PH 202 Homework Assignment Chapter on Faraday & Induction – 28 Problems Total

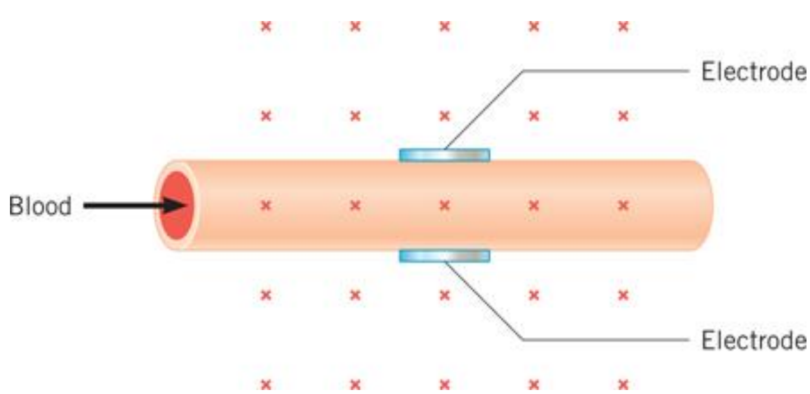
1. A 0.80-m aluminum bar is held with its length parallel to the east–west direction and dropped from a bridge. Just before the bar hits the river below, its speed is 22 m/s, and the emf induced across its length is 6.5 x 10^{-4} V. Assuming the horizontal component of the earth's magnetic field at the location of the bar points directly north, **(a)** determine the magnitude of the horizontal component of the earth's magnetic field, and **(b)** state whether the east end or the west end of the bar is positive.

Solution for Problem 1

2. Near San Francisco, where the vertically downward component of the earth's magnetic field is 4.8 x 10^{-5} T, a car is traveling forward at 25 m/s. The width of the car is 2.0 m. **(a)** Find the emf induced between the two sides of the car. **(b)** Which side of the car is positive—the driver's side or the passenger's side?

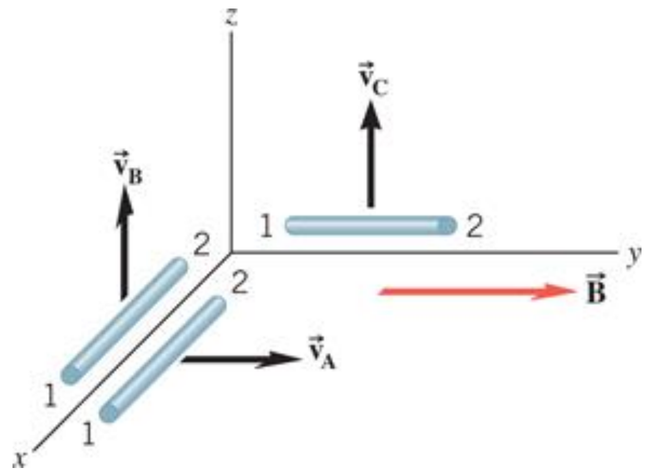
Solution for Problem 2

3. The drawing shows a type of flow meter that can be used to measure the speed of blood in situations when a blood vessel is sufficiently exposed (e.g., during surgery). Blood is conductive enough that it can be treated as a moving conductor. When it flows perpendicularly with respect to a magnetic field, as in the drawing, electrodes can be used to measure the small voltage that develops across the vessel. Suppose that the speed of the blood is 0.30 m/s and the diameter of the vessel is 5.6 mm. In a 0.60-T magnetic field what is the magnitude of the voltage that is measured with the electrodes in the drawing?



