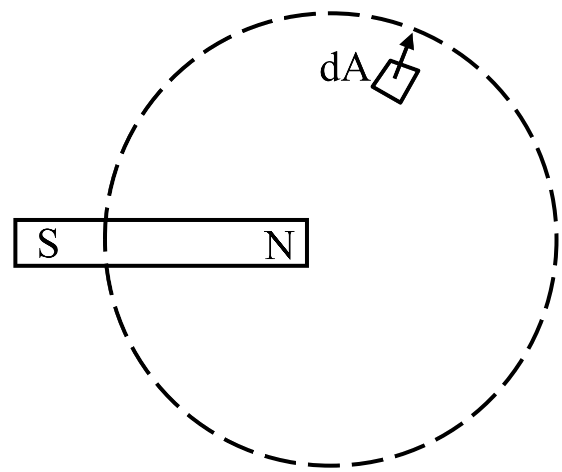
Faraday CT's

F-1. A bar magnet is partly inside an (imaginary) closed surface S, as shown. What can you say about the magnetic flux through the surface? $\oint_S \vec{B} \cdot d\vec{A}$ is..

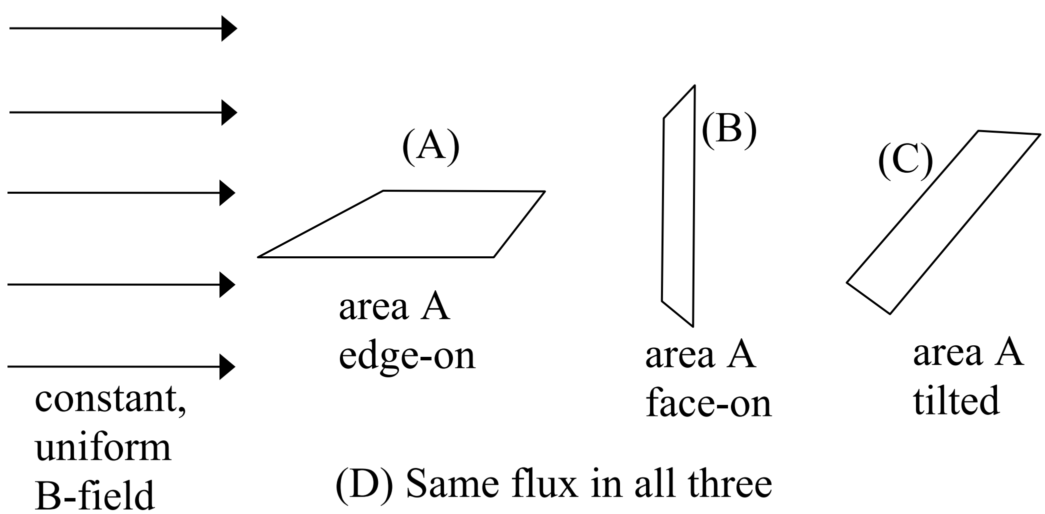


A) zero B) positive C) negative

D) impossible to tell from the information given

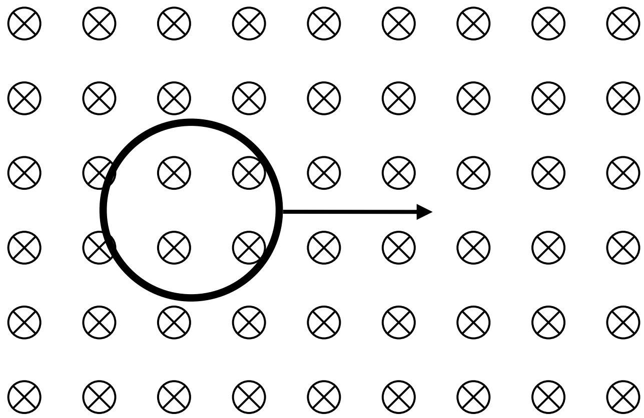
Answer: zero. Gauss's Law for B-fields is $\oint_S \vec{B} \cdot d\vec{A} = 0$

F-2. A square loop of area A is in a constant uniform magnetic field.
In which situation is the magnitude of the magnetic flux through the loop the ***smallest***?



