Physics 7B
Spring 2000
Final Exam
R. Packard

Name:_____SID_____

The problems are weighted as shown in the left margin. Do not perform any numerical calculations until you have a final algebraic answer with a box drawn around it. Any symbol not given in the problem statement should be defined by you. Cross out work you do not wish to be graded. The neater you work, the more partial credit you are likely to earn.

If some problems have multiple parts and you can't solve an earlier part, use a symbol for the part you can't get and keep going.

Some of the problems are challenging and if you find them difficult, probably most students will agree. Since your final grade is determined by your grade relative to others, do not be discouraged by not being able to solve the problem completely. If you cannot solve a problem right away, leave it and return to it later. If you do not understand the problem ask a proctor for clarification.

1._____

2._____

3._____

4._____

5._____

6._____

7._____

Total_____

1. (40pts) A resistance R of 3Ω is connected in series with a 200μF capacitor, C and a switch. The parallel plate capacitor has a gap d of 0.1mm and the two plates are circular.

a) Find the strength of the magnetic field at the outside edge of the capacitor as a function of time if at t=0 the capacitor is charged to 300V and the switch is closed. Work this out first algebraically and provide numerical values at the end.

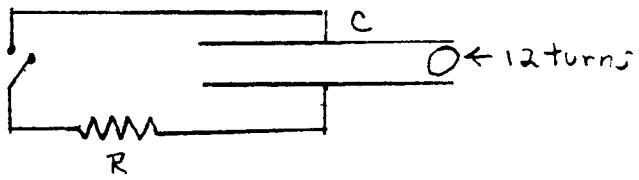
b) A 12 turn coil of wire (circular turns, 0.1 diameter) is placed just inside the edge of the capacitor with the axis of the coil perpendicular to the axis of the capacitor. Find the maximum induced EMF across the coil. Assume that the magnetic field is uniform across the coil. If you can't get the answer to part a) just assume a symbol B for this part.

The next three parts don't depend on the answers to part a and b so you should be able to proceed even without the previous answers.

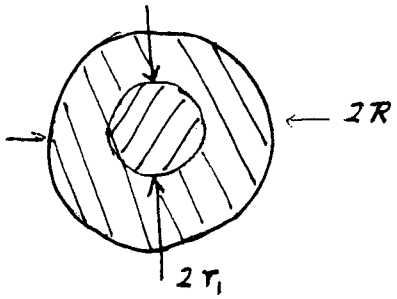
c) If the resistor is immersed in 2gm of water, what is the increase in the water's temperature after the currents in the circuit have died away?

d) If a dielectric is slipped into the capacitor gap (filling the gap) the rise in temperature of the water (relative to case c above) increases by 50%. What is the dielectric constant of the material?

e) If the resistor is changed so that its resistance drops by 25%, does the heating of the water (in part c) increase? Decrease? or stay the same?

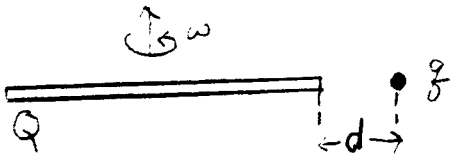


2. (15pts) A wire of radius R is made by having a coaxial core of one metal surrounded by a second metal. Let the inner core have radius r_1, and resistivity ρ_1. Let the outer conductor have resistivity ρ_2. Find the magnetic field as a function of distance from the center when a total current I flows through the wire. Consider the three cases $r<r_1$, $r_1<r<R$, and $r>R$.

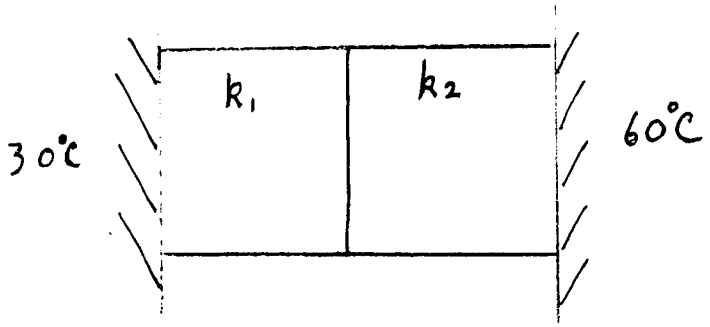


3. (10pts) An aluminum cup (linear expansion coefficient of aluminum is $2.3 \times 10^{-6}/°C$) of inner volume $V=110 cm^3$ is filled to the brim with a liquid whose volume expansion coefficient is $5 \times 10^{-4}/°C$. How much fluid, if any, will spill out of the cup when the temperature is raised by 28°C.

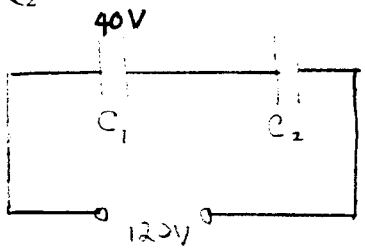
4. (20) A uniformly charged rod of length L and charge Q spins at angular velocity ω about an axis through the center of the rod perpendicular to the length.
   A. Calculate the magnetic moment.
   B. If the rod stops spinning, calculate the electric force on a test charge q positioned a distance d from the rod as shown in the figure below.



5. (10pts) Two identically sized cubes of volume $8m^3$ each, sit between baths at temperatures 30°C and 60°C as shown. One cube has a thermal conductivity k_1= 2W/mK and the other has k_2=5W/mK. Find the heat flow in Watts.



6. (10) A capacitor C_1=0.2μF is in series with another capacitor C_2.There are 120V across the outer terminals and the voltage across C_1 is 40V. The total energy stored in the two capacitors is 1440μJ. Find C_2 and the charge Q_2 on it.



7. (15) As shown in the figure below, 1.0 mole of a diatomic ideal gas is used as a working substance in a heat engine. Path 1 is an isothermal expansion from volume V_a to $3V_a$. Path 2 is a constant volume decrease in pressure and path 3 is an adiabatic compression. For each piece of the path (1, 2, and 3) find a) heat absorbed by the gas b) work done on the gas, c) entropy change of the gas. Finally calculate the efficiency of this heat engine. Express all the answers in terms of R and T_a, the initial temperature.