Physics 111 Homework Solutions Week #6 - Wednesday

Friday, February 07, 2014

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

18.4 The magnetic field is given by $B(t) = 0.1 + 0.05t$ so that

$$\frac{\Delta B(t)}{\Delta t} = \frac{(5.1-0.1)\text{T}}{(100-0)\text{s}} = 0.05\tfrac{\text{T}}{\text{s}}$$ The induced *emf* is

$$\varepsilon = -\text{N}\frac{\Delta\Phi_B}{\Delta t} = -(7..85\times10^{-3}\,\text{m}^2)(0.05\tfrac{\text{T}}{\text{s}}) = -3.93\times10^{-4}\,\text{V}\,.$$

18.6The emf is given by

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

$$= \tfrac{1}{2}\times 50\times10^{-6}T\times(2.5m)^2\times\left(4\tfrac{rev}{s}\times\frac{2\pi rad}{1rev}\right) = 0.00395M = 3.95mV$$

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

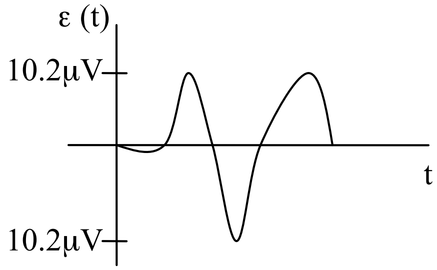
18.7 The *emf* is given by $\varepsilon = Blv$ so that the speed of the 737 would be

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

18.8 The emf is given as

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

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



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

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

18.14 The *emf* is given from Faraday's law as a motional *emf*, $\varepsilon = vlB$ 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

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

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

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

Monday, February 10, 2014

Questions

- None

Multiple-Choice

- None

Problems

- None

Tuesday, February 11, 2014

Chapter 19

Questions

19.2 Electromagnetic waves and waves on a string are similar in that they both are transverse waves that travel with a speed that is dependant on the material through which the waves pass. They are different in that electromagnetic waves do not need a material to propagate unlike waves on a string.

19.3 See Wednesday's class notes for the solution.

Multiple-Choice

19.1 D
19.2 D
19.3 C
19.4 D

Problems

19.1 The maximum electric and magnetic field amplitudes are related through $E_{\max} = cB_{\max} = 3\times10^{8}\,\tfrac{m}{s} \times 2\times10^{-7}\,T = 60\,\tfrac{N}{C}$.

19.2. Since $E_{\max} = cB_{\max}$ then $B_{\max} = \frac{E_{\max}}{c} = \frac{2\times10^{-4}\,\frac{N}{C}}{3\times10^{8}\,\frac{m}{s}} = 6.67\times10^{-13}\,T$ in the z-direction.

19.3. The intensity is given as $I = \frac{cB^2}{2\mu_0} = \frac{\left(3\times10^{8}\,\frac{m}{s}\right)\left(5\times10^{-7}\,T\right)}{2\left(4\pi\times10^{-7}\,\frac{Tm}{A}\right)} = 29.8\,\tfrac{W}{m^2}$.

19.15 The frequency is given as $f = \frac{c}{\lambda} = \frac{3\times10^{8}\,\frac{m}{s}}{5.5\times10^{-7}\,m} = 5.5\times10^{14}\,s^{-1}$.