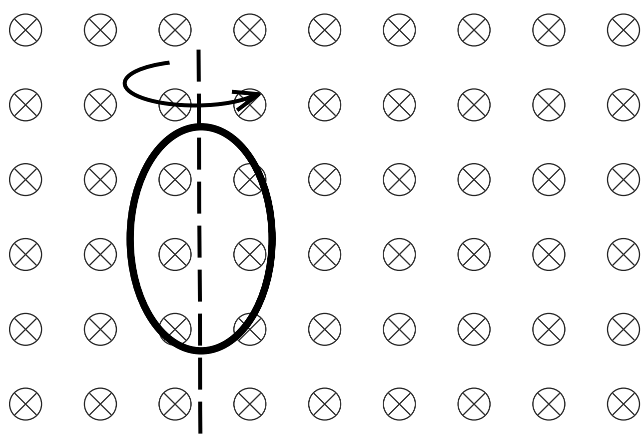
Answer: For case A, the flux is zero.

F-3. A loop of wire is moving rapidly through a uniform magnetic field as shown.
True (A) or False(B): there is a non-zero emf induced in the loop.



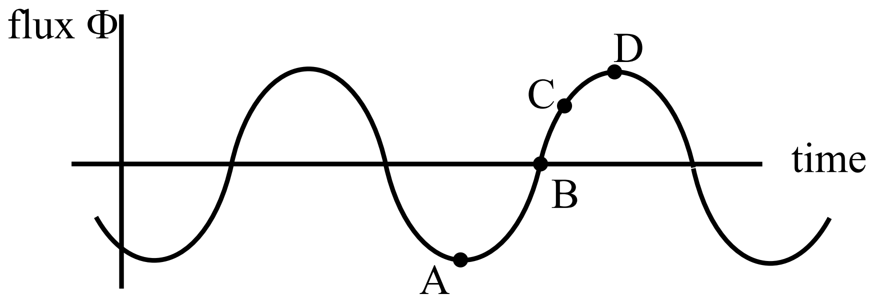
Answer: The emf is zero, since there is no ***change*** in flux.

F-4. A loop of wire is spinning rapidly about a stationary axis in uniform magnetic field as shown.
True(A) or False(B): there is a non-zero emf induced in the loop.



Answer: There is an emf, since the flux = $B \cdot A \cdot \cos\theta$, and the angle θ is changing.

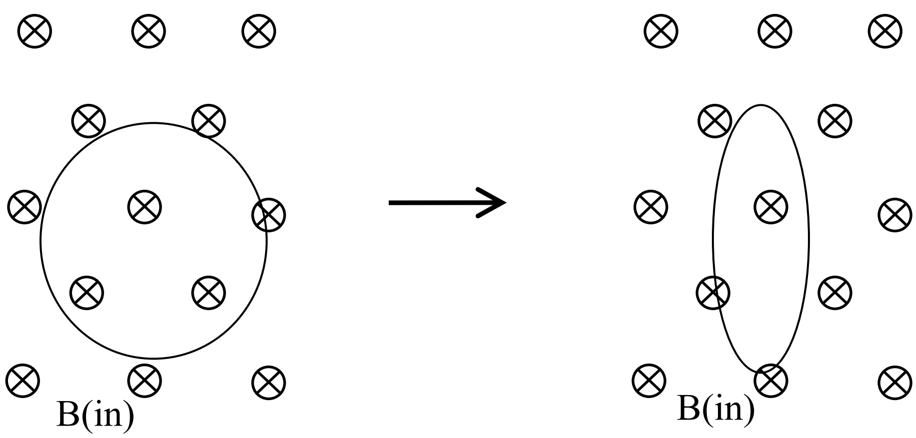
F-5. The magnetic flux through a loop of wire is shown. At which point is the magnitude of the emf induced in the loop a **maximum**?



Answer: The rate of change of flux is maximum at point B. At points A and D, the rate of change of flux is zero.

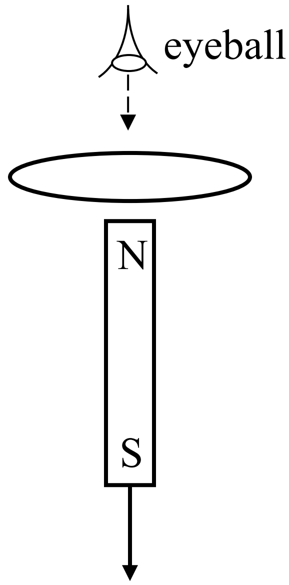
F-6. A loop of wire is sitting in a uniform, constant magnet field as shown. Suddenly, the loop is bent into a smaller area loop. During the bending of the loop, the induced current in the loop is ...

