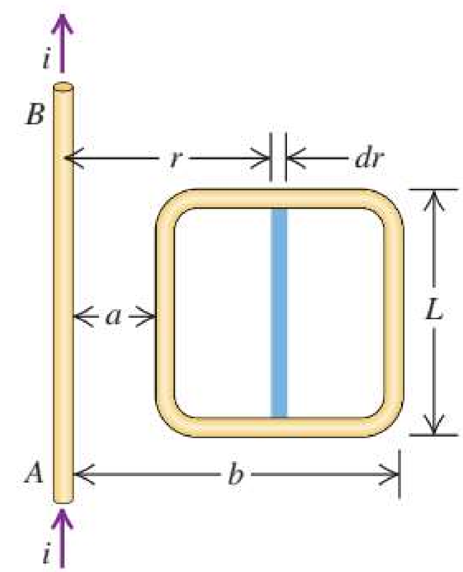
1. The current in the windings of a toroidal solenoid is 2.400 A. There are 500 turns, and the mean radius is 25.00 cm. The toroidal solenoid is filled with a magnetic material. The magnetic flux density inside the windings is found to be 1.940 T. Please calculate
(a) the relative permeability and
(b) the magnetic susceptibility of the material that fills the toroid.

2. The current in the long, straight wire *AB* shown in **Fig. E29.7** is upward and is increasing steadily at a rate *di*>*dt*.
(a) At an instant when the current is *i*, what are the magnitude and direction of the flux density ***B*** at a distance *r* to the right of the wire?
(b) What is the flux $d\Phi_B$ through the narrow, shaded strip?
(c) What is the total flux through the loop?
(d) What is the induced emf in the loop?
(e) Evaluate the numerical value of the induced emf if a = 12.0 cm, b = 36.0 cm, L = 24.0 cm, and *di*>*dt* = 9.60 A>s

Figure **E29.7**



3. One practical way to measure magnetic field strength uses a small, closely wound coil called a *search coil*. The coil is initially held with its plane perpendicular to a magnetic field. The coil is then either quickly rotated a quarter-turn about a diameter or quickly pulled out of the field.

(a) Derive the equation relating the total charge Q that flows through a search coil to the magnetic-field magnitude B. The search coil has N turns, each with area A, and the flux through the coil is decreased from its initial maximum value to zero in a time Δt. The resistance of the coil is R, and the total charge is $Q = I\Delta t$, where I is the average current induced by the change in flux.

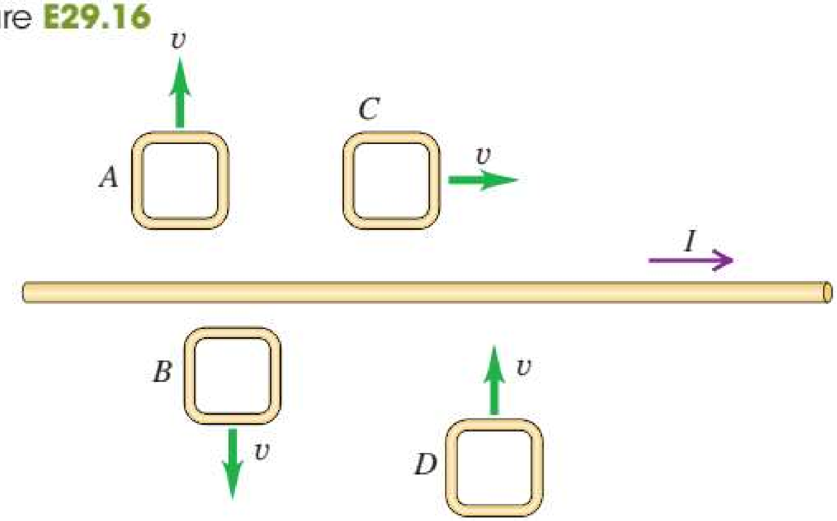
(b) In a credit card reader, the magnetic strip on the back of a credit card is rapidly "swiped" past a coil within the reader. Explain, using the same ideas that underlie the operation of a search coil, how the reader can decode the information stored in the pattern of magnetization on the strip.

