Chapter 23 Solutions – Problems 1, 3, 6, 7, 9, 13, 17, 19, 23, 25, 27, 30

9. Imagine a bar of iron on which are wound 2 coils. One coil is called the primary, and the other is called the secondary. A change in current through the primary causes the magnetic flux through the bar to change. This changing flux also passes through the secondary and induces a voltage in the secondary. (Remember that the area of a loop is (pi)r^2. Therefore,

   Magnitude of E_{ind} = (500 loops) (0.62 T)(pi)(0.0040 m)^2/(0.03 s) = 0.52 V

13. Flux can change either because 1) the area through which the field passes changes, 2) the field itself changes, or 3) both the area and the field change. In this problem, the magnetic field stays constant, but the area changes. From the sketch, observe that in a time interval delta *t*,

   the change in area = (0.045 m)(*v*)(delta *t*).

   a. Therefore, substituting numbers into Faraday's law, with *v* = 0.20 m/s,

   $$\frac{\Delta\phi}{\Delta t} = B\frac{\Delta A}{\Delta t} = (0.25)\frac{(0.045)(0.20)\Delta t}{\Delta t} = 2.25\times 10^{-3}\ \mathrm{V}$$

   .

   b. The numerical answer to a) is the emf. Since the downward pointing flux is decreasing in magnitude, the induced emf and current will act to try to retard this shrinking flux. The induced current (by Lenz's law) creates a downward pointing magnetic field through the loop and this implies a clockwise current.

   c. If R = 0.020 ohms, then current = V/R = (0.00225 V) /(0.020 ohms) = 0.11 V.

17. The turn ratio in an ideal transformer is equal to the ratio of the voltages. The turn ratio must therefore be (120 V)/(9.0 V). A backwards connection would step up the voltage instead of stepping it down. The stepped up voltage would be (120/9) x 120 V, or 1600 V.

19. a. This is a step-up transformer since there are more turns on the secondary than on the primary.

    b. Since the ratio of secondary to primary turns is 20 to 1, the output voltage is 20 times larger than the input voltage. Thus, an input of 120 V results in an output of V_{out} = 20 x 120 V = 2400 V.

23. When the motor runs, it produces ¼ hp. Using the conversion factor 1 hp = 746 J, we know that the power used by the motor is (1/4)(746) = 186.5 watts. There is also a small power loss in the resistance of the motor, but neglecting it will give a close approximation the total

power. Since power = IV, the current is

I = (186.5 W)(110 V) = 1.7 A.

Now, to get the back emf, we use the loop equation, substituting the approximate current. The circuit loop contains the 110 volt source, the small resistance and the motor. The small resistance produces a voltage drop of IR = (1.7 A)(0.59) = 0.85 V, and the motor has a back emf that must account for the rest of the total drop. The loop equation is then 110 – IR – emf = 0, giving an emf = 109.15 V.

Correcting for the power loss in the resistance is not all that hard. The power output of the motor plus the power lost in the resistance is the total power supplied by the source. Thus

$186.5\text{ W} + I^2R = IV$.

The resulting equation is

$186.5 + 0.5\, I^2 = 110\, I$,

leading to the result I = 1.72 A and a back emf of 109.14 V, almost the same as before.