PHYS 202 OUTLINE FOR PART II
MAGNETISM

Magnetism

A. Magnets   S-13,14
     1. magnetic field (**B**) causes force on moving charge:

$$\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}, \quad \textbf{magnitude}: F = q\,v\,B\,\sin(\theta_{vB})$$

$$\textbf{direction}: \text{right hand rule: thumb} = \text{hand} \times \text{fingers}$$

     2. units: 1 Tesla = 10,000 Gauss = Nt sec/Coul meter

     3. mass spectrometer: $r = m\,v / q\,B$

B. Electromagnets   S-15
     1. magnetic field generated by moving charges

         (just like E acts on charges, E due to charges,

          just like g acts on masses, g due to masses)

$$B = (\mu_o/4\pi)\, q\,\mathbf{v} \times \mathbf{r}/r^2 \quad \text{(here } \mathbf{r} \text{ indicates UNIT VECTOR - direction only)}$$

           [qv can be replaced by $I\ell$, so B proportional to I]

     2. for a loop of current: $B = \mu_o\,N\,I / 2\,R$

C. Electric motor   S-16,17
     1. force on a wire: $F = I\,L\,B\,\sin(\theta_{IB})$
     2. electric meters: $\tau = r\,F\,\sin(\theta_{rF})$; $\tau = k\,\theta$ (spring)

          $(A = rL)$, so $N\,A\,I\,B = k\,\theta$,   or $I \propto \theta$.

     3. electric motors: $\tau = r\,F\,\sin(\theta_{rF}) = N\,A\,I\,B\,\sin(\theta_{IB})\,\sin(\theta_{rF})$

          $\tau_{avg} = N\,A\,I\,B\,(2/\pi)$; $P = \tau\,\Delta\theta/\Delta t$ so $P_{avg} = \tau_{avg}\,\omega = 4fNAIB$

Supplementary Problems (S-):

13. An electron is moving North with an initial speed of 2×10^5 m/s through a magnetic field directed down of strength 152 Gauss. a) What is the magnitude and direction of the magnetic force on the electron? b) What is the magnitude of the acceleration of the electron?

14.   A certain mass spectrograph consists of a magnet of strength .30 T and the (singly charged) ions are injected into the field with a speed of 4×10^5 m/sec. If the DIAMETER of the orbit of the ions is measured to be 44.2 cm, what is the mass in kilograms of each ion? in amu ?

15.   A current of 5 amps flows through a loop of wire that has 45 turns and a radius of 7 cm. What is the strength of the magnetic field at the center of the coil?

16.   Describe how an electric motor works.

17. An electric motor has 1000 windings wound around an area of 45 cm² in a magnetic field of 0.3 T. If a current of 5 amps flows through the windings, what is the (a) maximum torque produced? (b) average torque?

Answers to Supplementary Problems:

13. a) 4.86×10^{-16} Nt directed East; b) 5.35×10^{14} m/s².   14. 2.66×10^{-26} kg, 16 amu.

15. 2.02×10^{-3} T.   17. a) 6.75 Nt m; b)4.3 Nt m.

Induced Voltages and Inductance

A. Electric generators   S-18,19,20

    1. Faraday's law: $V = \Delta[B\, A \cos(\theta)]/\Delta t$

    2. electric generators:

        a) rotate wire in B field, so $\theta = \omega t$

        b) $V_{AC} = N\,B\,A\,\omega \sin(\omega t)$; $V_o = NBA\omega$

    3. inductors: $V_L = L\,\Delta I/\Delta t$;   and $E_{stored} = \frac{1}{2}\,L\,I^2$;   units for L: Henry
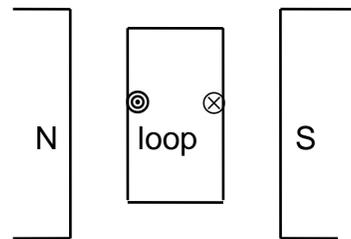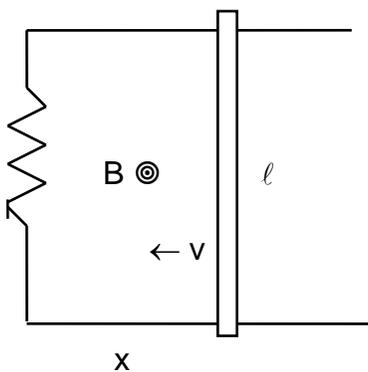
B. Light
    1. Electric Fields can cause currents which cause Magnetic Fields
    2. Magnetic Fields can cause Electric Fields when oscillating
    3. Get Electromagnetic Waves, which is what light can be identified as!

