniform electric field of 1 Volt/meter. Which box contains the most energy?

A. The box of magnetic field
B. The box of electric field
C. They are both the same
D. Not enough information given

Two long solenoids, A and B, with same current I, same turns per length n. Solenoid A has twice the diameter of solenoid B.

Energy = U, energy density = u = U/V.

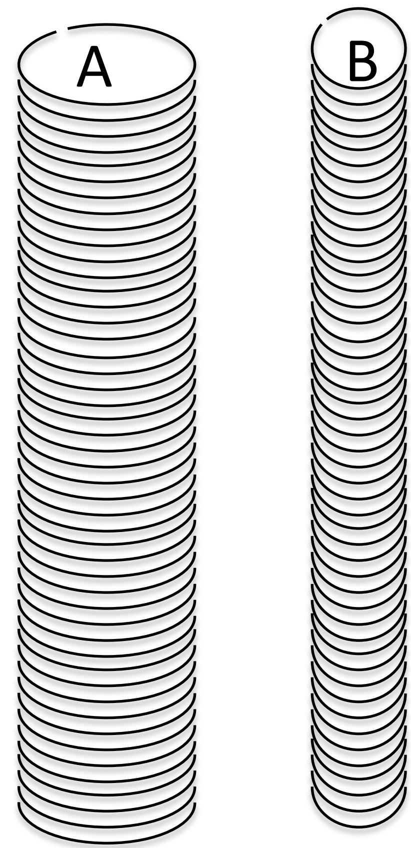
A) $U_A > U_B$ , $u_A = u_B$

B) $U_A = U_B$ , $u_A < u_B$

C) $U_A > U_B$ , $u_A < u_B$

D) $U_A > U_B$ , $u_A > u_B$

E) None of these



The laws governing electrodynamics which we have derived so far are:

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \qquad \nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad \nabla \times \mathbf{B} = \mu_0 \mathbf{J}$$

These laws are valid

A. Always
B. if the charges are not accelerating
C. if the fields are static
D. if the currents are steady
E. if the fields are not in matter, but in vacuum

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.

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

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{thru}$$

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.

Take the divergence of the curl of any (well-behaved) vector function **F**, what do you get?

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

A. Always 0

B. A complicated partial differential of **F**

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

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

E. ???

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

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

What do you get?

A. 0=0 (is this interesting!!?)

B. A complicated partial differential equation (perhaps a wave equation of some sort ?!) for **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 **J** =

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

B. A complicated partial differential of B

C. Always 0

D. ??

Our four equations, Gauss's Law for E and B, Faraday's Law, and Ampere's Law are entirely consistent with many experiments. Are they consistent with charge conservation?

A) Yes. And, I'm prepared to say how I know
B) No. And, I'm prepared to say how I know.
C) ????

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.

The path can be:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{thru}$$

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.

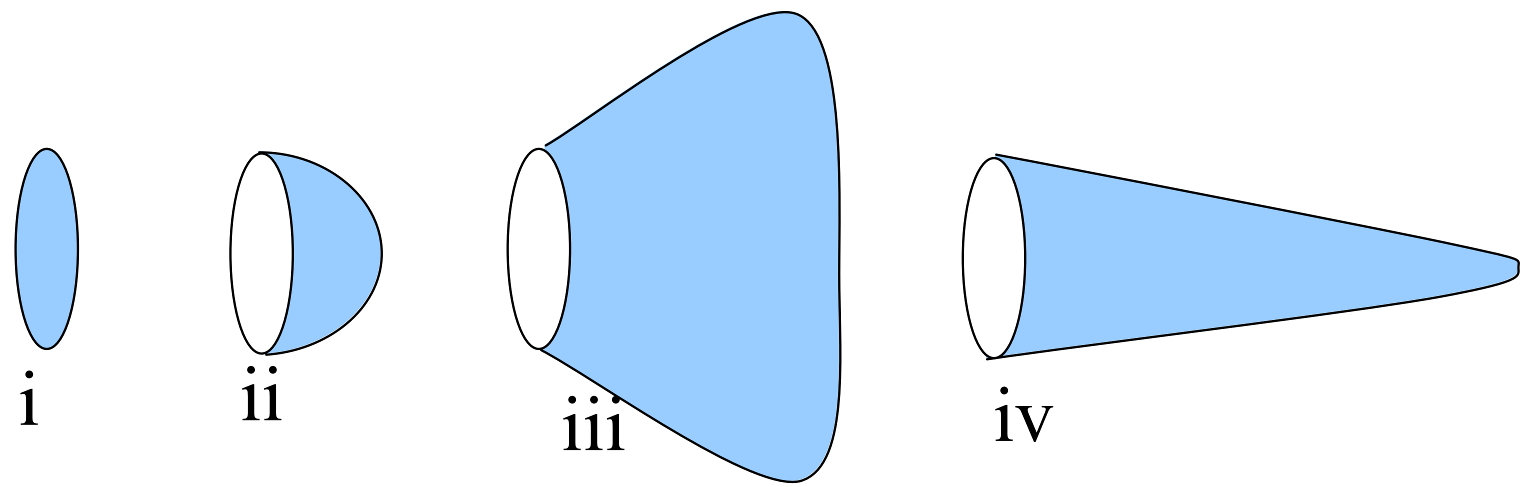
Ampere's Law relates the line integral of B around some closed path, to a current flowing through a surface bounded by the chosen closed path.

