Physics 212 Twelfth week assignment:

Reading: Study sections 4 and 5 of chapter 21. In this connection you should refresh your memory of the material in waves which you studied in Physics 211.

. Finally, study sections 6 through 10 of chapter 21.

Tues, Nov 13: Lecture.

Homework problems to be handed in at the beginning of the Workshop on Wed, Nov 14: problems 29 and 33 of chapter 21.

Wed, Nov 14: In this Workshop you will have the opportunity to discuss a sample Exam 3. Copies will be distributed on a separate sheet.

Thurs, Nov 15: Exam 3. The material between exam 2 and exam 3 will be highlighted. However, as usual, you are still expected to remember the material before exam 2.

Homework problems to be handed in at the beginning of the Workshop on Fri, Nov 16: problems 35, 40 and 49 of chapter 21.

Fri, Nov 16: In this Workshop you will first consider question 14 on page 990. Next work on the "exercises on waves" on the other side of this sheet. Finally consider problem 45 of chapter 21.

Exercises on Waves: We will define a wave from the math point of view simply as some shape f(x) which travels with a constant velocity v.

a) Take the shape first to be a "bell curve", $f(x) = \exp(-x^2)$. Sketch this shape; you might use a calculator or a graphing calculator if you like but no need for much accuracy here.

b) Sketch the shape for $f(x-2) = \exp(-(x-2)^2)$. Recognize this as the shape which has been moved two units to the right. Now, why does f(x-vt) correspond to a wave which moves to the right with velocity v?

c) What is the interpretation of f(x+vt)?

d) Set u=x-vt and consider f(u). Note, by the chain rule df/dx =(df/du)(du/dx) =df/du. Also note that df/dt =-v df/du. (Here we keep t fixed when differentiating with respect to x and vice versa)

e) Take derivatives with respect to x and t again and verify $$\frac{\partial^2 f}{\partial x^2} - \frac{1}{v^2}\frac{\partial^2 f}{\partial t^2} = 0$$

This is called the "wave equation". Whenever we see this wave equation we are guaranteed that it has solutions which move any shape we like with uniform velocity.

f)An interesting example is f(u) =sin(ku)= sin(k(x-vt)). Sketch this shape as a function of x for t=0. Note that the function starts its second cycle past the origin when $k\lambda=2\pi$, defining the wavelength λ.

g)Sketch the above shape as a function of t for x=0. Note that the function starts its second cycle past the origin when $kv\tau = 2\pi$, defining the period τ. The frequency is given by $\nu=1/\tau$.

h) Evaluate the product $\nu\lambda$ from f) and g) above.

SAMPLE EXAM 3

1 Multiple choice questions; 25 points.

(a) Two long, straight, parallel wires are one meter apart. Each wire carries current of the same magnitude. The force between the two wires will:

A. push the wires apart.

B. pull the wires together.

C. pull the wires together if the currents are in the same direction.

D. pull the wires together if the currents are in opposite directions.

E. None of these.

(b) The red end of a girl scout compass points north when in the woods here in the U.S. If this same compass is taken to Australia, in their outback wilderness:

A. It will not work at all.

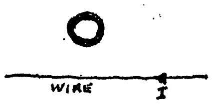
B. The red end will still point north.

C. The red end will now point south.

D. The red end will point east since Australia is so far west of us.

E. Assuming the compass interacts only with the magnetic field of the earth, any of these could be possible..

(c) A circular loop is placed directly above a straight wire. Both the loop and the wire are in the plane of this sketch. The current is flowing as shown. When this current decreases in magnitude, what will be the direction of the current, if any, induced in the loop?



