Solution for EMI Practice Problems

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Question 1

$$\phi = \text{BA}cos\theta \text{ where the angle is between the area vector and the magnetic field lines}$$
$$\phi = 0.5T \times (0.2m)^2 cos0^0$$
$$\phi = 0.02\text{Wb}$$

Question 2
We know that magnetic flux is the magnetic flux multiplied by the area. The area of a circular loop of conductor is given by: πR^2
$$\phi = \text{BA}cos\theta$$
$$\phi = B\pi R^2$$

Question 3
The angle given in this question is the angle between the Area Vector and the magnetic field. As we have seen in class, the component that produces the flux is adjacent to the angle thus being B$\cos\theta$.

$$\phi = BAcos\theta$$
$$\phi = 2T \times (0.4m)^2 \times cos60^0$$
$$\phi = 0.16Wb$$

Question 4
According to Lenz's law we know that the induced current works ao as to oppose the change causing it. In our case here, the cause is the motion of the loop of wire, thus the according to Lenz's law we know that the induced current will be opposing any type of motion that caused the change in flux.
Question 5
For current to be induced in the wire, we need motion. Just holding the wire at a distance will produce no flux change, therefore, there will be no current in the ring. More information is required if there is motion or not.
Question 6
Same as Question 5.
Question 7
If the magnetic field suddenly disappears, Lenz's law tells us that the induced current will do the opposite of that. Meaning, the induced current will create a magnetic field to oppose what happened and will create a magnetic field out of the page. For such a magnetic field to be created, we can use right hand rule and see that the current should be in the the counterclockwise direction.
Question 8
This question is the opposite of the case in Question 7. If the magnetic field grows stronger, the induced current will act in such a way that it will oppose the increase. If an into the page magnetic field is increasing, the current will produce an out of the page magnetic field and for that to happen, the current should be counterclockwise.
Question 9
Each charge in the wire ML experiences a magnetic force of magnitude $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$. The negatively charged electrons will accelerate in response to this force. Since they cannot leave the wire, negative charge will accumulate on one end of the wire, while positive charge will be left behind on the other end. In our case here, the direction force on the negative charges will be $\mathbf{F} = -\hat{i} \times -\hat{k} = -\hat{j}$. The direction of the force on our positive charges will be $\mathbf{F} = +\hat{i} \times -\hat{k} = \hat{j}$. Thus our positive charges will be accumulating at the top of the wire around M since the force is upwards on them while our negative charges will accumulate around L since the force on them is downwards. This will create a potential difference where M is on higher potential and L is on Lower.
Question 10
Similar to the explanation in Question 9, we will find M to be accumulation of the negative charges making it

at a lower potential while L is going to be at higher potential.

Question 11

We know that this is the case for motional EMF and thus,

$$\varepsilon = Blv = Bav \text{... since l=a in our case}$$
$$I = \frac{\varepsilon}{R} = \frac{Bav}{R}$$

As we have seen in questions above, the current will be from higher potential to lower potential and thus it will be counterclockwise.

Question 12

Magnetic force, according to Ampere's law is given by:

$$\text{F} = \text{BIl} = \text{BIa}$$

We have calculated the current in Question 11, substituting, we get:

$$F = B \times \frac{Bav}{R} \times a = \frac{B^2a^2v}{R}$$

The direction of the force is given by Ia×B=$-\hat{j} \times -\hat{k} = \hat{i}$ which means that the force is in the direction of the motion.

Question 13

$$\phi_i = 0.5T \times 0.2m^2 \times \sin 90^0 = 0.1Wb$$
$$\phi_i = 0.5T \times 0.2m^2 \times \sin 0^0 = 0Wb$$
$$\varepsilon = -\frac{\Delta\phi}{\Delta t} = -\frac{0.1Wb}{0.1s}$$
$$\varepsilon = 1.0V$$

Question 14

If there is an induced current **I** in a wire with a resistance of **R**, we can say that the induced emf is **IR**. We know, according to Faraday's law that:

$$\varepsilon = -\frac{\Delta\phi}{\Delta t} = \frac{A\Delta B}{\Delta t} = A \times \frac{\Delta B}{\Delta t}$$
$$\varepsilon = A \times \frac{\Delta B}{\Delta t}$$
$$\frac{\Delta B}{\Delta t} = \frac{\varepsilon}{A} = \frac{\mathbf{IR}}{a^2} \text{ ... since the Area, A=a}^2$$

Question 15

There is no current induced in this case because we have seen that the velocity and magnetic field have to be perpendicular.

Question 16

Consider the magnetic field is out of the page

When the loop enters the field, a clockwise current will be induced in the wire. The force on the wire will be F=$Il \times B = -\hat{j} \times \hat{k} = -\hat{i}$ as it enters the loop and F=$Il \times B = \hat{j} \times \hat{k} = \hat{i}$ as it leaves. Thus, the force will be to the left as it enters and to the right as it leaves.

Question 17

The force on the positive charges is given by F=$+\hat{i} \times \hat{k} = -\hat{j}$ while the force on the negative charges is F=$-\hat{i} \times \hat{k} = \hat{j}$ and thus the positive charges accumulate at the bottom(L) of the wire while the negative charges accumulate at the top(M).

Question 18

We know when the switch is closed, the current will go through a counterclockwise path in loop 1. However, in loop 2, the current induced will be due to mutual inductance and it works to oppose the cause. The cause is a flux of out of the page in loop 2 and the current in loop 2 will create a magnetic field into the page according to Lenz's law. For that to be the case, the current should be clockwise.

Question 19

The only case that will not produce current in loop 2 is when we rotate it with respect to its axis when switch is closed for a long time because no change in flux will occur. In the other cases, there will always be a change in flux, so EMF will be induced.

Question 20

When the magnet passes through the coil it will face opposition from the coil of wire according to Lenz's law and thus its acceleration will decrease and be less than g.