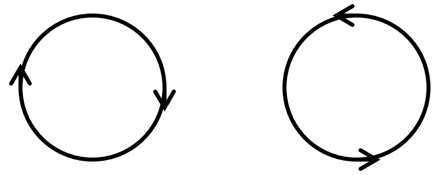
A) zero B) clockwise C) counterclockwise



Answer: Clockwise. Lenz's Law says the induced B-field must fight the change in flux. In this case, the flux through the loop is decreasing, so to fight the decrease, the induced B-field must be in the same direction as the original B-field (into the page). To create an induced field into the page, the current in the loop must be clockwise.

F-7. A bar magnet is positioned below a horizontal loop of wire with its North pole pointing toward the loop. Then the magnet is pulled down, away from the loop. As viewed from above, is the induced current in the loop clockwise or counterclockwise?



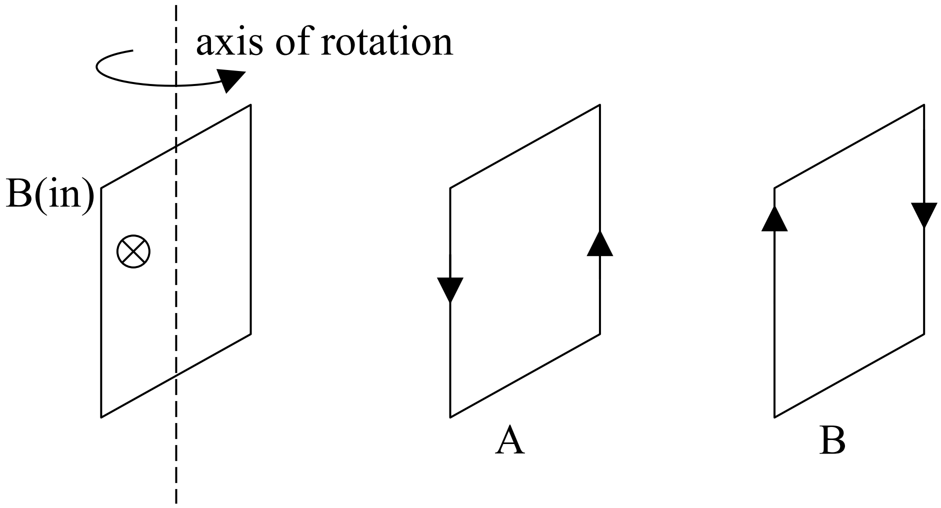


A) clockwise

B) counter-clockwise

Answer: Counterclockwise. As the magnet moves away, the flux through the loop is decreasing. To fight the decrease, the induced field should be in the same direction as the original field.

F-8. A square loop is rotating in a fixed, external magnetic field into the page. At the instant shown, the loop is out of the plane of the page with left side of the loop above the page and coming out of the page, the right side in going in. The direction of the induced current is ...