The <u>surface</u> can be:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{thru}$$

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

Rank order $\left|\iint \vec{\mathbf{J}} \bullet d\vec{\mathbf{A}}\right|$ (over blue surfaces) where **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!!

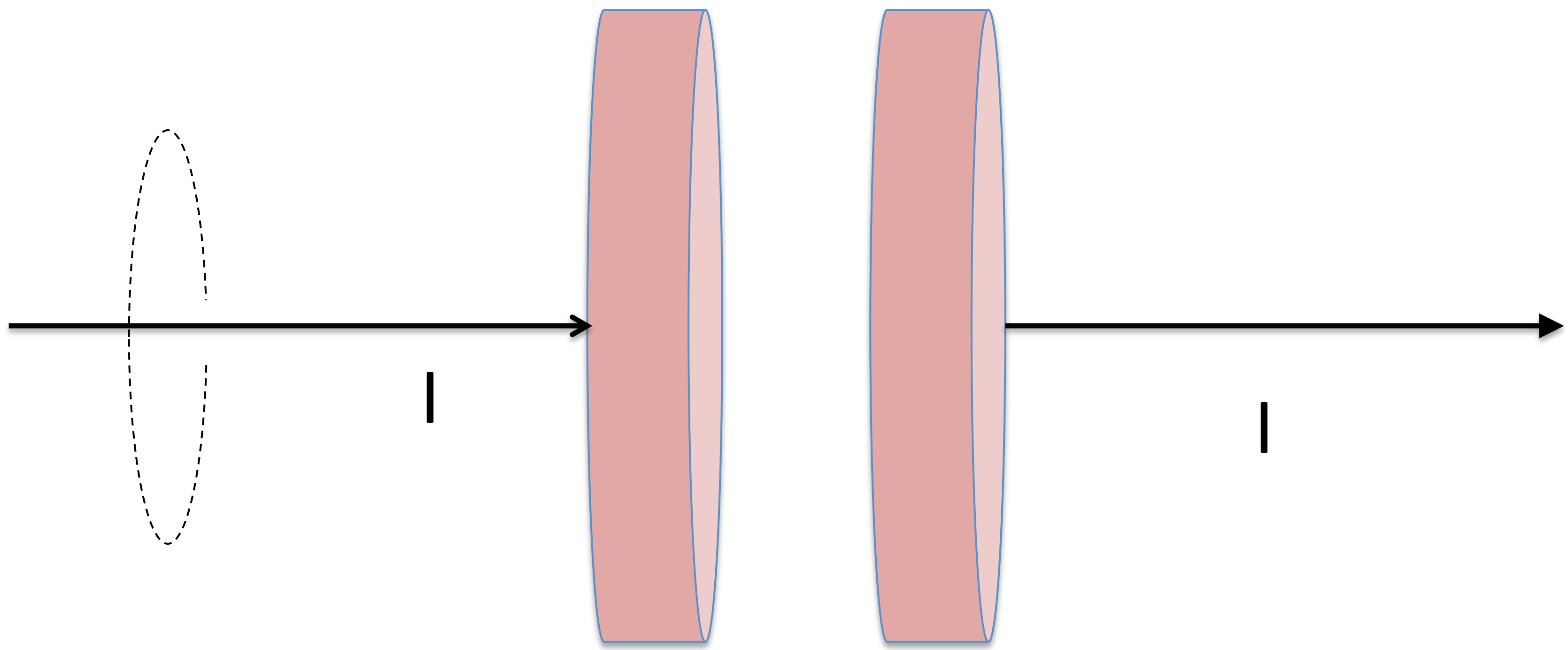
E) Not enough info given!!

