Week 9 Homework

Physics 1B

March 7, 2007

1 Serway C20.9

Direction of eddy currents: Upon entry into the field, the change in flux is directed into the page. An eddy current is induced to oppose this magnetic flux, so the current it induces creates a field directed out of the page. Therefore, the current is counterclockwise. Upon exit from the field, the change in flux is directed out of the page. Therefore, to oppose this flux change, the eddy current is clockwise. From right hand rule 1, we see that the force on the rightmost part of the slab upon entering the field is parallel to the base, directed away from the region of the magnetic field. Upon leaving the field, the force is directed into from the field region, also parallel to the base.

2 Serway C20.10

An emf will only be induced in the loop if there is a change in flux through the loop. Since the current through the transmission line is an alternating current, it periodically switches directions. This will change the magnetic field in time, creating a magnetic flux. The magnetic field lines due to a long straight wire circle around the wire. Therefore, the ideal orientation of the loop would position the field created by the straight wire to be perpendicular to the plane of the loop (this would maximize the flux through the loop when the current changed directions). You could put the loop around the transmission line, but you wouldn't want the cross-sectional area of the transmission line to be parallel with the loop.

3 Serway C20.14

It is not possible to have a constant emf without having infinite fields or areas, which are not physically possible.

4 Serway C20.19

The current induced is left to right through the resistor. The straight wire produces a magnetic field into the page at the location of the circuit. This magnetic field decreases as the current is turned off. Therefore, the change in flux due to this decrease is out of the page. To oppose this change in flux, a current is induced in the loop to create a change in flux in the opposite direction: into the page. Right hand rule 2 shows that to produce a magnetic field into the page, the current through the resistor must move left to right.

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16. $\mathcal{E} = -N \dfrac{\Delta \Phi_B}{\Delta t}$

$\Delta \Phi_B = \Delta B_\perp \cdot A$

$= (-2.2\ T)(100\ cm^2 \cdot \dfrac{1\ m^2}{100^2\ cm^2})$

$= -2.2 \times 10^{-2}\ T \cdot m^2$

$N = 200$

$\Delta t = 0.10 s$

$\mathcal{E} = -200 \dfrac{(-2.2 \times 10^{-2}\ T \cdot m^2)}{0.10\ s}$

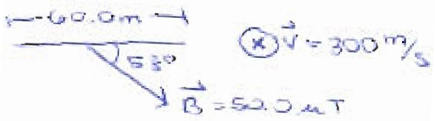
$= 44\ V$

$\mathcal{E} = IR$

$I = \dfrac{44 V}{5.0\ \Omega}$

$\boxed{I = 8.8\ A}$

19.

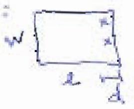


In equilibrium, electric force $F_e = qE$ due to charge separation = magnetic force $F_m = qvB_\perp$. Potential difference $\Delta V = E\ell = vB_\perp \ell$

$\Delta V = (300\ m/s)(50.0 \times 10^{-6}\ T) \sin 58° (60.0\ m)$

$\boxed{\Delta V = 0.763\ V}$

1B Week 9 HW

25. a) As the coil enters the magnetic field, say a distance d into the field: 

an emf of $\mathcal{E} = -N\dfrac{\Delta\Phi_B}{\Delta t} = -N\dfrac{Bwd}{\Delta t}$ is induced. This emf produces a current $I = \mathcal{E}/R$ in the loop. This current feels force of $F = NIwB$ due to the magnetic field. (We assume d is very small, so we neglect the force on the top and bottom of the loop). Noting $\Delta t = d/v$ and substituting,

$$F = N\left(\frac{\mathcal{E}}{R}\right)wB$$

$$= N\left(\frac{-NBwd}{R\,d/v}\right)wB$$

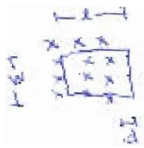
$$= -N^2B^2w^2v/R.$$

The magnitude of the force on the wire is $\boxed{F = \dfrac{N^2B^2w^2v}{R}}$.