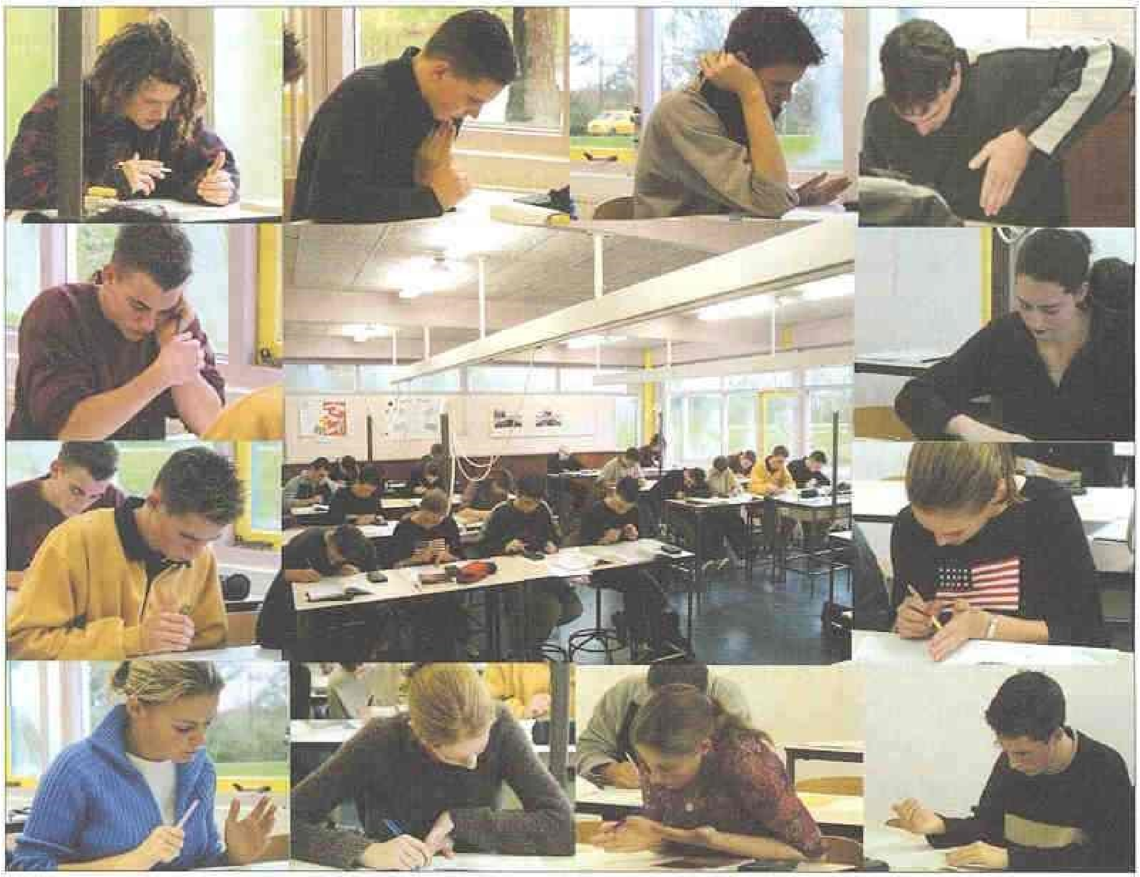


C) Neither

Answer: B, clockwise

F-9. Are these students going to get the correct answer on the question involving the right-hand rule? A) Yes B) No

Photo of the Month

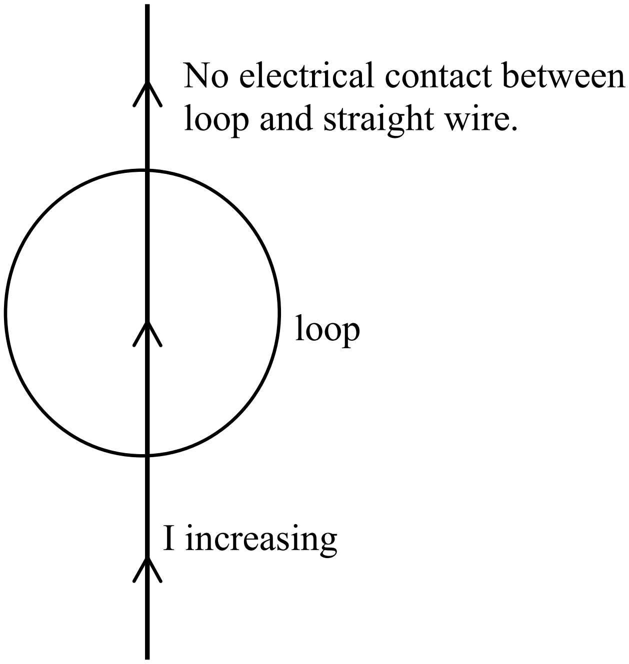


Tjeerdo Wieberdink, a high school physics teacher in Wieringerwerf, The Netherlands, contributed these photos of his physics students taking an exam on the Lorentz force and magnetic fields. He posted the collage in his school with the caption "What is the topic of this examination?"

Photo by Tjeerdo Wieberdink, tjw@beuk.nl

Answer: No, because they are using the LEFT hand!

F-10. A long, straight wire carrying an ***increasing*** current I passes along a diameter of a wire loop. The straight wire and the loop are in the same plane but are not in electrical contact.



The induced current in the loop is:

A) zero.

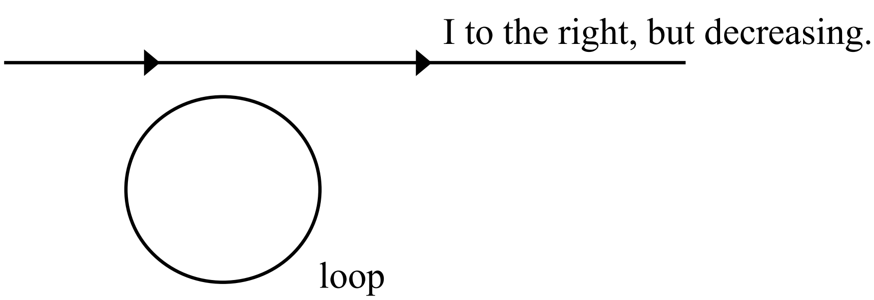
B) counter-clockwise

C) clockwise.

