Practice Test II

Problems from College Physics Giambattista

Chapter 19

38. The net force in the y-direction must be zero; use Newton's second law.

$\Sigma F_y = 0 = ILB\sin\theta - mg = 0,$ then

$$I = \frac{mg}{LB\sin\theta} = \frac{(0.025\text{ kg})\left(9.8\ \frac{\text{N}}{\text{kg}}\right)}{(1.00\text{ m})(0.75\text{ T})\sin 90°} = 0.33\text{ A.}$$

The magnetic force must be upward to oppose gravity, so according to the RHR and $\vec{\mathbf{F}} = I\vec{\mathbf{L}} \times \vec{\mathbf{B}},$ the current is 0.33 A to the left.

39. (a) Calculate the force on each wire segment.

$$\vec{\mathbf{F}}_{\text{top}} = I\vec{\mathbf{L}}_{\text{top}} \times \vec{\mathbf{B}} = (1.0\text{ A})(0.300\text{ m right}) \times (2.5\text{ T out of the page}) = \boxed{0.75\text{ N in the } -y\text{-direction}}$$

$$\vec{\mathbf{F}}_{\text{bottom}} = I\vec{\mathbf{L}}_{\text{bottom}} \times \vec{\mathbf{B}} = -I\vec{\mathbf{L}}_{\text{top}} \times \vec{\mathbf{B}} = \boxed{0.75\text{ N in the } +y\text{-direction}}$$

$$\vec{\mathbf{F}}_{\text{left}} = I\vec{\mathbf{L}}_{\text{left}} \times \vec{\mathbf{B}} = (1.0\text{ A})(0.200\text{ m up}) \times (2.5\text{ T out of the page}) = \boxed{0.50\text{ N in the } +x\text{-direction}}$$

$$\vec{\mathbf{F}}_{\text{right}} = I\vec{\mathbf{L}}_{\text{right}} \times \vec{\mathbf{B}} = -I\vec{\mathbf{L}}_{\text{left}} \times \vec{\mathbf{B}} = \boxed{0.50\text{ N in the } -x\text{-direction}}$$

(b) $F_{\text{net},\,x} = 0.50\text{ N} - 0.50\text{ N} = 0$

$F_{\text{net},\,y} = 0.75\text{ N} - 0.75\text{ N} = 0$

So, $\vec{\mathbf{F}}_{\text{net}} = 0.$

40. (a) Calculate the force on each wire segment.

$$\vec{\mathbf{F}}_{\text{top}} = I\vec{\mathbf{L}}_{\text{top}} \times \vec{\mathbf{B}} = (1.0\text{ A})(0.300\text{ m right}) \times (2.5\text{ T left}) = 0$$

$$\vec{\mathbf{F}}_{\text{bottom}} = I\vec{\mathbf{L}}_{\text{bottom}} \times \vec{\mathbf{B}} = -I\vec{\mathbf{L}}_{\text{top}} \times \vec{\mathbf{B}} = 0$$

$$\vec{\mathbf{F}}_{\text{left}} = I\vec{\mathbf{L}}_{\text{left}} \times \vec{\mathbf{B}} = (1.0\text{ A})(0.200\text{ m up}) \times (2.5\text{ T left}) = 0.50\text{ N out of the page}$$

$$\vec{\mathbf{F}}_{\text{right}} = I\vec{\mathbf{L}}_{\text{right}} \times \vec{\mathbf{B}} = -I\vec{\mathbf{L}}_{\text{left}} \times \vec{\mathbf{B}} = 0.50\text{ N into the page}$$

(b) $\vec{\mathbf{F}}_{\text{net}} = \vec{\mathbf{F}}_{\text{top}} + \vec{\mathbf{F}}_{\text{bottom}} + \vec{\mathbf{F}}_{\text{left}} + \vec{\mathbf{F}}_{\text{right}} = 0 + 0 + 0.50\text{ N out of the page} + 0.50\text{ N into the page} = 0$

Chapter 20

7. (a) The magnetic field is into the page at the loop and the electrons' average velocity is zero. So, there is $\boxed{\text{no magnetic force}}$ on the electrons, thus $\boxed{\mathcal{E} = 0}$ and $\boxed{I = 0}$.

(b) $\vec{\mathbf{v}} = 0.45\text{ m/s}$ to the right and $\vec{\mathbf{B}} = \dfrac{\mu_0 I}{2\pi r}$ into the page. $\vec{\mathbf{F}} = -e\vec{\mathbf{v}} \times \vec{\mathbf{B}},$ so the force on the electrons is down.