We are interested in B on the dashed "Amperian loop", and plan to use $\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{thru}$ to figure it out.

What is $I_{thru}$ here?

A) I B) I/2 C) 0 D) Something else

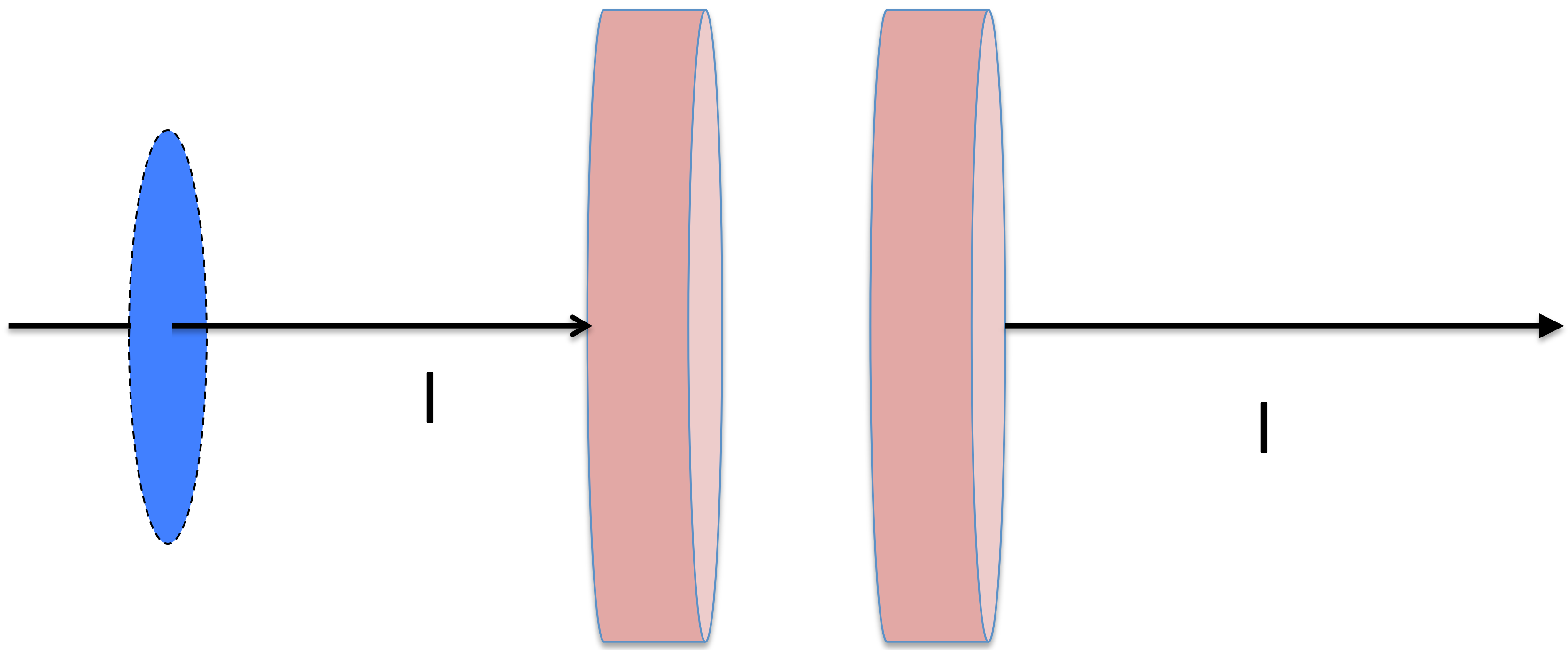
E) Not enough information has been given!



