Answers to selected problems from Essential Physics, Chapter 20

1. (a) $3 > 4 > 1 = 2$ (b) $3 > 1 = 2 > 4$

3. (a) Yes, if there continues to be no magnetic field passing through the loop.
   (b) Yes, if the magnetic field through the loop is changing with time, and just happens to be passing through zero at this one instant.

5. There is no induced current.

7. To the right.

9. $2 > 1 > 3$

11. "A non-zero potential difference when the switch closes that quickly drops to zero." In this situation, closing the switch results in the magnetic flux through the transformer coil changing from zero to some non-zero, but constant, value. Thus, there is only an induced emf momentarily, while the flux is changing.

13. (a) 9.0 mV   (b) 0   (c) 7.8 mV

15. $t_C > t_B > t_A = t_D$

17. (a) No change. In this case, the flux depends only on the field and on the area of the loop.   (b) The maximum emf increases by a factor of 3, because moving the loop across the field boundaries 3 times faster increases the rate of change of the magnetic flux through the loop by a factor of 3.   (c) The maximum induced current also increases by a factor of 3. It is proportional to the induced emf, by Ohm's Law.

19.   (a) This is possible if the current is increasing in magnitude. To oppose the extra field lines that pass through the loop out of the page, the induced current generates a magnetic field that is into the page – this requires a clockwise current.
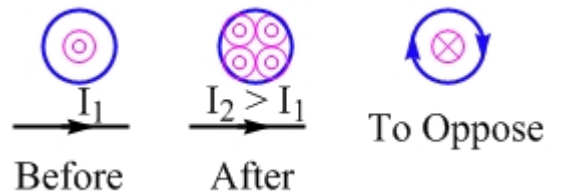

   (b) This is possible if the current is decreasing in magnitude. To oppose the loss of field lines that pass through the loop into of the page, the induced current generates a magnetic field that is into the page – this requires a clockwise current.
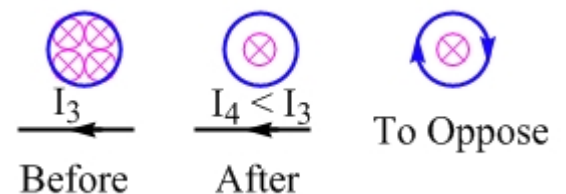
23. (a) The induced emf is the same at all three times. The induced emf depends on the time rate of change of the magnetic flux, which is the slope of the graph. Because the flux vs. time graph has a constant slope, the induced emf has a constant value.
(b) 5.0×10^{-4} V

25. (a)

Induced emf (V)
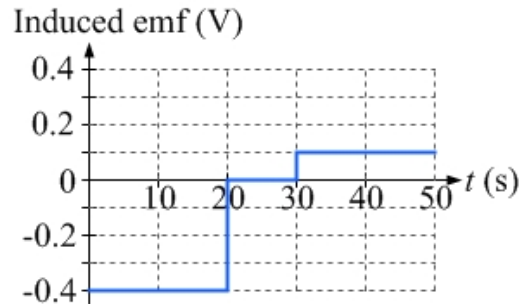
(b) clockwise

(c) clockwise

(d) counterclockwise

29. The rod will be moving faster in the first experiment, when the switch is open. When the switch is closed, in experiment 2, an induced current flows through the rod. The magnetic field acts on this current to exert a force to the left on the moving rod, reducing the rod's acceleration to the right.

31. 90 V

33. 4.8×10^{5} rad/s

35. (a) We expect the current associated with the back emf to subtract from the original current. This is consistent with Lenz's law, in which loops tend to oppose whatever is causing the flux to change through them, which in this case is the spin because of the original current.
   (b) The net current drops as the motor speed increases. Thus, the lights in your house dim briefly initially, when there is no induced current associated with the back emf, and the net current through the device is large. When the net current in the device drops after a few seconds, the lights return to normal brightness.

37. (a) 12 A (b) 80 W (c) The input power is 240 W. If the computer used 80 W, the remaining 160 W must be dissipated in the transformer itself, raising the temperature of the transformer.

39. (a) The standard European outlet supplies 240 V, while the standard American outlet supplies 120 V. Devices are generally designed to operate with either one or the other of these voltages, but not both.   (b) 2:1
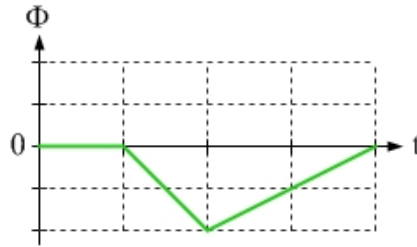
41. (a) 3.0×10^{-4} T m^2 (b) 70.5°

43. (a) 0.80 A counterclockwise   (b) 0.80 A clockwise   (c) 0.80 A clockwise
    (d) 1.6 A counterclockwise

45. The direction of the induced current is clockwise.

Before   After   To Oppose

47. (a)

(b) Multiple graphs are possible. What matters is the slope of the graph in the different regions. You can slide the entire graph up or down, to give a much different flux graph, while still producing the same graph of induced emf.

51. (a) Counterclockwise (b) The net force is down, away from the long straight wire (c) The net force causes the loop to move away from the wire, toward a region of reduced flux. This is completely consistent with Lenz's law. The increased current in the long straight wire causes the magnetic flux through the loop to increase. By Lenz's law, the induced current produces a force that attempts to bring the flux through the loop back toward its original value.

53. (a) $I = \dfrac{\varepsilon}{R}$, clockwise (b) $F_{net} = \dfrac{\varepsilon LB}{R}$, to the right (c) $I = 0$ (d) $F_{net} = 0$

(e) $v = \dfrac{\varepsilon}{BL}$, to the right

55. (a) left-to-right   (b)

Initially   Terminal velocity
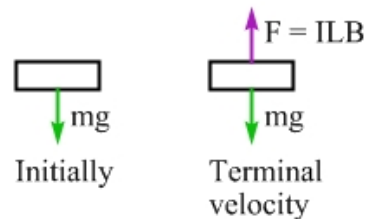
(c) $v = \dfrac{mgR}{B^2 L^2}$

(d) The brightness of the bulb increases as the rod accelerates, and then the bulb maintains a steady glow after the rod has reached its terminal velocity.

57. The train would still slow down, which makes sense from the perspective of energy conservation. Reversing the field reverses the direction of the swirling eddy currents, but reversing both the current and the field keeps the forces in the same direction. Thus, the forces still act to slow the rotation rate of the wheels, which slows the train.

59. In a solid core, the changing magnetic flux in the core tends to produce eddy currents that circulate in planes that are perpendicular to the direction of the magnetic field passing through the core. These currents give rise to a magnetic field that tends to reduce the time rate of change of the magnetic field in the core, reducing the induced emf in the secondary coil. With laminated sheets, the eddy currents are confined to tiny swirls within each sheet, minimizing their negative impact.