Answer: zero. The net flux through the loop is zero, because the flux on the right side of the straight wire has flux of one sign, and the flux on the left side has the other sign.

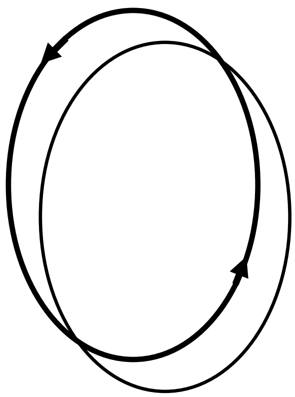
F-11. A loop of wire is near a long straight wire which is carrying a large current I, which is ***decreasing***. The loop and the straight wire are in the same plane and are positioned as shown. The current induced in the loop is

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



Answer: ~~counter~~clockwise

F-12. Two loop of wires labeled A and B are placed near each other as shown. A large current I in loop A is suddenly turned on. This causes an induced current in loop B which causes



A) A net replusive force - the two loops repel

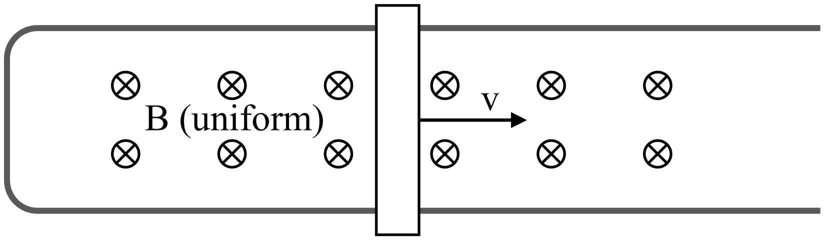
B) A net attractive force - the two loops attract

C) whether the force is attractive or repulsive depends on whether the current in first loop is CW or CCW

D) No net force.

Answer: net repulsive force.

F-13. The bar sliding on the U-shaped metal rails is pulled to the right with constant speed v. There is a constant uniform B-field into the page.



Which way is the induced current in the bar?

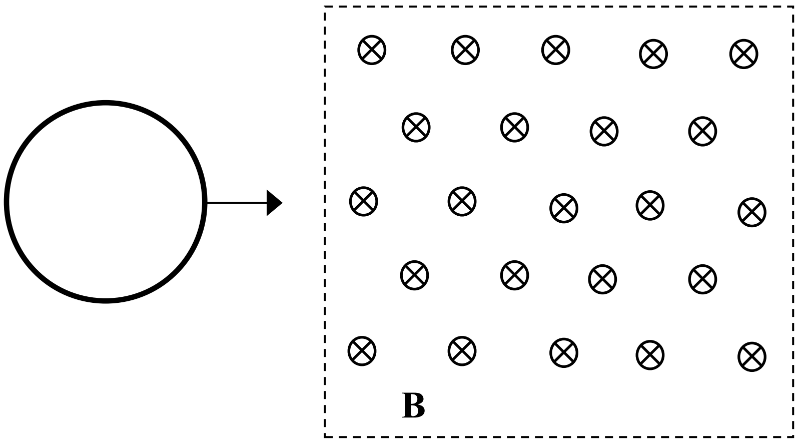
A) up ↑ B) down ↓ C) there is no induced current

Which way is the magnetic force on the bar due to the external B-field?

A) up ↑ B) down ↓ C) right → D) left ← E) zero

Answers: The induced current in the bar is up. The magnetic force on the bar is to the left (opposite the motion). This is an example of eddy current damping.

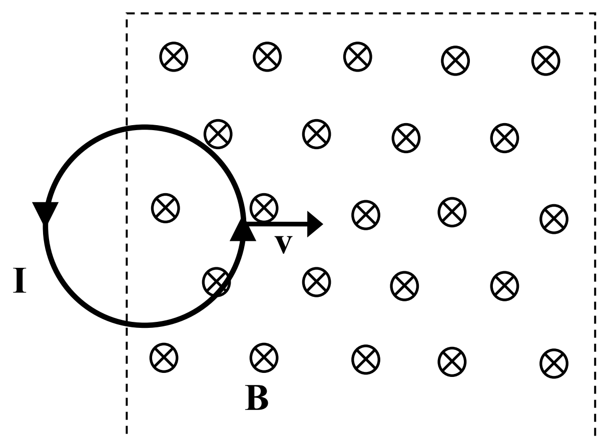
F-14. A wire loop, moving right, enters a region where there is a constant, uniform magnetic field pointing into the page.