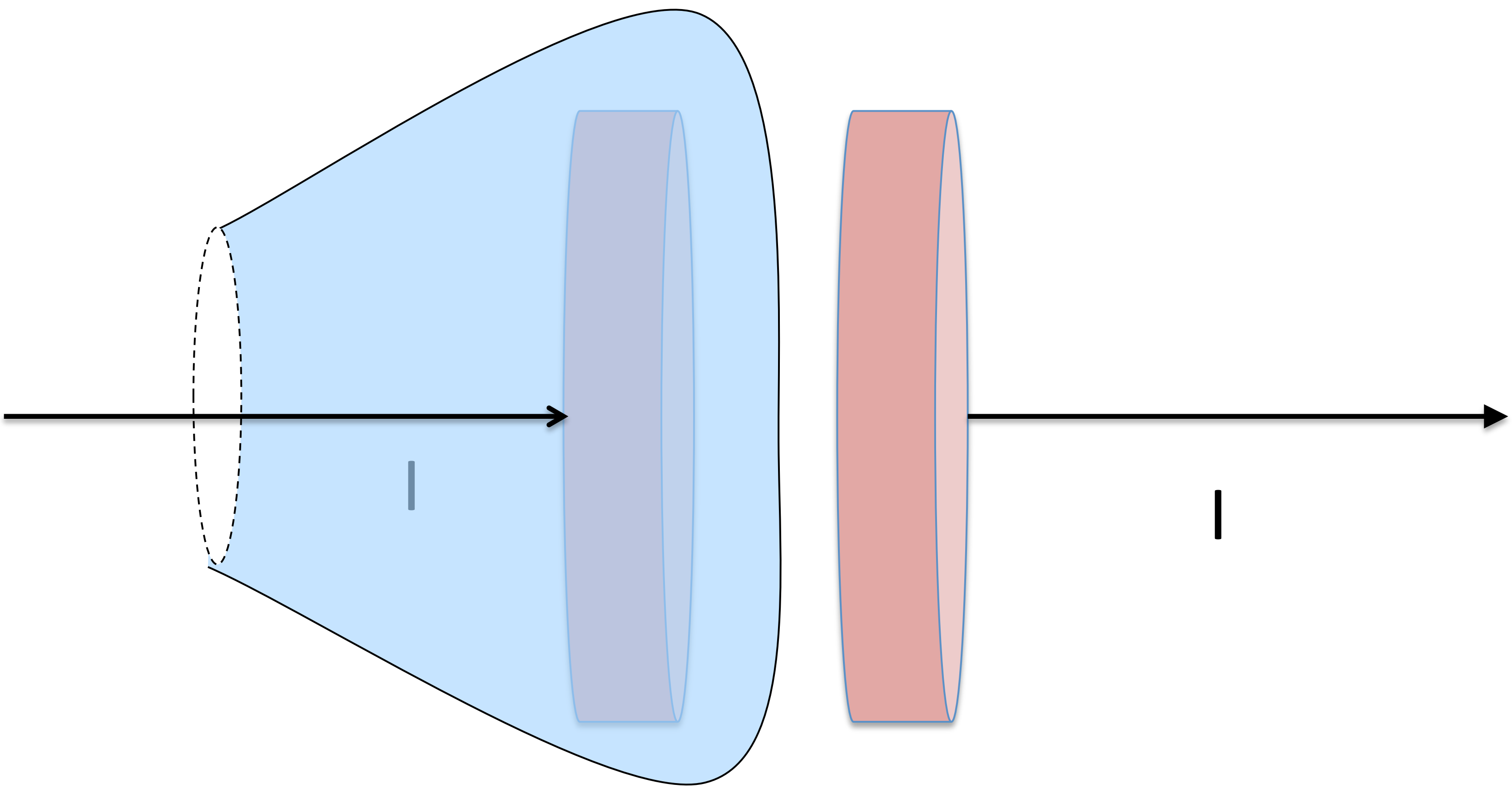
We are interested in B on the dashed "Amperian loop", and plan to use $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{thru}$ to figure it out. What is $I_{thru}$?

*The surface over which we will integrate J·dA is shown in light blue.*

A) I B) I/2 C) 0 D) Something else E) ??



We are interested in B on the dashed "Amperian loop", and plan to use $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{thru}$ to figure it out. What is $I_{thru}$?
*The surface over which we will integrate J·dA is shown in light blue.* A) I B) I/2 C) 0 D) Something else E) ??



A constant current flows into a capacitor. Therefore, the capacitor voltage drop:

A) is zero.

B) is a non-zero constant.

C) has a constant change with time.

D) has a constant integral with time.

E) None of the above.

A parallel plate capacitor has a constant current delivered to it, leading to a relationship between current and voltage of:

A) $I = \dfrac{A}{\varepsilon_0 d}\dfrac{dV}{dt}$

C) $I = \dfrac{d}{\varepsilon_0 A}\dfrac{dV}{dt}$

B) $I = \dfrac{\varepsilon_0 d}{A}\dfrac{dV}{dt}$

D) $I = \dfrac{\varepsilon_0 A}{d}\dfrac{dV}{dt}$

Our four equations, Gauss's Law for E and B, Faraday's Law, and Ampere's Law are entirely consistent with many experiments.
Are they RIGHT?