The force is perpendicular to the lengths of the top and bottom sides, so no current flows. The current flows upward in the left and right sides. Since the left side is closest to the wire, the magnetic field strength there is greater than that at the right side, thus the force is greater and the current flows $\boxed{\text{CW}}$.

Each vertical side acts like a battery with $\mathcal{E} = vBL.$ The net emf is

$$\mathcal{E}_{\text{net}} = vL(B_{\text{L}} - B_{\text{R}}) = \frac{\mu_0 IvL}{2\pi}\left(\frac{1}{r_{\text{L}}} - \frac{1}{r_{\text{R}}}\right).$$

$$\mathcal{E}_{\text{net}} = \frac{\left(4\pi \times 10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}\right)(6.8\text{ A})\left(0.45\ \frac{\text{m}}{\text{s}}\right)(0.023\text{ m})}{2\pi}\left(\frac{1}{0.090\text{ m}} - \frac{1}{0.113\text{ m}}\right) = \boxed{32\text{ nV}}$$

Calculate the current in the loop.

$$I_{\text{loop}} = \frac{\mathcal{E}_{\text{net}}}{R} = \frac{3.183 \times 10^{-8}\text{ V}}{79\ \Omega} = 400\text{ pA}$$

The magnetic force on the loop is given by $\vec{\mathbf{F}} = I_{\text{loop}}\vec{\mathbf{L}}\times\vec{\mathbf{B}}$. The top and bottom experience equal and opposite forces. The force on the left is to the left and on the right is to the right. Let positive be to the left. The net force is

$$F_{\text{net}} = I_{\text{loop}}L(B_{\text{L}} - B_{\text{R}})$$
$$= \frac{m_0 ILI_{\text{loop}}}{2p}\left(\frac{1}{r_{\text{L}}} - \frac{1}{r_{\text{R}}}\right)$$
$$= \frac{\left(4p\times10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}\right)(6.8\text{ A})(0.023\text{ m})(4.03\times10^{-10}\text{ A})}{2p}\left(\frac{1}{0.090\text{ m}} - \frac{1}{0.113\text{ m}}\right)$$
$$= 2.9\times10^{-17}\text{ N}$$

So, $\vec{\mathbf{F}} = 2.9\times10^{-17}\text{ N}$ $\boxed{\text{to the left}}$.

(c) The electric power dissipated in the loop is

$$P_{\text{E}} = I\% = (4.03\times10^{-10}\text{ A})(3.18\times10^{-8}\text{ V}) = \boxed{1.3\times10^{-17}\text{ W}}.$$

The rate at which the external force does work is

$$P_{\text{F}} = \frac{\Delta W}{\Delta t} = Fv = (2.85\times10^{-17}\text{ N})\left(0.45\ \frac{\text{m}}{\text{s}}\right) = 1.3\times10^{-17}\text{ W}.\ \text{Thus, } P_{\text{E}} = P_{\text{F}}.$$

19. $\%_2 = \frac{N_2}{N_1}\%_1 = \frac{200}{4000}(2.2\times10^3\text{ V}) = \boxed{110\text{ V}}$

20.

$$\frac{\%_2}{\%_1} = \frac{N_2}{N_1}$$
$$I_2 = \frac{N_1}{N_2}I_1 = 100(1.0\times10^{-3}\text{ A}) = 0.10\text{ A}$$

21.(a) $\frac{N_2}{N_1} = \frac{\%_2}{\%_1} = \frac{8.5\text{ V}}{170\text{ V}} = \boxed{\frac{1}{20}}$

(b) $N_1 = \frac{\%_1}{\%_2}N_2 = \frac{170\text{ V}}{8.5\text{ V}}(50) = \boxed{1000}$

41.(a) Find the maximum current that flowed through the inductor.

$$I = \frac{\%}{12\ \Omega} = \frac{6.0\text{ V}}{12\ \Omega} = 0.50\text{ A}$$

Calculate the stored energy.

$$U = \frac{1}{2}LI^2 = \frac{1}{2}(0.30\text{ H})(0.50\text{ A})^2 = \boxed{38\text{ mJ}}$$

(b) $P = I\%$ and $I = 0.50$ A (at $t = 0$).

$|\%|$ = the voltage drop across the resistors $= (0.50\text{ A})(30\ \Omega) = 15\text{ V}$

So, $P = -(0.50\text{ A})(15\text{ V}) = \boxed{-7.5\text{ W}}$, where $P < 0$ since the energy of the inductor is decreasing.

