HW #8 Solutions

Ch. 21

Q6) a) The current moves through R_B from right to left. Using the right hand rule for solenoids, the left side of coil B is a north pole. Over by coil A, the field due to coil B is pointing from right to left inside coil A. As coil B moves closer to coil A, the strength of this field increases, as does the flux. By Lenz' Law the induced current in coil A should create a magnetic field that opposes the increase in flux, so the field from the induced current should point from left to right in coil A. In other words, the right side of coil A should be a north pole. Then the current in resistor A goes from left to right.

Another way to decide about the current direction is to note that the field produced by coil A should push against coil B as it is moved toward coil A. Since the right side of coil B is a S pole, it makes sense that the left side of coil A should also be a S pole.

b) If coil B is moved away, everything is reversed, so the current through resistor A goes from right to left.

c) If the resistance is increased, the current decreases. In terms of the field at coil A, this is the same as if coil B is moving away from coil A, so the answer is the same as the answer to b), namely the current goes from right to left.

Q10) The armature is turning CW, and the induced current is going into the page on the left side of the loop (segment ab) and coming out of the page on the right side (segment cd). The magnetic field points from left to right. By the right hand rule, the force on segment ab is down, and the force on segment cd is up. These two forces cancel, but the torques due to the forces do not. The torque is in the CCW direction and so opposes the spinning of the armature.

Q13) There are fewer eddy currents in the slotted bar because the slots prevent large circular paths. Eddy currents obey Lenz's Law, so if there are less eddy currents, there will be a weaker force opposing the motion of the bar.

P1) $$\varepsilon = -\frac{2\Delta\Phi_B}{\Delta t} = -\frac{2\cdot(38-(-50)Wb)}{0.42s} = -419 volts$$

I have included the minus sign, but it really is not necessary, and contains no meaningful information. It is there to tell us that the emf would produce a current in a direction so as to *oppose* the change in flux, but whether the emf is a positive or negative number does not matter for our purposes.

P2) As the loop is pushed in to the field, the number of field lines through the loop pointing into the page increases. To oppose this increase in flux, the induced current must produce a field out of the page. By the right hand rule, the induced current in the loop is CCW.

P5)

$$\varepsilon = -\frac{\Delta\Phi_B}{\Delta t} = -\frac{BA\cos\theta_f - BA\cos\theta_i}{\Delta t} = -\frac{(1.5T)\cdot(\pi\cdot(0.06m)^2\cos 90^\circ - (1.5T)\cdot(\pi\cdot(0.06m)^2\cos 0^\circ}{0.20s}$$

$$= \frac{0.017Wb}{0.20s} = 0.085 volts$$

Again, whether the emf is positive or negative does not matter.

P8) a) The field inside the big coil (and the small coil) points out of the page (by the RHR). If the resistance is increased, the current will decrease, so the field is getting weaker. The current induced in the small coil will oppose the weakening of the field, so it will point out of the page. Thus the current induced in the small coil will be CCW.

b) To the left of the large coil the field is pointing into the page, so the answer is reversed. The induced current will be CW.

P10) The right side of the solenoid is a N pole and the left side is a S pole, so the field through the loop points from left to right, i.e. toward the S pole. This field is weakening as the solenoid is moved to the right, so the induced current must produce a field from left to right through the loop. By the right hand rule the current is flowing CCW, looking at the loop from the solenoid side.

P11) a) The flux is BA. $A = \pi r^2 = \pi\cdot(0.06\text{m})^2 = 0.0113\ \text{m}^2$. The change in flux is $\Delta B \cdot A = (0.97\ \text{T}) \cdot (0.0113\ \text{m}^2) = 0.011$ Wb. The emf is 0.011/0.180s = 0.061 volts.

b) Imagine looking at the loop and seeing the field going away from you. After 0.180 s the field is now coming toward you. To oppose this change, the induced current should create a field that goes away from you. By the RHR, the current will be CW around the loop.

P13) a) The flux through the coil is decreasing because the area is decreasing. To make up for this decrease, the induced current must produce a B field into the paper inside the loop, thus the current must be clockwise.

b)

$$\varepsilon = -\frac{\Delta\Phi_B}{\Delta t} = -\frac{BA_f - BA_i}{\Delta t} = -\frac{(0.75T)\cdot(\pi\cdot(0.03m)^2 - (0.75T)\cdot(\pi\cdot(0.10m)^2}{0.50s}$$

$$= \frac{0.021Wb}{0.50s} = 0.043 volts$$

Again, I have left in the minus sign, which in this case gets cancelled, but when using this formula the minus sign is only there to remind us about Lenz's Law.

c) $$I = \frac{\varepsilon}{R} = \frac{0.043}{2.5} = 0.017A$$

P18)

a) To find current we need to know the emf and the resistance. The length of the wire is $2\pi r N = 2\cdot\pi\cdot(0.11\text{m})\cdot 20 = 13.8$ m. The cross sectional area of the wire is $\pi r^2 = \pi\cdot(0.0026/2)^2 = 0.0000053\ \text{m}^2$. The resistivity of copper is 1.68×10^{-8} ohm·m. So
$R = (1.68 \times 10^{-8}\ \text{ohm}\cdot\text{m})\cdot(13.8\ \text{m})/(0.0000053\ \text{m}^2) = 0.044\ \Omega$.

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t} = -20\left(\frac{\Delta BA}{\Delta t}\right) = -20\pi(.11m)^2\left(\frac{\Delta B}{\Delta t}\right) = -20\pi(.11m)^2(0.00865\tfrac{T}{s}) = -0.0066V.$$

We ignore the minus sign, it has no physical meaning, so the current is 0.0066 V/0.044 Ω = 0.15 A.

b) The rate at which thermal energy is produced is the power = I^2R = 0.00099 W.

P23) The peak voltage produced by the coil is NBωA, so 120 volts = 320·0.65·ω·$(0.21)^2$. Solving we get ω = 13.1 s^{-1}. Thus the frequency is 13.1/2π = 2.1 Hz.

P36) The output voltage is 120 V · 1340/330 = 487 V. Assuming 100% efficiency, the input power equals the output power so $V_{in}I_{in} = V_{out}I_{out}$. Solving for I_{in} gives 487·15/120 = 61 A.