A) Yes. And, I'm prepared to say how I know
B) No. And, I'm prepared to say how I know.
C) What?! Are we philosophers?

Our four equations, Gauss's Law for E and B, Faraday's Law, and Ampere's Law are entirely consistent with many experiements. Are they INTERNALLY CONSISTENT?

A) Yes. And, I'm prepared to say how I know
B) No. And, I'm prepared to say how I know.
C) Ummm…, could we play with them for a bit?

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

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

The integral form of this equation is:

$$A) \quad \iint \mathbf{B} \cdot d\mathbf{a} = \mu_0 I_{enc} + \mu_0 \varepsilon_0 \frac{d}{dt} \oint \mathbf{E} \cdot d\mathbf{l}$$

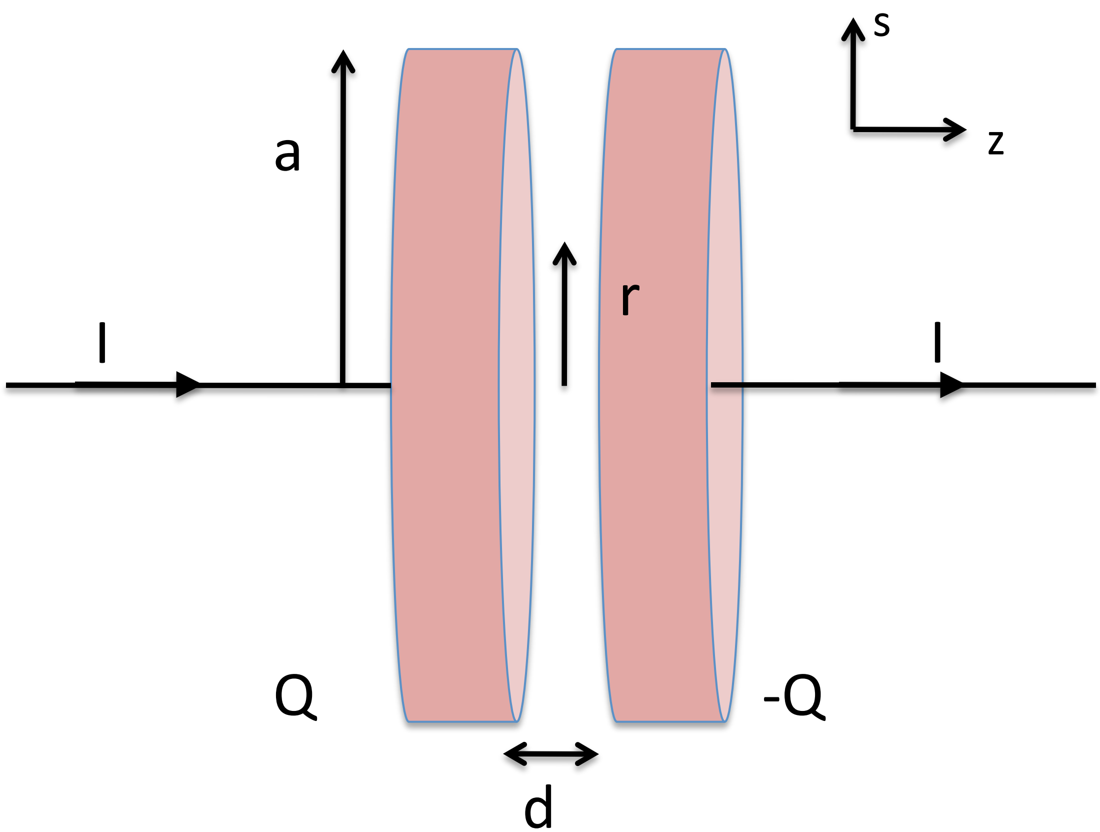
$$B) \quad \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{enc} + \mu_0 \varepsilon_0 \frac{d}{dt} \oint \mathbf{E} \cdot d\mathbf{l}$$

$$C) \quad \iint \mathbf{B} \cdot d\mathbf{a} = \mu_0 I_{enc} + \mu_0 \varepsilon_0 \frac{d}{dt} \iint \mathbf{E} \cdot d\mathbf{a}$$

$$D) \quad \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{enc} + \mu_0 \varepsilon_0 \frac{d}{dt} \iint \mathbf{E} \cdot d\mathbf{a}$$

E) Something else/???