As the loop enters the B-field, the current induced in the loop is ...
A) CW B) CCW

Answer: The induced current is CCW .

F-15. A wire loop is pulled to the right enters a region where there is a constant, uniform magnetic field pointing into the page.



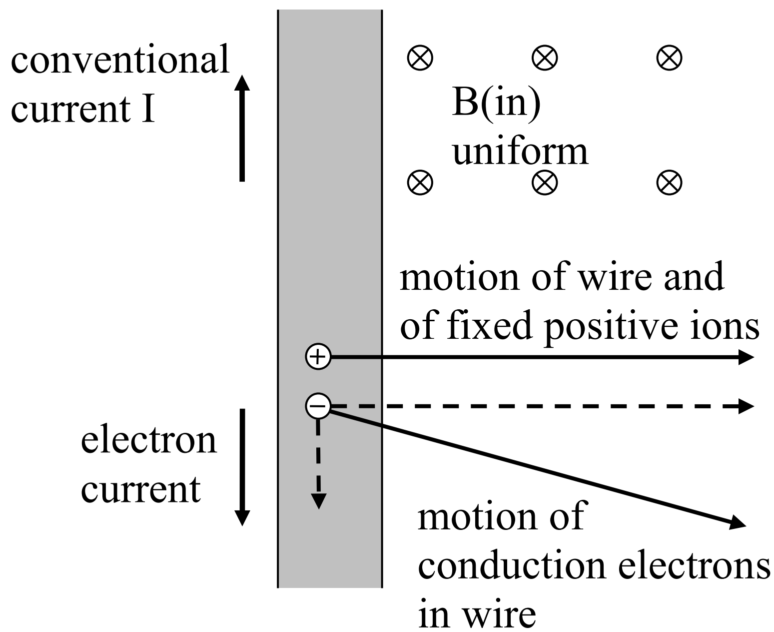
As the loop enters the B-field, the induced current is CCW. The direction of the force on the loop from the B-field is ...

A) right → B) ← C) up ↑ D) ↓down
E) there is no net force

Answer: The direction of the magnetic force on the loop is to the left.

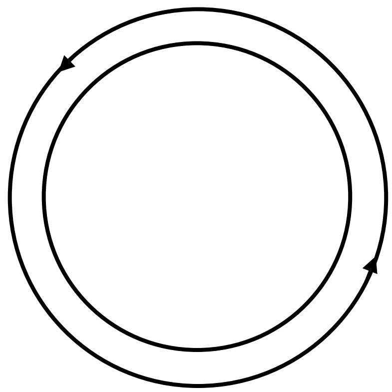
F-16. The vertical wire shown is moving to the right in a uniform magnetic field which is into the page. There is a current upward, meaning that there is a flow of electrons downward. The fixed positive ions in the wire are moving to the right, along with the wire. The negative conduction electrons are moving to the right and down. What is the direction of the **net magnetic force** on this segment of the wire?

A) Up B) Down C) Left D) Right E) None of these



Answer: the net magnetic force is to the left

F-17. Two concentric circular loops of wires. A large current I in larger outer loop is suddenly turned on. This causes an induced current in the smaller inner loop which causes



A) the inner loop to be compressed

B) the inner loop to be expanded

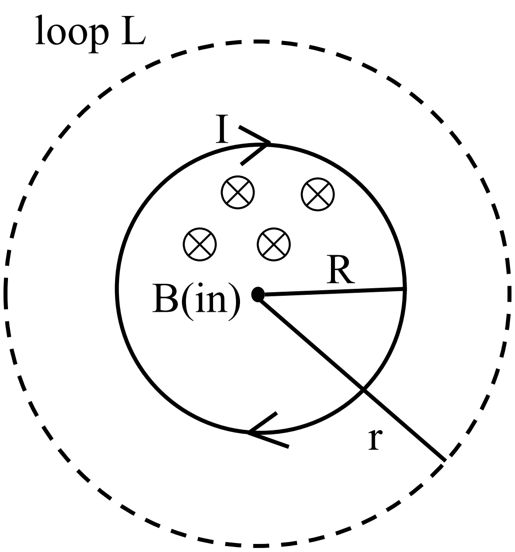
C) no forces on the inner loop

D) the inner loop to be either compressed or expanded, depending on whether the current in the outer loop is CW or CCW