(c) Assume that $U_{\text{f}} \approx 0$.

$$P_{\text{av}} = \frac{\Delta U}{\Delta t} = \frac{0 - 38\times10^{-3}\text{ J}}{1.0\text{ s}} = \boxed{-38\text{ mW}}$$

(d) Solve for t when $I = 0.0010 I_0$.

$$I = I_0 e^{-t/t}$$

$$e^{t/t} = \frac{I_0}{I}$$

$$\ln e^{t/t} = \ln \frac{I_0}{I}$$

$$t = t \ln \frac{I_0}{I}$$

$$= \frac{L}{R_{\text{eq}}} \ln \frac{1}{0.0010}$$

$$= -\frac{0.30\text{ H}}{18\ \Omega + 12\ \Omega} \ln 0.0010$$

$$= \boxed{69\text{ ms}}$$

Since 69 ms << 1.0 s, the assumption in part (c) is valid.

Chapter 21

7. (a) The current alternates about zero in an ac circuit, so $I_{\text{av}} = \boxed{0}$.

(b) The average of the square of the current is $I_{\text{rms}}^2 = (2.50\text{ A})^2 = \boxed{6.25\text{ A}^2}$.

(c) $I = \sqrt{2} I_{\text{rms}} = \sqrt{2}(2.50\text{ A}) = \boxed{3.54\text{ A}}$

9. (a) $P_{\text{av}} = 1200\text{ W}$ and $V_{\text{rms}} = 120\text{ V}$. Calculate R.

$$R = \frac{V_{\text{rms}}^2}{P_{\text{av}}} = \frac{(120\text{ V})^2}{1200\text{ W}} = \boxed{12\ \Omega}$$

(b) Use Ohm's law.

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{R} = \frac{120\text{ V}}{12\ \Omega} = \boxed{10\text{ A}}$$

(c) The average power is half the maximum power.

$$P_{\text{max}} = 2P_{\text{av}} = 2(1200\text{ W}) = \boxed{2.4\text{ kW}}$$

Chapter 22

12. (a) The frequency, wavelength, and speed of EM radiation are related by $l f = c$.

$$f = \frac{c}{l} = \frac{3.00\times10^8\ \frac{\text{m}}{\text{s}}}{0.20\times10^{-9}\text{ m}} = \boxed{1.5\times10^{18}\text{ Hz}}$$

(b) According to Figure 22.6, the waves are $\boxed{\text{x-rays}}$.

13.(a) $\frac{790\text{ THz}}{380\text{ THz}} = 2.1 \approx 2^1$

The human eye can perceive $\boxed{\text{about one octave}}$ of visible light.

(b) Microwaves range from about 1 mm to 30 cm. The corresponding frequencies are

$$f = \frac{c}{l} = \frac{3.00\times10^8\ \frac{\text{m}}{\text{s}}}{1\times10^{-3}\text{ m}} = 3\times10^{11}\text{ Hz}$$

and

$$f = \frac{3.00\times10^8\ \frac{\text{m}}{\text{s}}}{30\times10^{-2}\text{ m}} = 1\times10^{9}\text{ Hz}$$

Then, $\dfrac{3\times10^{11}\text{ Hz}}{1\times10^{9}\text{ Hz}} = 300 \approx 2^{8.2}$.

So, the microwave region is $\boxed{\text{approximately 8 octaves}}$ wide.

Chapter 23

18. **(a)** Solving Snell's law for n_2 gives

$$n_1 \sin q_1 = n_2 \sin q_2$$
$$n_2 = n_1 \frac{\sin q_1}{\sin q_2}$$

For red light:

$$n_{\text{red}} = 1.000 \frac{\sin 26.00°}{\sin 10.48°} = \boxed{2.410}$$

For blue light:

$$n_{\text{blue}} = 1.000 \frac{\sin 26.00°}{\sin 10.33°} = \boxed{2.445}$$

(b) To get the ratio of the speeds, express the speeds using the indices of refraction.

$$n = \frac{c}{v} \rightarrow v = \frac{c}{n}$$

The ratio becomes

$$\frac{v_{\text{red}}}{v_{\text{blue}}} = \frac{c/n_{\text{red}}}{c/n_{\text{blue}}} = \frac{n_{\text{blue}}}{n_{\text{red}}} = \frac{\sin 10.48°}{\sin 10.33°} = \boxed{1.014}.$$

(c) With no dispersion, all colors would undergo the same refraction. $\boxed{\text{The diamond would be clear, with no color.}}$