C. Biomagnetism

Supplementary Problems (S-):

18. Clearly draw in the **direction** of the induced current in each of the three diagrams, or write NONE if there is no induced current.

a) the external magnetic field through the loop is out of the paper and is constant in strength, the bar is moving to the left.

c) consider the induced current in the circuit labelled B due to the switch being opened in the circuit labelled A.

N | loop | S

B ◎ ℓ

← v

b) the loop is rotating so that the right side is moving into the paper and the left side is moving out of the paper.

A   B

S

+ -

V_{bat} R

x
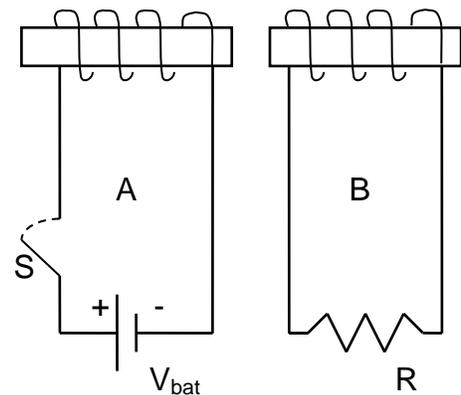
19.   Design an electric generator that will provide 120 volts rms.

20. Consider an inductor of 800 mH. a) How much current is required for 1 joule of energy to be stored in the inductor? b) If a constant DC current of 5 amps runs through the inductor, what is the voltage across the inductor? c) If an AC current of 5 amps at a frequency of 200 Hertz runs through the inductor, what is the induced voltage across the inductor?

Answers to Supplementary Problems:
20. (a) 1.581 amps; (b) 0 volts; (c) $V_L = 5{,}027 \sin[(1257 \text{ rad/sec})^*t]$ or 3554 volts-rms.

Alternating Current Circuits

A. A.C. Current   S-21

   1. sine waves: $V = V_{peak} \sin(\omega t)$

   2. average values:

       a) average $V = 0$ since average of $\sin(\theta) = 0$

       b) RMS: (root-mean-square) $V_{rms} = 2^{-\frac{1}{2}} V_{peak} = \sqrt{\frac{1}{2}} \approx .707 V_{peak}$

   3. power: $P_{inst} = IV$; $P_{avg} = I_{rms} V_{rms} = V_{rms}^2/R = \frac{1}{2} V_{peak}^2/R$

B. Circuit elements and impedence   S-22

   1. capacitive reactance: $X_c = 1/(\omega C)$ [in Ω's]

   2. inductive reactance: $X_L = \omega L$ [in Ω's]

   3. impedence: $Z = [R^2 + (X_L - X_c)^2]^{\frac{1}{2}}$, phase: $\theta = \tan^{-1}[(X_L - X_c)/R]$

   4. generalized Ohm's Law: $V_{rms} = I_{rms} Z$

   5. AC Power$_{avg}$ $= I_{rms}^2 R = I_{rms} V_{rms} \cos(\theta) \neq V_{rms}^2/Z$.

C. Household wiring & Safety

D. Bioelectricity

Supplementary Problems (S-):
21.   If the rms voltage of a household electrical receptical is 120 volts, what is the peak voltage at the outlet? If an rms current of 20 amps flows through a circuit hooked up to the outlet, what is the peak current? What is the average power flowing through the circuit? At 9 cents per kilowatt-hour, how much will it cost to run the circuit for 1 day? for one month (30 days) ?

22. Consider a series RLC circuit with an oscillating voltage source of 110 volts (rms) at 60 Hz. The resistance is 62 Ω, the capacitance is 16 μF, and the inductance is 90 mH. a) What is the capacitive reactance (X_C) ? b) What is the inductive reactance (X_L) ? c) What is the impedance (Z) of the circuit? d) What is the rms current throught this circuit? e) Explain why $V_{ac}(t) = V_L(t) + V_C(t) + V_R(t)$ but V_{AC-rms} does not equal $V_{L-rms} + V_{C-rms} + V_{R-rms}$.

Answers to Supplementary Problems:
21. 169.7 volts; 28.3 amps; 2400 Watts; $5.18 ; $155.20 .
22. (a) 165.79 Ω; (b) 33.93 Ω; (c) 145.7 Ω; (d) .755 amps-rms; (e) you are on your own!
HINT: consider conservation of energy, definition of voltage, and phase angles.