Answer: the inner loop is compressed

F-18. A long solenoid of radius R has an ***increasing*** current causing an ***increasing*** B-field in its interior. An end-on view of the solenoid is shown below. A student wishes to compute the E-field outside the solenoid at a distance r (r > R) from the center. She applies Faraday's Law in the form

$$\oint_{L(A)} \vec{E}\cdot d\vec{l} = -\frac{d}{dt}\left[\int_A \vec{B}\cdot d\vec{A}\right]$$ to the imaginary loop L of radius r.



Is there a non-zero E-field outside the solenoid?

A) No, E = 0 outside the solenoid

B) Yes, the E-field circulates CCW

C) Yes, the E-field circulates CW

D) Yes, there is a radial E-field.

Answer: There is a non-zero E-field and it circulates CCW about the center. There can be no radial E-field, because the solenoid is electrically neutral. If you apply Gauss's Law to a closed cylinder of radius r, centered on the solenoid, the electric flux on that closed surface must be zero (since the enclosed charge is zero) and any radial E-field would cause a non-zero flux.

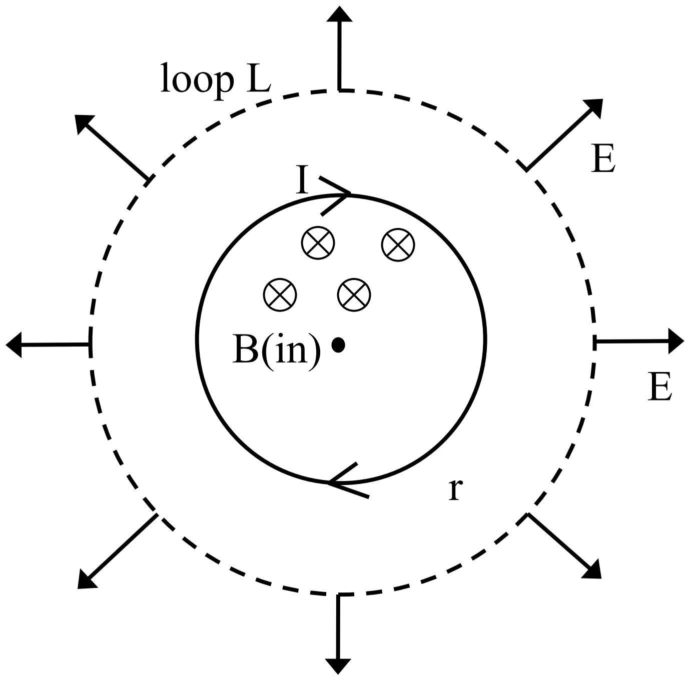
F-19. The student begins by writing $-\frac{d}{dt}\left[\int_A \vec{B}\cdot d\vec{A}\right] = -\frac{d}{dt}(BA) = -A\frac{dB}{dt}$

What is the correct expression for A?

A) πR^2 B) πr^2 C) $4\pi R^2$ D) $4\pi r^2$ E) None of these.

Answer: $A = \pi R^2$ The B-field is zero outside the solenoid, so the area outside the solenoid and within the loop L does not contribute to the magnetic flux. Only the area inside the solenoid contributes to the magnetic flux.

F-20. For the case of a long solenoid with increasing current, and an increasing B-field inside, a student proposed that the induced E-field has a radial component as shown. Is this possible?



A) Yes, this is possible.

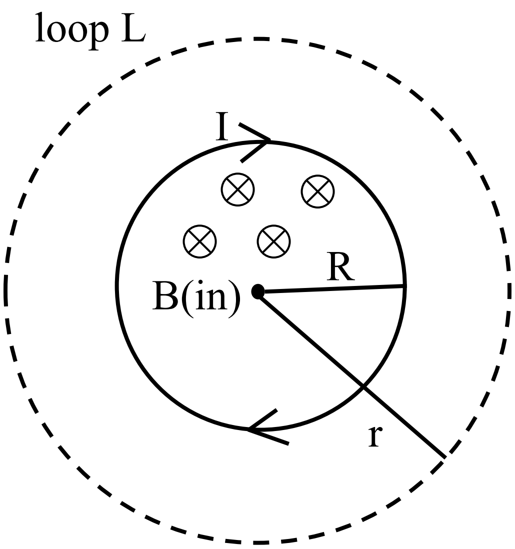
B) No, because this would violate Gauss's Law.