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. $\pm\hat{\varphi}$

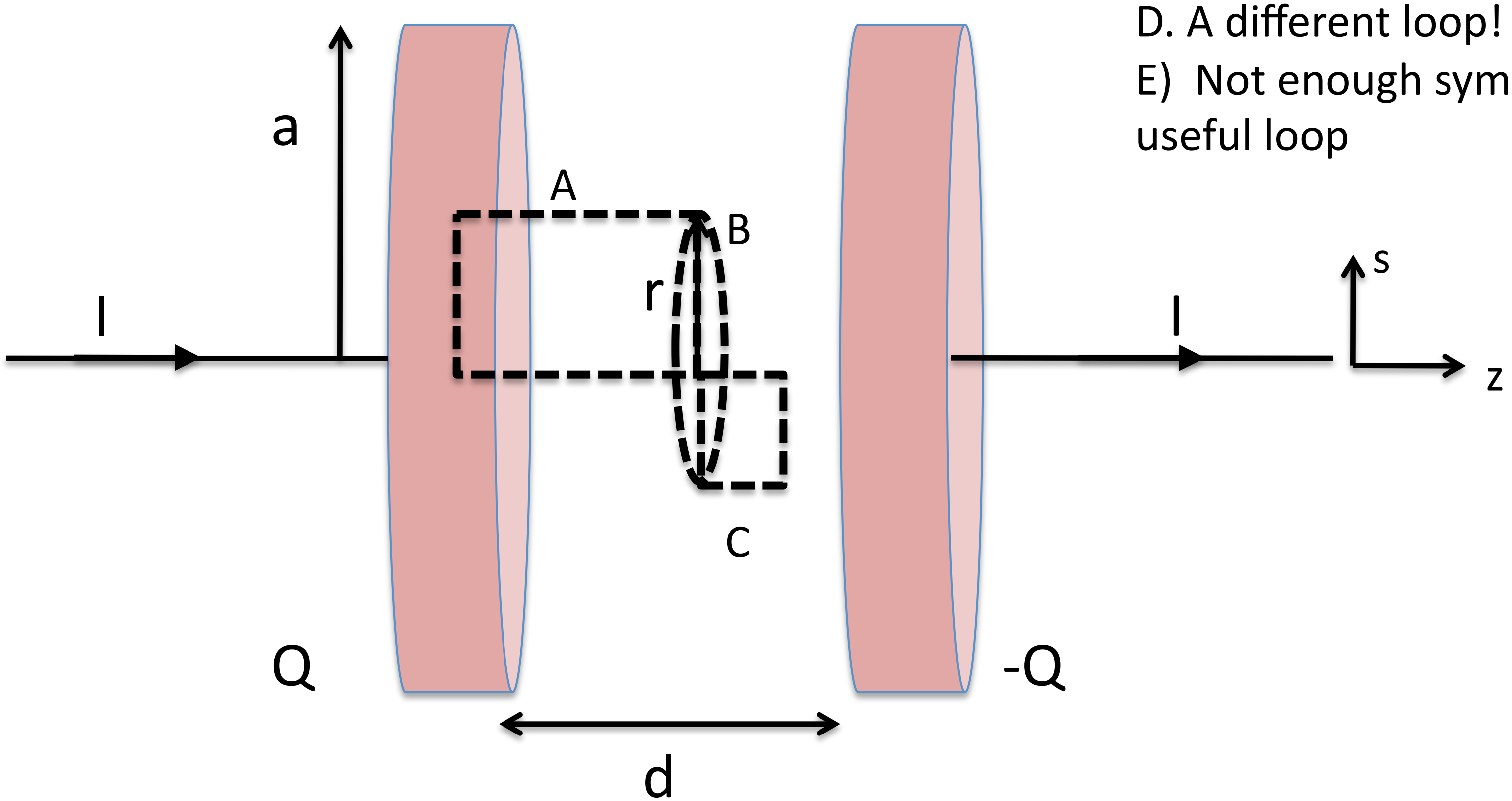
B. 0

C. $\pm\hat{z}$

D. $\pm\hat{s}$

E. ???

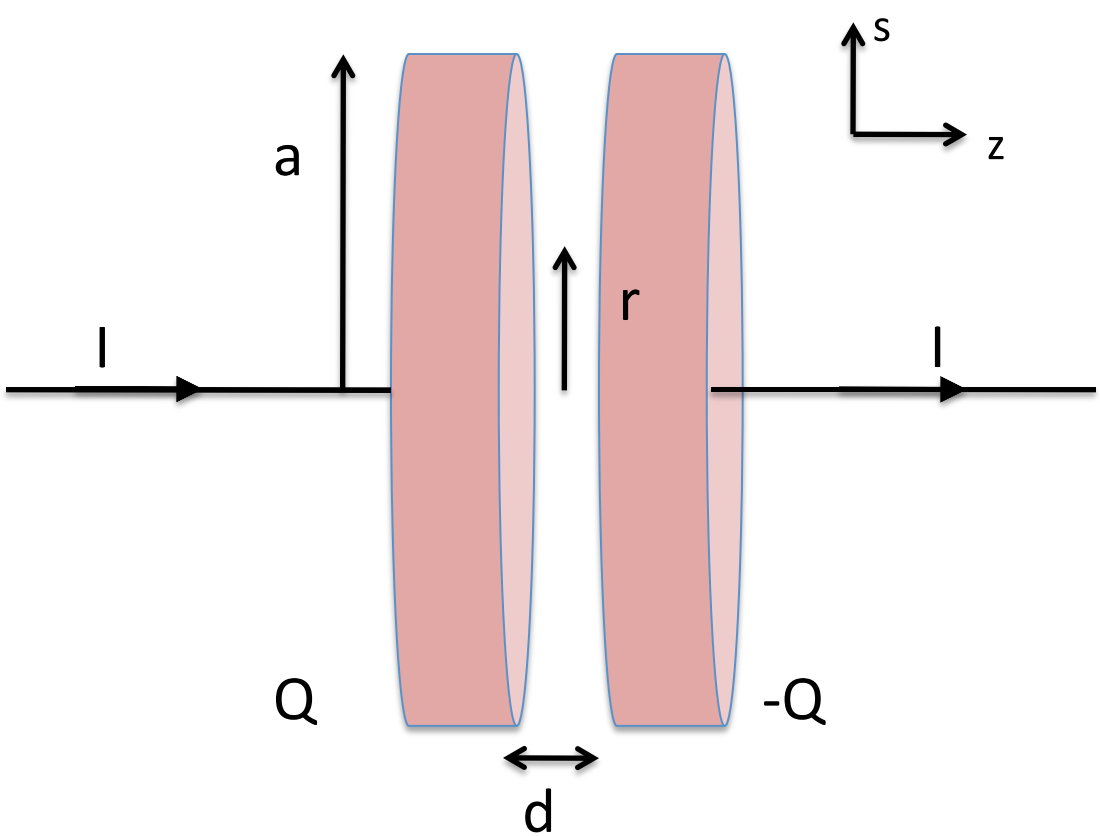
Consider a large parallel plate capacitor as shown, charging so that $Q = Q_0+\beta t$ on the positively charged plate. Assuming the edges of the capacitor and the wire connections to the plates can be ignored, what kind of amperian loop can be used between the plates to find the magnetic field B halfway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




D. A different loop!

E) Not enough symmetry for a useful loop

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 magnitude of the magnetic field B halfway between the plates, at a radius r?




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

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

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

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

E. None of the above

The laws governing electrodynamics which we have derived so far are:

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \qquad \nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \qquad \nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

These laws are valid

A. Always
B. if the charges are not accelerating
C. if the fields are static
D. if the currents are steady
E. if the fields are not in matter, but in vacuum

The cube below (side a) has uniform polarization $\mathbf{P}_0$ (which points in the z direction.)

What is the total dipole moment of this cube?