19. For the longest visible wavelengths, $n_2 = 1.517$, and by Snell's law

$$n_1 \sin q_1 = n_2 \sin q_2$$
$$\sin q_2 = \frac{n_1}{n_2} \sin q_1$$
$$q_2 = \sin^{-1}\left(\frac{1.000}{1.517} \sin 55.0°\right) = 32.7°$$

Find q_3.

$$60.0° + 90.0° + a = 180.0° \rightarrow a = 30.0°$$
$$q_2 + (90.0° + q_3) + a = 180.0°$$
$$q_2 + q_3 + 30.0° = 90.0°$$
$$q_3 = 60.0° - q_2$$
$$= 60.0° - 32.7° = 27.3°$$

Use Snell's law again.

$$n_2 \sin q_3 = n_1 \sin q_4$$
$$\sin q_4 = \frac{n_2}{n_1} \sin q_3$$
$$q_4 = \sin^{-1}\left(\frac{1.517}{1.000} \sin 27.3°\right) = 44.1°$$

For the shortest visible wavelengths, set $n_2 = 1.538$ and follow the same process. Find q_2.

$$q_2 = \sin^{-1}\left(\frac{1.000}{1.538} \sin 55.0°\right) = 32.18°$$

Find q_3.

$$q_3 = 60.0° - 32.18° = 27.82°$$

Find q_4.

$$q_4 = \sin^{-1}\left(\frac{1.538}{1.000}\sin 27.82°\right) = 45.9°$$

The range of refraction angles is $\boxed{44.1° \le q \le 45.9°}$.

21. From Table 23.1, the index of refraction for diamond is 2.419, for air it is 1.000, and for water it is 1.333.

(a) The critical angle for diamond in air is

$$q_c = \sin^{-1}\frac{n_t}{n_i} = \sin^{-1}\frac{1.000}{2.419} = \boxed{24.42°}.$$

(b) The critical angle for diamond in water is

$$q_c = \sin^{-1}\frac{n_t}{n_i} = \sin^{-1}\frac{1.333}{2.419} = \boxed{33.44°}.$$

(c) Under water, the larger critical angle means that fewer light rays are totally reflected at the bottom surfaces of the diamond. Thus, less light is reflected back toward the viewer.

26. Solve for n_i in the critical angle equation.

$$q_c = \sin^{-1}\frac{n_t}{n_i}$$

$$\sin q_c = \frac{n_t}{n_i}$$

$$n_i = \frac{n_t}{\sin q_c} = \frac{1.20}{\sin 45.0°} = \boxed{1.70}$$

27. **(a)** The reflected light is totally polarized when the angle of incidence equals Brewster's angle.

$$q_B = \tan^{-1}\frac{n_t}{n_i} = \tan^{-1}\frac{1.333}{1.000} = 53.12°$$

The angle below the horizontal is the complement of this angle.

$$90° - 53.12° = \boxed{36.88°}$$

(b) For Brewster's angle, the reflected light is polarized perpendicular to the plane of incidence.

(c) When the angle of incidence is Brewster's angle, the incident and transmitted rays are complementary.

$$q_t = 90° - q_i = 90° - 53.12° = 36.88°$$

The angle below the horizontal is the complement of this angle.

$$90° - 36.88° = \boxed{53.12°}$$

29. **(a)** At Brewster's angle, the reflected and transmitted rays are perpendicular to each other. However, at angles greater than or equal to the critical angle, no rays are transmitted. So the critical angle is always greater than Brewster's angle, regardless of n_1 and n_2 (assuming $n_2 < n_1$).

(b) For $n_1 < n_2$ there is no critical angle, and

$$q_B = \tan^{-1}\frac{n_2}{n_1} > \tan^{-1}1 = 45°$$

So, $\boxed{q_B > 45°}$.

44. The mirror is concave, so $f = \frac{R}{2} = \frac{5.0\text{ m}}{2} = 2.5\text{ m}.$ Find the image location for each case using the mirror equation.

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$q = \left(\frac{1}{f} - \frac{1}{p}\right)^{-1}$$

Initially, $p = 2.0$ m.

$$q_{\text{initial}} = \left(\frac{1}{2.5\text{ m}} - \frac{1}{2.0\text{ m}}\right)^{-1} = -10\text{ m}$$

Finally, $p = 6.0$ m.

$$q_{\text{final}} = \left(\frac{1}{2.5\text{ m}} - \frac{1}{6.0\text{ m}}\right)^{-1} = 4.3\text{ m}$$

The image moves from 10 m behind the mirror to 4.3 m in front of it.