C) No, because this would violat some other law.

Answer: No, because this would violate Gauss's Law. There can be no radial E-field, because the solenoid is electrically neutral. If you apply Gauss's Law to a closed cylinder of radius r, centered on the solenoid, the electric flux on that closed surface must be zero (since the enclosed charge is zero) and any radial E-field would cause a non-zero flux.

F-21. For distances $r > R$ from the center of the solenoid, how does the magnitude of the electric field depend on r?

A) E = zero B) $E \propto 1/r$ C) $E \propto r$ D) $E \propto r^2$ E) $E \propto r^3$



Answer: $E \propto 1/r$ Be sure you know how to derive this result.

F-22. A long solenoid of radius R contains a uniform magnetic field B which is increasing at a steady rate [$B(t) = C\,t$, where C is a constant]. For distances $r < R$ from the center of the solenoid, inside the solenoid, how does the magnitude of the Electric field depend on r?

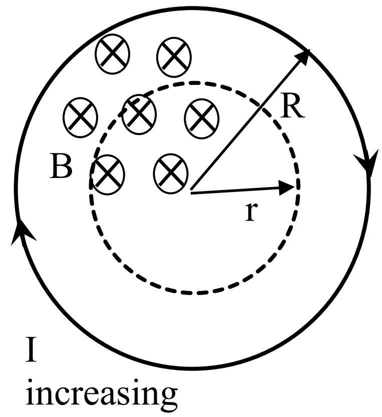
A) E = zero

B) $E \propto 1/r$

C) $E \propto r$

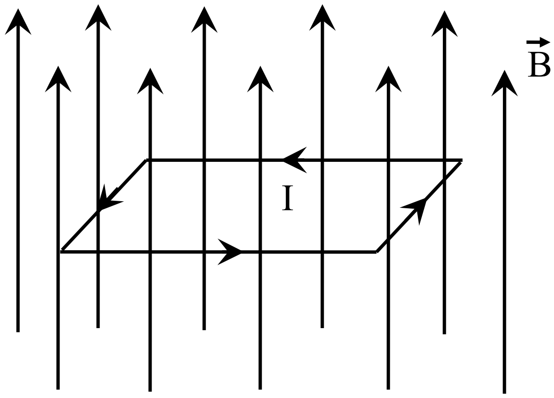
D) $E \propto r^2$

E) $E \propto r^3$



Answer: $E \propto r$ Be sure you know how to derive this result!

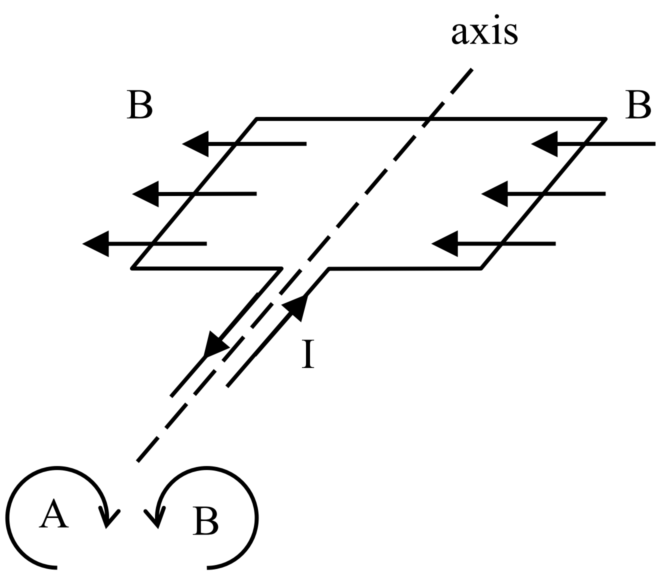
F-23. A rectangular loop is placed in a uniform magnetic field with the plane of the loop perpendicular to the direction of the field. If a current is made to flow through the loop in the sense shown by the arrows, the field exerts on the loop...



A) a net force only
B) a net torque only
C) a net force and a net torque
D) neither a net torque nor a net force.

Answer: neither a net torque nor a net force.

F-24. An electric motor consists of a coil, free to turn on an axis, and located in an magnetic field B created by an arrangement of permanent magnets. With the current and field directions as shown, which way will the coil rotate?



A) CW

B) CCW

C) the coil won't rotate when at this particular orientation

Answer: B, CCW