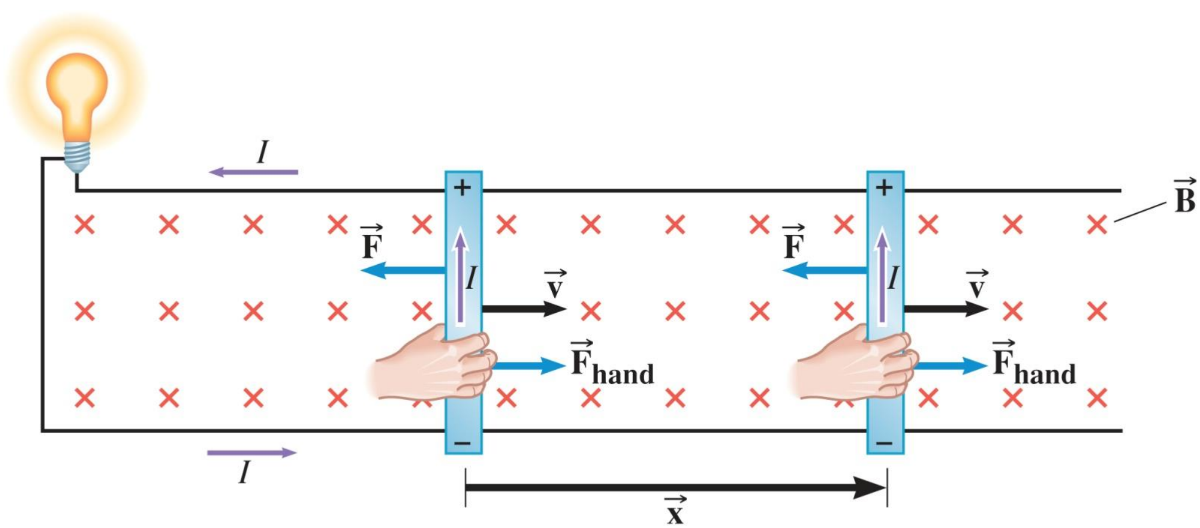
Solution for Problem 3

4. The drawing shows three identical rods (A, B, and C) moving in different planes. A constant magnetic field of magnitude 0.45 T is directed along the +*y* axis. The length of each rod is L = 1.3 m, and the rods each have the same speed, $v_A = v_B = v_C$ = 2.7 m/s. For each rod, find the magnitude of the motional emf, and indicate which end (1 or 2) of the rod is positive.



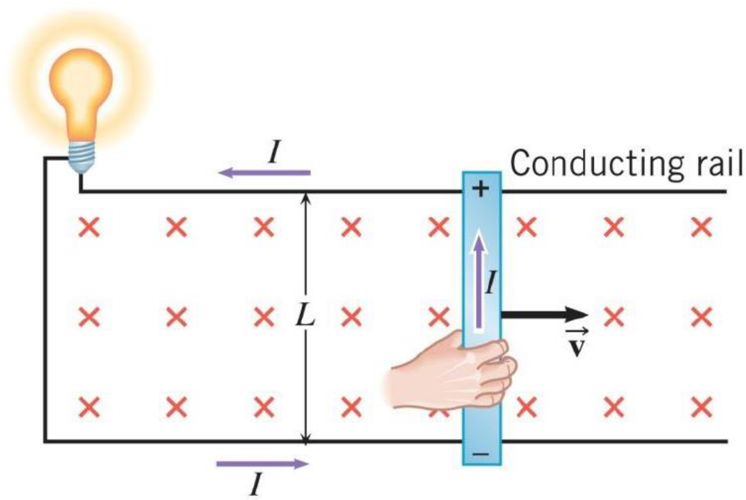
Solution for Problem 4

5. Multiple-Concept Example 2 discusses the concepts that are used in this problem. Suppose that the magnetic field in Figure 22.5 has a magnitude of 1.2 T, the rod has a length of 0.90 m, and the hand keeps the rod moving to the right at a constant speed of 3.5 m/s. If the current in the circuit is 0.040 A, what is the average power being delivered to the circuit by the hand?



