# *Physics 111 Homework Solutions for Friday 2/6 and Monday 2/9*

## *Friday, February 6, 2015*

### *Chapter 18*

### *Questions*

18.1 Since the number of magnetic field lines per unit area can be thought of as the strength of the magnetic field, then we can think of the magnetic flux as the total number of magnetic field lines that pass through a loop of wire that has cross sectional area A. The magnetic flux is given .as $\cos\theta BA_B = \Phi$ . In order to change the magnetic flux any one of the above three can change.

18.4

a) since the magnetic field is increasing into the page, by Faraday's law the current will be counter clockwise in order to oppose the changing magnetic flux.

b) Given the direction of rotation the current flow will initially be clockwise to oppose the decreasing magnetic flux. Then the current flow will change direction and become counter clockwise as the magnetic flux changes across the area of the coil. Thus the induced current will alternate its direction.

c) Since the coil is being stretched its area is changing and the magnetic field is decreasing, so the induced current is clockwise.

d) Since both the field and the coil rotate together, there is no change in magnetic flux through the coil, so the current induced is zero.

18.5

a) As the current increases steadily along the x-axis the magnetic flux will increase in the coil and there will be a counter clockwise induced current to oppose the change in flux.

b) If the current in the wire is constant and the coil moves downward the magnetic flux will decrease (since the magnetic field is decreasing) and there will be a clockwise induced current.

c) If the current is constant and the loop remains stationary then there is no change in magnetic flux and the induced current is zero.

d) If the current decreases and the coil moves downward then the magnetic field is decreasing as well as the magnetic flux. Thus there will be a clockwise-induced

### *Multiple-Choice*

18.2 A
18.3 A
18.4 C
18.5 B

***Problems***

18.5 For an order of magnitude estimate of the induced *emf* detected by a search coil near a long neuron is given by

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t} = \frac{\frac{\mu_0 I}{2\pi r}\times\pi a^2}{t} \approx \frac{\left(10\times10^{-7}\,\tfrac{Tm}{A}\right)\left(10\times10^{-12}\,A\right)\left(0.1m\right)^2}{2\left(0.01m\right)\left(1\times10^{-3}\,s\right)} \approx 1\times10^{-14}\,\mathrm{V}.$$

18.6 The emf is given by

$$\varepsilon = Bl\bar{v} = Bl\left(\frac{l\omega}{2}\right) = \tfrac{1}{2}Bl^2\omega$$

$$= \tfrac{1}{2}\times50\times10^{-6}T\times\left(2.5m\right)^2\times\left(4\,\tfrac{rev}{s}\times\frac{2\pi rad}{1rev}\right) = 0.00395M = 3.95mV$$

and here the average velocity of the blade was used since all parts of the blade do not experience the same translational speed through space.

An alternate solution $\varepsilon = \left|\frac{\Delta\phi_B}{\Delta t}\right| = \left|\frac{\Delta\left(BA\cos\theta\right)}{\Delta t}\right| = \left|\frac{B\Delta A}{\Delta t}\right| = \left|\frac{B(\Delta\theta)L^2}{2\Delta t}\right| = \left|\frac{B\omega L^2}{2}\right|$, where the fraction of the area of the circle swept out after a time $t > 0$ is given by $\Delta A = fraction \times A = \left(\frac{\Delta\theta}{2\pi}\right)\pi r^2 = \frac{(\Delta\theta)L^2}{2}$. Inserting the known values, we have that the induced potential difference across the bar is

$$\varepsilon = \left|\frac{B\omega L^2}{2}\right| = \left|\frac{50\times10^{-6}T\times25.1\,\tfrac{rad}{s}\times\left(2.5m\right)^2}{2}\right| = 0.00395V = 39.5mV.$$

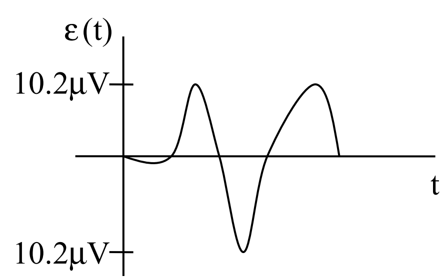
18.7 The *emf* is given by $\varepsilon = Blv$ so that the speed of the 737 would be

$$v = \frac{\varepsilon}{Bl} = \frac{1.5V}{50\times10^{-6}T\times40m} = 750\,\tfrac{m}{s}.$$

18.8 The emf is given as

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t} = -NB\cos\theta\frac{\Delta A}{\Delta t}$$

$$\varepsilon = -200\times50\times10^{-6}T\times\cos62\times\left(\frac{39cm^2\times\frac{1m^2}{\left(100cm\right)^2}}{1.8s}\right) = -1.02\times10^{-5}V = -10.2\mu V$$



## *Monday, February 9, 2015*

### *Chapter 18*

### *Questions*

18.6

a) If the current in the small coil is increasing as shown then the current in the large coil is ccw.
b) If the small coil is moving away then the flux is decreasing in the larger coil, so the induced current is cw.
c) If the large coil is moving toward the smaller coil then the flux through the larger coil is increasing and the induced current in the large coil is ccw.
d) If the small coil is rotated ccw around a vertical axis, then the induced current is alternating, first in the cw direction and then in the ccw direction.

18.8 As the north pole of the magnet approaches, the flux increases through the cross sectional area of the coil. To oppose this change in flux, the coil produces a magnetic field that points out. The direction of the induced current is ccw when viewed looking at the coil along the bar magnet (from S to N). As the magnet recedes the magnetic flux is decreasing and thus a current and a field will be produce to oppose this change. The induced current is cw viewed looking at the coil along the bar magnet (from S to N).

### *Multiple-Choice*

18.7 A
18.8 D
18.9 D

### *Problems*

18.11 The electric field is given as $\mathrm{E} = \frac{\varepsilon}{l} = \frac{vlB}{l} = vB = (2\,\tfrac{\mathrm{m}}{\mathrm{s}})(1.2\mathrm{T}) = 2.4\,\tfrac{\mathrm{N}}{\mathrm{C}}$.

18.12 The force needed to pull the rod is

$$F = IlB = \frac{\varepsilon}{R}lB = \frac{Blv}{R}lB = \frac{vl^2B^2}{R} = \frac{2\,\tfrac{m}{s}\times(0.2m)^2\times(1.2T)^2}{(100\Omega)} = 0.00115N = 1.15\mathrm{mN}.$$

18.14 The *emf* is given from Faraday's law as a motional *em*f, $\varepsilon = vlB$ where the velocity is obtained from the continuity of the fluid flow. We have the flow rate given as $Av = \pi r^2 v = 10\,\frac{\text{gallons}}{\text{min}}$ and converting 10 gallons to cubic meters we have

$$10\text{ gallons}\times\frac{3.78\text{ L}}{1\text{ gallon}}\times\frac{1\times10^{-3}\mathrm{m}^3}{1\text{ liter}} = 0.0378\mathrm{m}^3.$$ Therefore the velocity is

$$v = \frac{0.0378\mathrm{m}^3}{60\mathrm{s}}\times\frac{1}{\pi(0.1\mathrm{m})^2} = 0.020\,\tfrac{\mathrm{m}}{\mathrm{s}}$$ and the induced *emf* is

$$\varepsilon = (0.020\,\tfrac{\mathrm{m}}{\mathrm{s}})(0.2\mathrm{m})(0.05\mathrm{T}) = 0.2\mathrm{mV}.$$