(c) Is it necessary that the credit card be "swiped" through the reader at exactly the right speed? Why or why not?

4. Does Lenz's law say that the induced current in a metal loop always flows to oppose the magnetic flux through that loop? Explain.

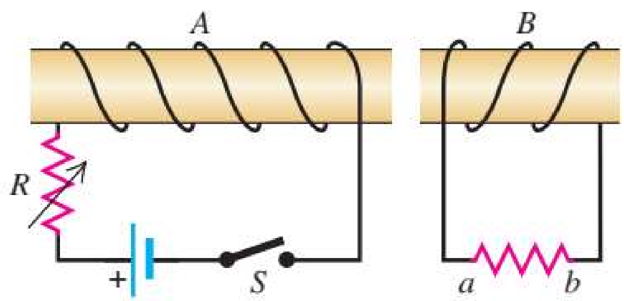
5. The current I in a long, straight wire is constant and is directed toward the right as in **Fig. E29.16**. Conducting loops A, B, C, and D are moving, in the directions shown, near the wire.
(a) For each loop, is the direction of the induced current clockwise or counterclockwise, or is the induced current zero?
(b) For each loop, what is the direction of the net force that the wire exerts on the loop? Give your reasoning for each answer.

Figure **E29.16**



6. Using Lenz's law, determine the direction of the current in resistor *ab* of **Fig. E29.19** when (a) switch *S* is opened after having been closed for several minutes; (b) coil *B* is brought closer to coil *A* with the switch closed; (c) the resistance of *R* is decreased while the switch remains closed.

Figure **E29.19**



7. Two coils have mutual inductance $M = 3.25 * 10^{-4}$ H. The current i_1 in the first coil increases at a uniform rate of 830 A/s.

(a) What is the magnitude of the induced emf in the second coil? Is it constant?

(b) Suppose that the current described is in the second coil rather than the first. What is the magnitude of the induced emf in the first coil?

8. Consider each of the electric- and magnetic-field orientations given next. In each case, what is the direction of propagation of the wave?
(a) $\boldsymbol{E}$ in the $+x$-direction, $\boldsymbol{B}$ in the $+y$-direction;
(b) $\boldsymbol{E}$ in the $-y$-direction, $\boldsymbol{B}$ in the $+x$-direction;
(c) $\boldsymbol{E}$ in the $+z$-direction, $\boldsymbol{B}$ in the $-x$-direction;
(d) $\boldsymbol{E}$ in the $+y$-direction, $\boldsymbol{B}$ in the $-z$-direction.

9. A sinusoidal electromagnetic wave is propagating in vacuum in the $+z$ direction. If at a particular instant and at a certain point in space the electric field is in the $+x$ direction and has magnitude 4.00 V/m, what are the magnitude and direction of the magnetic field of the wave at this same point in space and instant in time?

10. The 19th-century inventor Nikola Tesla proposed to transmit electric power via sinusoidal electromagnetic waves. Suppose power is to be transmitted in a beam of cross-sectional area 100 m^2. What electric- and magnetic-field amplitudes are required to transmit an amount of power comparable to that handled by modern transmission lines (that carry voltages and currents of the order of 500 kV and 1000 A)?

10. Unpolarized light with intensity I_0 is incident on two polarizing filters. The axis of the first filter makes an angle of 60.0° with the vertical, and the axis of the second filter is horizontal. What is the intensity of the light after it has passed through the second filter?

11. What is the thinnest soap film (excluding the case of zero thickness) that appears black when illuminated with light with wavelength 480 nm? The index of refraction of the film is 1.33, and there is air on both sides of the film.

12. **Compact Disc Player.** A compact disc (CD) is read from the bottom by a semiconductor laser with wavelength 790 nm passing through a plastic substrate of refractive index 1.8. When the beam encounters a pit, part of the beam is reflected from the pit and part from the flat region between the pits, so these two beams interfere with each other (Fig. E35.31). What must the minimum pit depth be so that the part of the beam reflected from a pit cancels the part of the beam reflected from the flat region? (It is this cancellation that allows the player to recognize the beginning and end of a pit.)

Figure **E35.31**