A. Clockwise.

B. Counter-clockwise.

C. No current will be induced in this situation.

D. The induced current will flow perpendicular to the sketch and out of it.

E. None of these.

(d) If an emf of 0.60 V. were induced in a circuit where the current changes by 0.50 A in 0.40 seconds, the self inductance is:

A. 0.12 H.

B. 0.48 H.

C. 0.75 H.

D. (5/4) H.

E. None of these.

(e) You want to build a generator by spinning a coil in the Earth's magnetic field. At your location **B** is 5.5×10^{-5} T and is directed at 40° below the horizontal. The coil available to you has 200 turns and a cross-section area of $0.040\ m^2$. If you rotate this coil around a vertical axis, what emf will you generate?

at 60 Hz

A. 0.026 V.

B. 0.11 V.

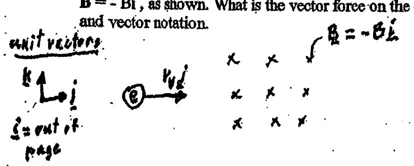
C. 0.13 V.

D. 0.17 V.

E. None of these.

2. (25 points).

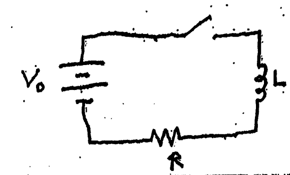
a) An electron (charge = -e) with velocity $v_y\,\mathbf{j}$ enters a region with uniform magnetic field $\mathbf{B} = -B\mathbf{i}$, as shown. What is the vector force on the electron? Use symbols and vector notation.



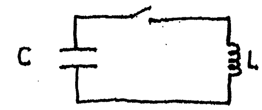
b) Denoting the electron mass as m, what is the acceleration of the electron and what is its direction (use vector notation) ? Explain why the electron should move in a circle. Sketch this circle and find its radius.

c) Now consider the case when the electron's velocity vector is given by $\mathbf{v} = v_x\,\mathbf{i} + v_y\,\mathbf{j}$. What is the force on the electron in this case? Use vector notation. Describe its motion.

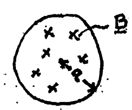
d) Sketch the graph of current vs. time after the switch is closed in the L-R circuit shown.



e) In the L-C circuit shown, the capacitor is initially charged to a potential, V_0. Sketch the graph of current vs. time in this case.



3. (25 points). A uniform magnetic field, B directed into the page exists within a wire loop of radius, a = 0.1 m. B is changing with time according to the formula $B = B_0 \cos(\omega t)$, with $B_0 = 2 \times 10^{-3}$ T and $\omega = 15$ rad/sec. The resistance, R of the wire loop is 0.3 Ω.

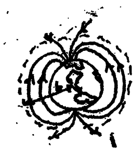


(a) What is the induced emf in the wire loop at any instant of time?

(b) What is the current in the wire at any instant of time?

(c) Sketch the graph of current vs. time. What is the *period* τ of this function I(t)?

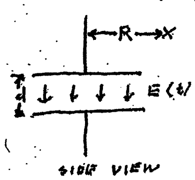
d) What is the power dissipated in the wire at each instant of time? Sketch the form of the graph.

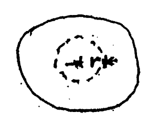


(e) The Earth and some of its magnetic field lines are sketched. What is the total magnetic flux diverging from the Earth, $\int \mathbf{B} \cdot d\mathbf{A}$ evaluated on a sphere (dashed curve) at a radius, b equal to twice the radius of the Earth?

4. (25 points).

A uniform electric field varying according to $E(t) = E_0 \cos(\omega t)$, where $E_0 = 100$ V/m and $\omega = 10^4$ rad/sec, exists between the plates of a circular capacitor as shown. The radius of each circular plate is 0.1 m. Note that $\mu_0 = 4\pi \times 10^{-7}$ T-m/A and $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/(N\text{-}m^2)$.





(a) What are the magnetic fields at each instant of time, in between the capacitor plates at a distance r from the center? Sketch the magnetic field vectors to show their directions.

(b) Given that the distance, d between the capacitor plates is 0.01 m, what is the voltage drop across the capacitor at each instant of time?

(c) What is the magnetic field at point **X** on the sketch, at a distance, R from the wire leading to the capacitor? (Hint: Use the surface originally used by James Clerk Maxwell in his treatment of the charging capacitor.)

(d) Identify the common occurences of electromagnetic waves having frequencies about: i. 1 MHz, ii. 100 MHz, iii. 1 GHz = 10^9 Hz and iv. 5×10^{14} Hz .