The change in flux is directed into the page upon loop's entry to field region. The loop induces a current creating flux out of the page, so the current moves up the right side of the loop. This current feels a force to the left (rhr #2)

b) There is no change in flux when the loop is in the field, so the magnetic force is zero.

c) As it leaves the field, the force has the same magnitude as in part (a) (similar reasoning applies). Here the change in flux is directed out of the page, so the loop induces current creating flux into the page. Thus, the current on the left side of the loop moves up. The magnetic force on this current is to the left (rhr #2).



1B Week 9 HW

26. The battery produces current right to left through the resistor. This creates magnetic flux to the left along the axis of the cylinder. To oppose this flux, a current in the opposite direction is induced, traveling left to right through the resistor.

28. a) The instant the switch is closed, the battery creates a current which creates a magnetic field to the right. A current is induced in the other circuit to oppose this change in flux. This current moves left to right through the resistor

b) After several minutes, the current is not changing, so there is no change in flux. Thus, no current is induced through the resistor.

c) Opening the switch stops current in the left circuit, creating flux to the right. The other [illegible] circuit induces a current to oppose this change in flux. This current moves right to left through the resistor.

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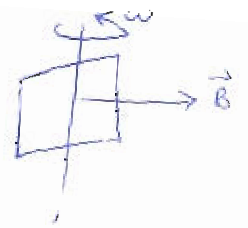
30.



$\mathcal{E}_{max} = NBA\omega$

$= (100)(2.0\times10^{-5}\,T)(0.040\,m^2)\left(2\pi \cdot 1500\,\frac{rad}{min} \times \frac{1\,min}{60\,s}\right)$

$\boxed{\mathcal{E}_{max} = 1.3\times10^{-2}\,V}$

34. a) $\mathcal{E}_{max} = NBA\omega$

$= (1000)(0.20\,T)(0.10\,m^2)\left(2\pi \cdot 60\,\frac{rad}{s}\right)$

$\boxed{\mathcal{E}_{max} = 7.5\times10^{3}\,V}$

b) Maximum induced voltage occurs when the magnetic field is parallel to the plane made by the loop.

46. a) $\tau = L/R$

$= \frac{8.00\times10^{-3}\,H}{4.00\,\Omega}$

$\boxed{\tau = 2.00\times10^{-3}\,s}$

b) $I = \frac{\mathcal{E}}{R}\left(1 - e^{-Rt/L}\right) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau}\right)$

$= \frac{6.00\,V}{4.00\,\Omega}\left(1 - e^{-250\times10^{-6}\,s/2.00\times10^{-3}\,s}\right)$

$\boxed{I = 0.176\,A}$

c) In steady state the current doesn't change so the inductor doesn't induce an opposing EMF.

$\therefore\ I = \frac{\mathcal{E}}{R} \longrightarrow \boxed{I = 1.5\,A}$

d) $I = \underbrace{\frac{\mathcal{E}}{R}}_{I_{max}}\left(1 - e^{-t/\tau}\right) \longrightarrow \frac{I}{I_{max}} = \left(1 - e^{-t/\tau}\right)$

$0.80 = 1 - e^{-t/2.00\times10^{-3}\,s}$

$\frac{-t}{2.00\times10^{-3}\,s} = \ln 0.20$

$\boxed{t = 3.22\,ms}$

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48. a) $L = \dfrac{\mu_0 N^2 A}{l}$

$$= \frac{(4\pi \times 10^{-7}\ T\cdot m/A)(300)^2[\pi(5.00\times 10^{-3}\ m)^2]}{20.0 \times 10^{-2}\ m}$$

$\boxed{L = 4.44\ mH}$

b) $PE_L = \frac{1}{2} L I^2$

$= \frac{1}{2}(4.44\times 10^{-3}\ H)(0.500\ A)^2$

$\boxed{PE_L = 0.555\ mJ}$