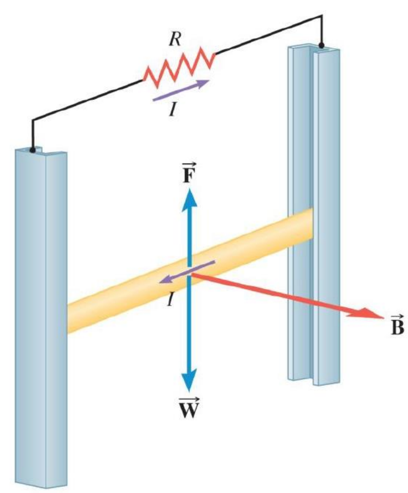
Solution for Problem 5

6. Suppose that the light bulb in Figure 22.4*b* is a 60.0-W bulb with a resistance of 240 Ω. The magnetic field has a magnitude of 0.40 T, and the length of the rod is 0.60 m. The only resistance in the circuit is that due to the bulb. What is the shortest distance along the rails that the rod would have to slide for the bulb to remain lit for one-half second?



Solution for Problem 6

7. A conducting rod slides down between two frictionless vertical copper tracks at a constant speed of 4.0 m/s perpendicular to a 0.50-T magnetic field. The resistance of the rod and tracks is negligible. The rod maintains electrical contact with the tracks at all times and has a length of 1.3 m. A 0.75-Ω resistor is attached between the tops of the tracks. **(a)** What is the mass of the rod? **(b)** Find the change in the gravitational potential energy that occurs in a time of 0.20 s. **(c)** Find the electrical energy dissipated in the resistor in 0.20 s.

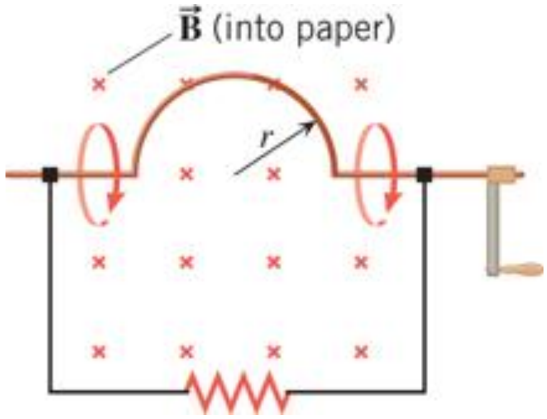


Solution for Problem 7

8. A standard door into a house rotates about a vertical axis through one side, as defined by the door's hinges. A uniform magnetic field is parallel to the ground and perpendicular to this axis. Through what angle must the door rotate so that the magnetic flux that passes through it decreases from its maximum value to one-third of its maximum value?

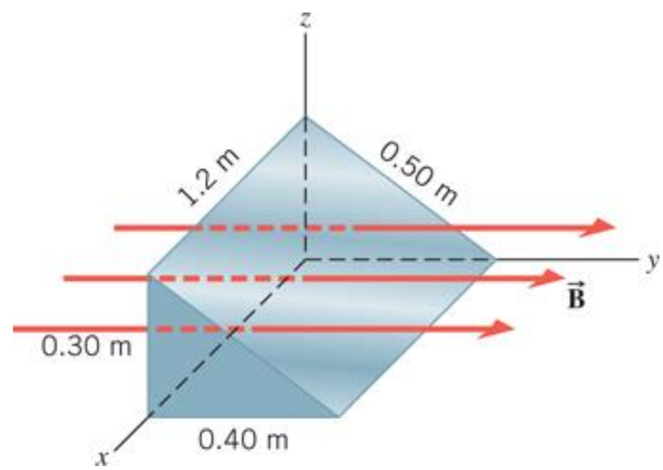
Solution for Problem 8

9. A loop of wire has the shape shown in the drawing. The top part of the wire is bent into a semicircle of radius r = 0.20 m. The normal to the plane of the loop is parallel to a constant magnetic field ($\phi = 0°$) of magnitude 0.75 T. What is the change $(\Delta\Phi)$ in the magnetic flux that passes through the loop when, starting with the position shown in the drawing, the semicircle is rotated through half a revolution?



