Final Exam
Physics 7b
Section 2
Fall 2004
R Packard

Name:_____   SID:_____

Section Number: _____

The relative weight of each problem is stated next to the problem. Work the easier ones first. Define physical quantities by letters and work all the problems algebraically before inserting any numbers. Enclose the final algebraic answer in a box before inserting numbers. Check the dimensions of your answer. To answer some of the questions may take several conceptual steps. If you aren't able to do all the steps, at least explain what you plan to do. **You will get partial credit for explaining a correct route to an answer even if you can't perform the calculations**. Cross out work you do not want counted.
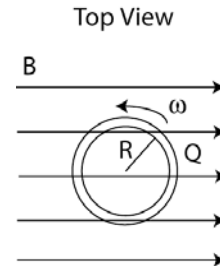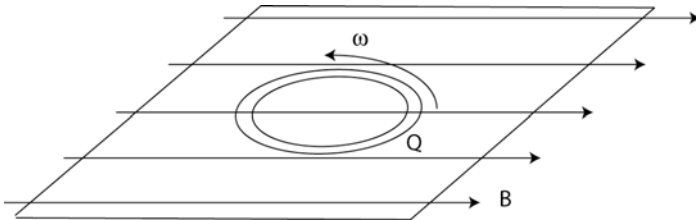
1._____

2._____

3._____

4._____

5._____

6._____

Total_____

1. (40 points) A ring of radius R, charge Q and mass M is spinning around its symmetry axis. The ring sits on a horizontal frictionless surface. A uniform external magnetic field of strength B is parallel to the plane of the ring. Find the angular velocity ω at which there is zero normal force between one edge of the ring and the surface.

Top View

2. (50 points) A loop of wire is wrapped around the connection of two solid cylinders, one of length ℓ_1 and thermal conductivity k_1 and the second of length ℓ_2 and thermal conductivity k_2. Both cylinders have diameter d. An electric heater element of resistance R is pasted against end 1 so that all the power dissipated in it must flow down the cylinders. The heater is connected across an oscillating voltage $V_o\sin\omega t$. The temperature of end 2 is thermally fixed at temperature T_2. The wire loop at the cylinder's joint has a linear temperature coefficient of resistance α. Assume initially that when the heater is off, the entire bar is at temperature T_2. (a) find the temperature of the end where the heater is attached. (b) Find the fractional change in the wire loop's resistance when the heater is turned on and all temperatures stabilize.
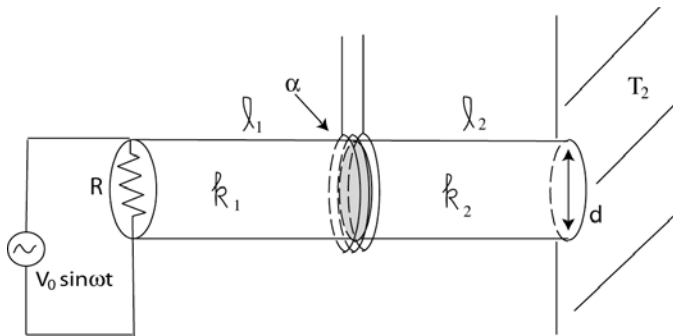
3. (50 points) A series LRC circuit is submerged in a fluid of volume V, mass density ρ and mass specific heat c. Initially the fluid's temperature is T_o and the capacitor is charged with Q_o. At t=0 the switched is closed. (a) Assuming the circuit is underdamped, how long does it take for the oscillation amplitude to drop to 1/2 of its initial value? (b) If at that moment, the circuit is removed from the fluid and the fluid reaches thermal equilibrium, what is the change in entropy of the fluid? Ignore the heat capacity of the R, C, and L.
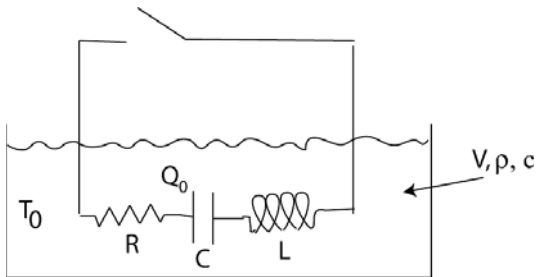
4. (40 points) In physics 7A you learned that a damped simple harmonic oscillator (mass m, spring constant k, frequency $\omega = \sqrt{k/m}$) experiences a linear friction force: $F_f = -b\dot{x}$ where $\dot{x}$ is the velocity. The transient response of the oscillator shows damped oscillations with damping time constant $\tau = 2m/b$. Consider such an oscillator where the mass m consists of a square loop of wire (side length L) that oscillates with one end in a uniform magnetic field B as shown in the figure. The wire has cross sectional area a and resistivity ρ. Compute b in terms of a, ρ, L, and B.
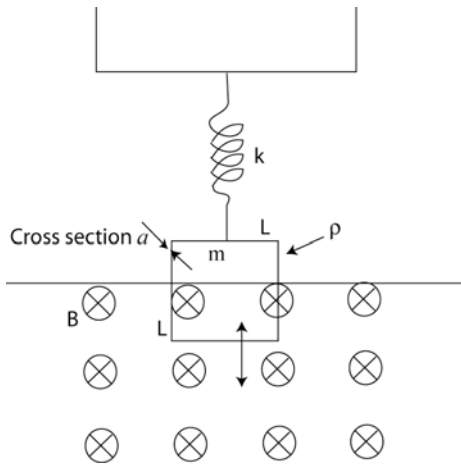
5. (40 points) A wire in a plane has the shape shown below. Two arcs of a wire circle are connected by wire radial segments. Use the Biot-Savart law to determine the magnetic field strength B at point C in terms of the radii R_1, R_2, θ and the current I.

I

R_2

R_1

θ

C
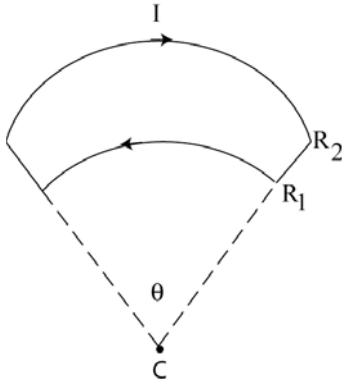
6. (60 points) A short length of wire of length a is moving at velocity v parallel to a long wire carrying a current I. The near end of the short wire is a distance b away from the long wire. A parallel plate capacitor with plate area A and plate separation d is filled with dielectric k and connected across the short wire. (a) Find the electric field, E, between the plates of the capacitor. (Hint: You have to do an integral.) (b) Find the charge, Q, on the capacitor. (c) If the capacitor is replaced with a resistor R which has heat capacity C, find the rate of temperature increase dT/dt in the resistor assuming no heat flows out of the resistor.

Area A
Separation d k

a

v   b

I