EXAM 3

Print your name and section clearly on all five pages. (If you do not know your section number, write your TA's name.) Show all work in the space immediately below each problem. **Your final answer must be placed in the box provided**. Problems will be graded on reasoning and intermediate steps as well as on the final answer. Be sure to include units wherever necessary, and the direction of vectors. **Each problem is worth 25 points**. In doing the problems, try to be neat. Check your answers to see that they have the correct dimensions (units) and are the right order of magnitudes. You are allowed one 5" x 8" note card and no other references. The exam lasts exactly one hour.

(Do not write below)

SCORE:

Problem 1: _____

Problem 2: _____

Problem 3: _____

Problem 4: _____

TOTAL: _____

Possibly useful information:

$\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$

$k = 8.99 \times 10^9 Nm^{-2} C^{-2}$

$\mu_0 = 4\pi \times 10^{-7} WbA^{-1} m^{-1}$

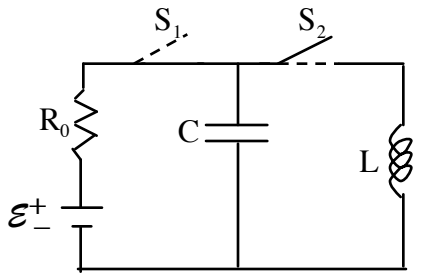
electron mass $m_e = 9.1 \times 10^{-31}$ kg

elementary charge $e = 1.6 \times 10^{-19}$ C

speed of light $c = 3.00 \times 10^8$ m/s

PROBLEM 1

In the circuit shown the resistor has value R_0 = 53 Ω, the inductor L=16 μH, the capacitor C = 23 μF, and the applied DC voltage $\mathcal{E}$ = 4.5 V. At time t=0 the switch S_2, which has been in the open position shown for a long time, is closed. (Switch S_1, which has been closed, stays closed at this point.)



a. What the current across resistor R_0 after the switch S_2 has been closed a long time? *(5 pts.)*

b. After the switch S_2 has been closed a long time τ, the switch S_1 is opened. How much energy is stored in the inductor at time τ? *(5 pts.)*

c. What is the total electrical energy in the inductor and capacitor at time 2τ? *(5 pts.)*

d. What is the oscillation period of the circuit with S_1 open and S_2 closed? *(5 pts.)*

e. Now S_1 is closed, S_2 is opened, and the DC voltage source replaced with an AC voltage source with maximum voltage 5.45 V at frequency 60.3 Hz. What is the time average of the power dissipated in the resistor after these changes are made? *(5 pts.)*

PROBLEM 2

The wave function describing the vertical position y(x,t) for a traveling wave on a taut string is

$y(x,t) =$ (0.353 m) sin (10.1πt + 2.59πx + $\pi/4$) (t measured in seconds and x in meters).

a. What is the velocity at which the wave is traveling? *(5 pts.)*

b. What is the vertical position of an element of the string at t = 0, x = 0.124 m? *(5 pts.)*

c. What is the maximum magnitude of the transverse speed of the string? *(5 pts.)*

d. The original wave combines with a second wave described by the wavefunction $y(x,t) =$ (0.353 m) sin (11.2πt +2.59πx + $\pi/4$) (t measured in seconds and x in meters). What is the resulting beat frequency? (Don't worry about how it is possible for the string to support waves with two different velocities.) *(5 pts.)*

e. For the combination of waves in part (d), what is the maximum displacement of the string at x=1.40 m that can occur at any time? *(5 pts.)*

PROBLEM 3

A siren speaker consists of a pipe closed on one end and open on the other. It emits sound at a fundamental frequency of 940 Hz. A steady wind is blowing with a speed of 20.0 m/s. Take the speed of sound in calm air to be 343 m/s.

a. What is the second-lowest resonant frequency (the first above the fundamental) that could be emitted by the siren? *(5 pts.)*

b. Find the wavelength of the sound at the fundamental frequency downwind of the siren (wind blowing in same direction as vector from siren to observer). *(5 pts.)*

c. Firefighters are approaching the siren from various directions at 30.0 m/s. What frequency does a firefighter hear if he or she is approaching from a downwind position, so that he or she is moving in the opposite direction as the wind is blowing? *(5 pts.)*

d. What frequency does a firefighter hear if he or she is approaching from an upwind position and moving with the wind? *(5 pts.)*

e. In the absence of wind, if the distance to the source is reduced by a factor of 3.1, what is the ratio of the intensity of the sound heard now to that before? *(5 pts.)*

PROBLEM 4

A linearly polarized electromagnetic wave of wavelength 1.43 cm is moving along the positive x axis. The electric field vector has a maximum value of 180 V/m and vibrates in the x-y plane. Assume the magnetic field component of the wave can be written in the form $B = B_{max}\sin(kx-\omega t)$.

a. Give the value of B_{max}. *(5 pts.)*

b. Find the frequency of this wave. *(5 pts.)*

c. Find the time average of the energy density of the wave. *(5 pts.)*

d. Find the intensity of this wave. *(5 pts.)*

e. Find the radiation pressure this wave exerts at normal incidence on a perfectly reflecting sheet. *(5 pts.)*