Solution for Problem 9

10. A five-sided object, whose dimensions are shown in the drawing, is placed in a uniform magnetic field. The magnetic field has a magnitude of 0.25 T and points along the positive *y* direction. Determine the magnetic flux through each of the five sides.



Solution for Problem 10

11. Magnetic resonance imaging (MRI) is a medical technique for producing pictures of the interior of the body. The patient is placed within a strong magnetic field. One safety concern is what would happen to the positively and negatively charged particles in the body fluids if an equipment failure caused the magnetic field to be shut off suddenly. An induced emf could cause these particles to flow, producing an electric current within the body. Suppose the largest surface of the body through which flux passes has an area of 0.032 m^2 and a normal that is parallel to a magnetic field of 1.5 T. Determine the smallest time period during which the field can be allowed to vanish if the magnitude of the average induced emf is to be kept less than 0.010 V.

Solution for Problem 11

12. A circular coil (950 turns, radius = 0.060 m) is rotating in a uniform magnetic field. At t = 0 s, the normal to the coil is perpendicular to the magnetic field. At t = 0.010 s, the normal makes an angle of $\phi = 45°$ with the field because the coil has made one-eighth of a revolution. An average emf of magnitude 0.065 V is induced in the coil. Find the magnitude of the magnetic field at the location of the coil.

Solution for Problem 12

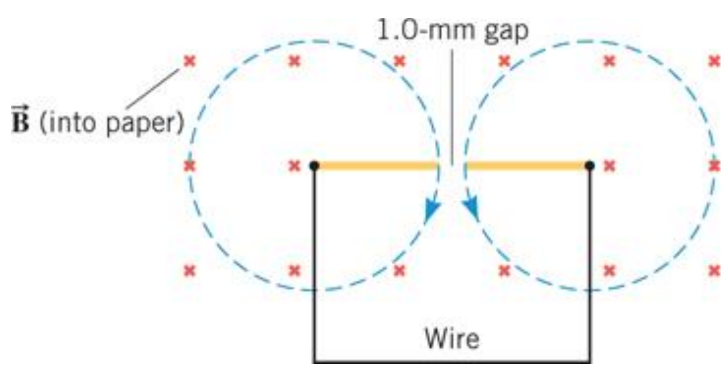
13. A uniform magnetic field is perpendicular to the plane of a single-turn circular coil. The magnitude of the field is changing, so that an emf of 0.80 V and a current of 3.2 A are induced in the coil. The wire is then re-formed into a single-turn square coil, which is used in the same magnetic field (again perpendicular to the plane of the coil and with a magnitude changing at the same rate). What emf and current are induced in the square coil?

Solution for Problem 13

14. A flat circular coil with 105 turns, a radius of 4.00×10^{-2} m, and a resistance of 0.480 Ω is exposed to an external magnetic field that is directed perpendicular to the plane of the coil. The magnitude of the external magnetic field is changing at a rate of $\Delta B / \Delta t = 0.783 \mathrm{T/s}$, thereby inducing a current in the coil. Find the magnitude of the magnetic field at the center of the coil that is produced by the induced current.

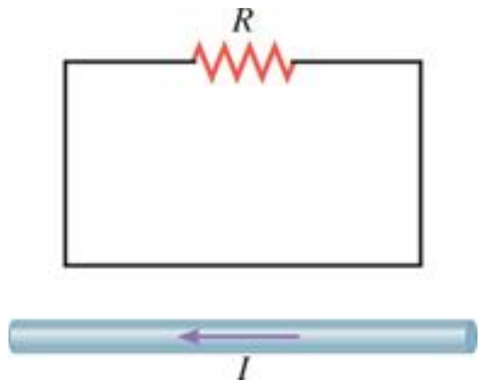
Solution for Problem 14

15. Two 0.68-m-long conducting rods are rotating at the same speed in opposite directions, and both are perpendicular to a 4.7-T magnetic field. As the drawing shows, the ends of these rods come to within 1.0 mm of each other as they rotate. Moreover, the fixed ends about which the rods are rotating are connected by a wire, so these ends are at the same electric potential. If a potential difference of 4.5×10^3 V is required to cause a 1.0-mm spark in air, what is the angular speed (in rad/s) of the rods when a spark jumps across the gap?