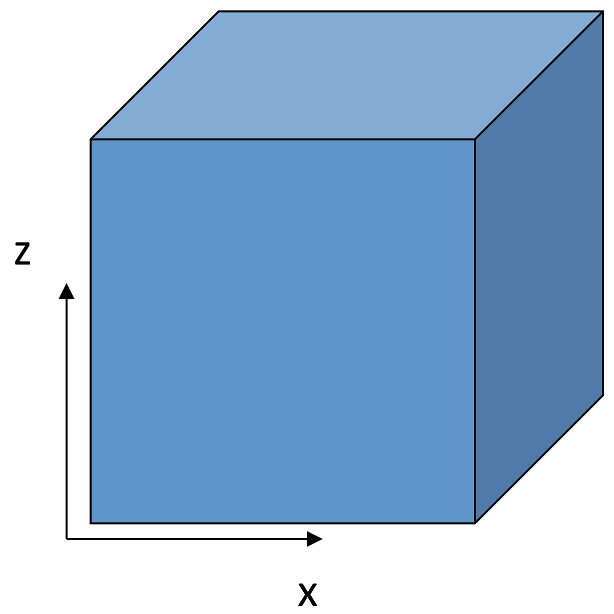
A) zero

B) $a^3\ P_0$

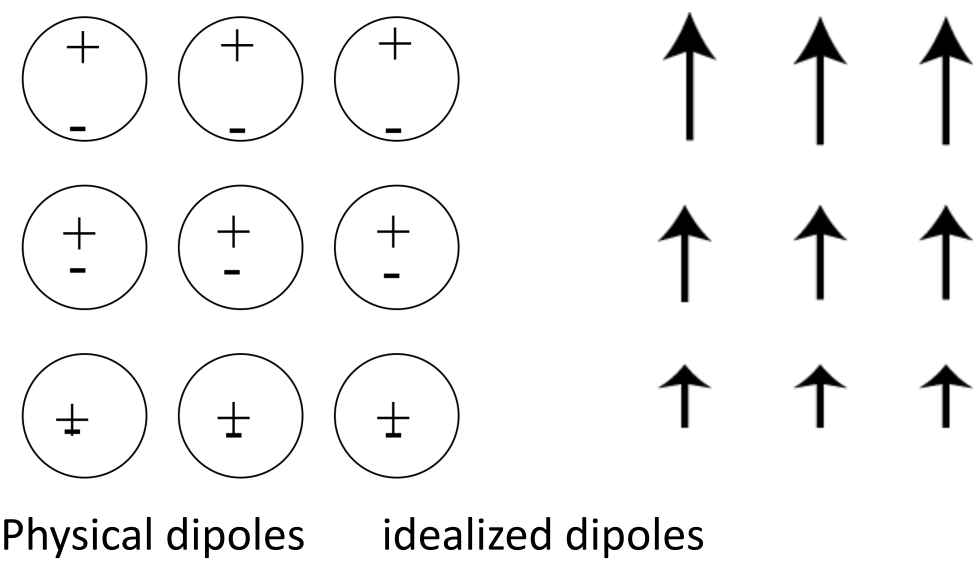
C) $P_0$

D) $P_0/a^3$

E) $2\ P_0\ a^2$



# In the following case, is the bound surface and volume charge zero or nonzero?




A. $\rho_b = 0, \sigma_b \neq 0$

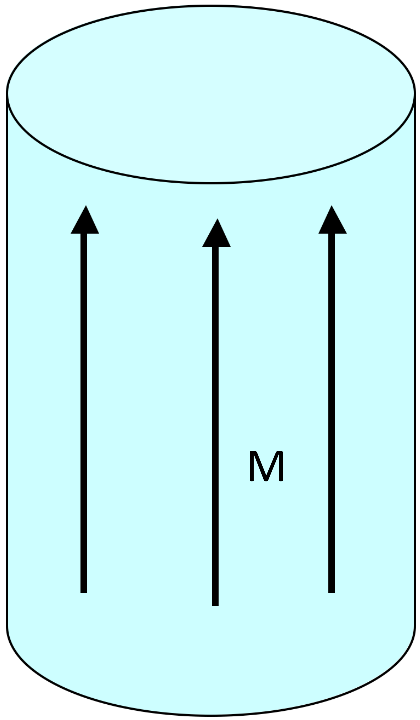
B. $\rho_b \neq 0, \sigma_b \neq 0$

C. $\rho_b = 0, \sigma_b = 0$

D. $\rho_b \neq 0, \sigma_b = 0$

A solid cylinder has uniform magnetization **M** throughout the volume in the z direction as shown. Where do bound currents show up?

A) Everywhere: throughout the volume and on all surfaces
B) Volume only, not surface
C) Top/bottom surface only
D) Side (rounded) surface only
E) All surfaces, but not volume



# Choose all of the following statements that are implied by $\oint \vec{E} \cdot d\vec{l} = -\frac{d}{dt}\iint \vec{B} \cdot d\vec{a}$

(I) $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ (II) $E_{above}^{//} = E_{below}^{//}$

(III) $E_{above}^{\perp} = E_{below}^{\perp}$

A) (I) only B) (II) only C) (I) and (II) only

D) (I) and (III) only E) Some other combo!

Choose all of the following statements that are implied by $\oiint \vec{B} \cdot d\vec{a} = 0$ (for any closed surface you like)

(I) $\vec{\nabla} \cdot \vec{B} = 0$

(II) $B^{//}_{above} = B^{//}_{below}$

(III) $B^{\perp}_{above} = B^{\perp}_{below}$

A) (I) only B) (III) only C) (I) and (II) only

D) (I) and (III) only E) Something else!