Final Exam
Physics 7b
Spring 2001
R Packard

Name:_____ SID:_____

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. If you cannot get an early part of a multipart problem, express the following steps in terms of symbols representing the quantity you couldn't find in the earlier part.

1._____

2._____

3._____

4._____

5._____

6._____

7._____

Total_____

1. (35pts) A capacitor C=2 μfd is charged with $Q=3x10^{-4}C$ and is connected in series with a wire of length l=3m. The wire has a circular cross-section with radius $r=1x10^{-5}$ m, a resistivity $\rho=9.7x10^{-8}\Omega m$, a mass $m=10^{-4}kg$ and specific heat c_p of $450J/kgC^{o}$. When the switch (shown below) is closed at t=0 the capacitor discharges through the resistor.

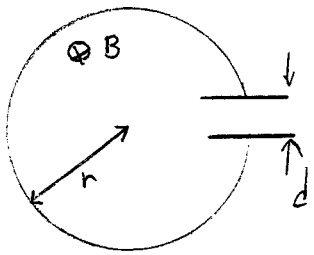
a. How long after the switch closes does the voltage on the capacitor reach 75 volts? Call this time t_1,

b. At t_1 what is the voltage across the resistance?

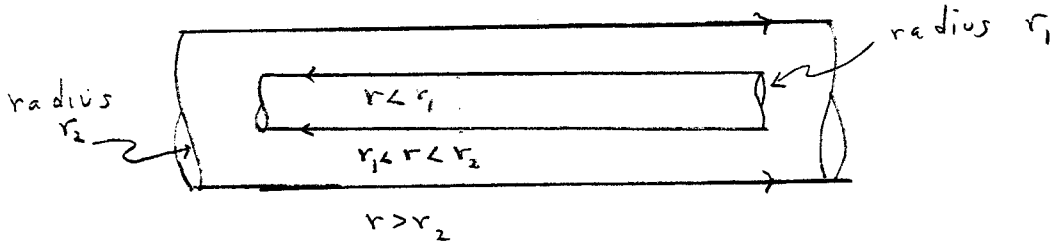
c. How much thermal energy is deposited in the wire by the discharge process?

d. What is the temperature rise of the wire due to the complete discharge process? Ignore heat lost to the environment during the discharge process.

2. (20pts) A flat circular loop (radius r=10cm) of wire connects the two sides of a parallel plate capacitor with gap d=0.1mm. The breakdown electric field strength of the air in the gap is $3\text{x}10^6$Nt/C. A uniform magnetic field perpendicular to the plane of the loop is increasing exponentially in time: $B = 2e^{3t}\,(T)$. What is the value of the magnetic field when the gap breaks down?



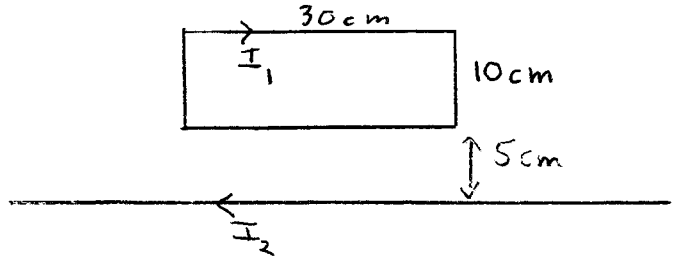
3. (20pts) Consider a long cable made of two coaxial thin cylinders. The inner cylinder has radius r_1 and the outer cylinder has radius r_2. The inner cylinder carries a current +I and –I flows in the outer conductor.
   a. Compute the magnetic field B for the three regions: $r<r_1$; $r_1<r<r_2$; and $r>r_2$ Neglect the thickness of the conductors. Do not just write down the answer from your notes. Show the calculation
   b. Use the result in part **a.** to compute the magnetic energy stored (per unit length) in the cable.



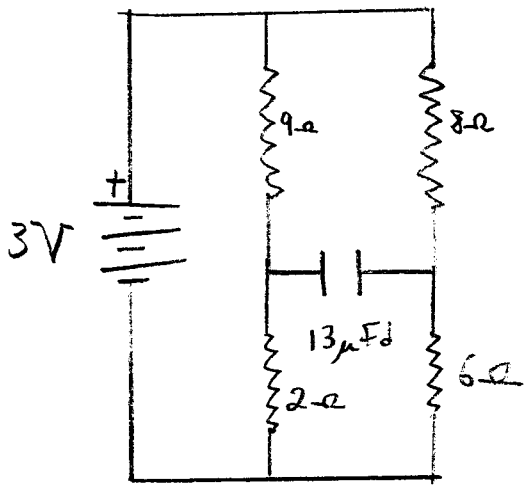
4. (20pts) A rectangular loop of wire with the dimensions shown below carries a current I_1=3 amps. The loop lies in a plane of a very long straight wire carrying a current I_2=22A.

a. Is there a torque on the loop? If your answer is yes compute the torque (magnitude and direction)

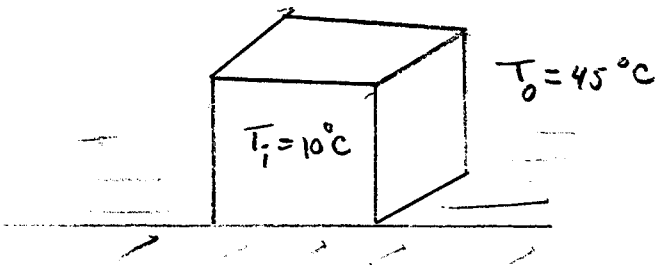
b. Is there a net force on the loop? If your answer is yes, compute the force (magnitude and direction).



5. (15pts) In the circuit shown below, find the energy stored on the capacitor when it is fully charged.



6. (30pts) A cubical food storage container (side length L=3m) has walls and roof of thickness d=0.1 m. The walls and roof are made of material with thermal conductivity κ=0.1J/smC°. On a hot day the outside temperature is 45°C. The owner of the food wants to keep the inside of the container at 10°C by running an electrically powered heat pump cooling system. The heat pump runs at 70% of the Carnot efficiency. If the cost of electricity is $0.30/kw-hr, how much does it cost to cool the container for ten hours? Ignore the heat loss through the floor.



7. (25pts) The x axis forms the symmetry axis of an infinitely long cylinder of radius R carrying a uniform positive charge density ρ. A shell with uniform surface charge density σ and radius 2R is centered on the origin. A charge –Q and mass m is released from the point x=0, y=R. Find its speed v when it reaches the origin.