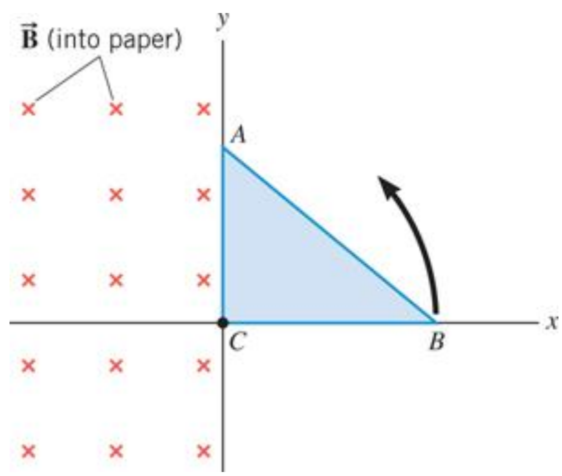
Solution for Problem 15

16. The drawing shows a straight wire carrying a current *I*. Above the wire is a rectangular loop that contains a resistor *R*. If the current *I* is decreasing in time, what is the direction of the induced current through the resistor *R*—left-to-right or right-to-left?



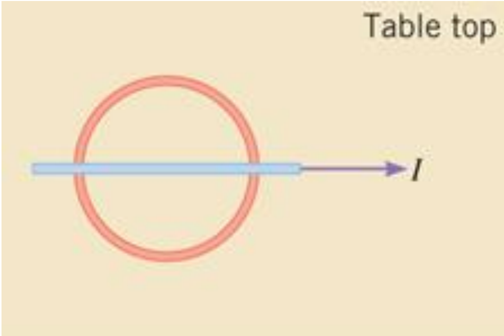
Solution for Problem 16

17. The drawing shows that a uniform magnetic field is directed perpendicularly into the plane of the paper and fills the entire region to the left of the *y* axis. There is no magnetic field to the right of the *y* axis. A rigid right triangle *ABC* is made of copper wire. The triangle rotates counterclockwise about the origin at point *C*. What is the direction (clockwise or counterclockwise) of the induced current when the triangle is crossing **(a)** the + *y* axis, **(b)** the - *x* axis, **(c)** the - *y* axis, and **(d)** the + *x* axis? For each case, justify your answer



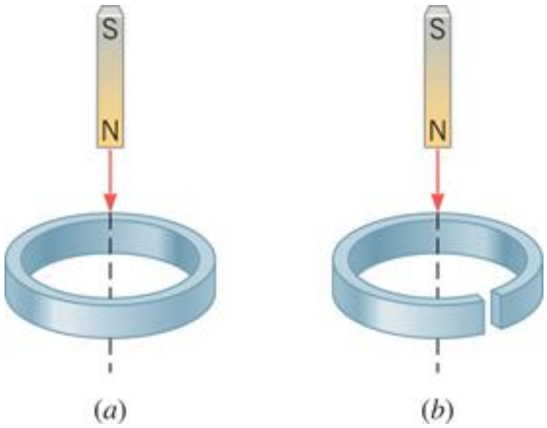
Solution for Problem 17

18. A circular loop of wire rests on a table. A long, straight wire lies on this loop, directly over its center, as the drawing illustrates. The current *I* in the straight wire is decreasing. In what direction is the induced current, if any, in the loop? Give your reasoning.



Solution for Problem 18

19. The drawing shows a bar magnet falling through a metal ring. In part *a* the ring is solid all the way around, but in part *b* it has been cut through. **(a)** Explain why the motion of the magnet in part *a* is retarded when the magnet is above the ring and below the ring as well. Draw any induced currents that appear in the ring. **(b)** Explain why the motion of the magnet is unaffected by the ring in part *b*.



Solution for Problem 19

20. A 120.0-V motor draws a current of 7.00 A when running at normal speed. The resistance of the armature wire is 0.720 Ω. **(a)** Determine the back emf generated by the motor.
(b) What is the current at the instant when the motor is just turned on and has not begun to rotate? **(c)** What series resistance must be added to limit the starting current to 15.0 A?

Solution for Problem 20

21. A generator has a square coil consisting of 248 turns. The coil rotates at 79.1 rad/s in a 0.170-T magnetic field. The peak output of the generator is 75.0 V. What is the length of one side of the coil?

Solution for Problem 21

22. A small rubber wheel on the shaft of a bicycle generator presses against the bike tire and turns the coil of the generator at an angular speed that is 38 times as great as the angular speed of the tire itself. Each tire has a radius of 0.300 m. The coil consists of 125 turns, has an area of 3.86×10^{-3} m^2, and rotates in a 0.0900-T magnetic field. The bicycle starts from rest and has an acceleration of + 0.550 m/s^2. What is the peak emf produced by the generator at the end of 5.10 s?

Solution for Problem 22

23. The earth's magnetic field, like any magnetic field, stores energy. The maximum strength of the earth's field is about 7.0×10^{-5} T. Find the maximum magnetic energy stored in the space above a city if the space occupies an area of 5.0×10^{8} m^2 and has a height of 1500 m.

Solution for Problem 23

24. Mutual induction can be used as the basis for a metal detector. A typical setup uses two large coils that are parallel to each other and have a common axis. Because of mutual induction, the ac generator connected to the primary coil causes an emf of 0.46 V to be induced in the secondary coil. When someone without metal objects walks through the coils, the mutual inductance and, thus, the induced emf do not change much. But when a person carrying a handgun walks through, the mutual inductance increases. The change in emf can be used to trigger an alarm. If the mutual inductance increases by a factor of three, find the new value of the induced emf.

Solution for Problem 24

25. Suppose you wish to make a solenoid whose self-inductance is 1.4 mH. The inductor is to have a cross-sectional area of 1.2×10^{-3} m^2 and a length of 0.052 m. How many turns of wire are needed?

Solution for Problem 25

26. The secondary coil of a step-up transformer provides the voltage that operates an electrostatic air filter. The turns ratio of the transformer is 50:1. The primary coil is plugged into a standard 120-V outlet. The current in the secondary coil is 1.7×10^{-3} A. Find the power consumed by the air filter.

Solution for Problem 26

27. The rechargeable batteries for a laptop computer need a much smaller voltage than what a wall socket provides. Therefore, a transformer is plugged into the wall socket and produces the necessary voltage for charging the batteries. The batteries are rated at 9.0 V, and a current of 225 mA is used to charge them. The wall socket provides a voltage of 120 V. **(a)** Determine the turns ratio of the transformer. **(b)** What is the current coming from the wall socket? **(c)** Find the average power delivered by the wall socket and the average power sent to the batteries.

Solution for Problem 27

28. A generating station is producing 1.2×10^6 W of power that is to be sent to a small town located 7.0 km away. Each of the two wires that comprise the transmission line has a resistance per kilometer of 5.0×10^{-2} Ω/km. **(a)** Find the power used to heat the wires if the power is transmitted at 1200 V. **(b)** A 100:1 step-up transformer is used to raise the voltage before the power is transmitted. How much power is now used to heat the wires?

Solution for Problem 28

Dr. Donovan's Classes Page	Dr. Donovan's PH 202 Homework Page
NMU Physics Department Web Page	NMU Main Page

Please send any comments or questions about this page to ddonovan@nmu.edu

This page last updated on January 6, 2021