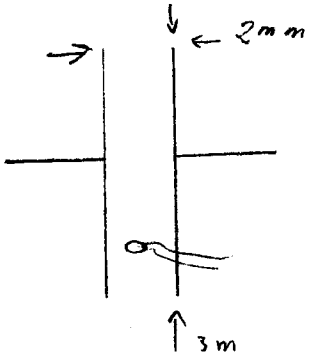
Physics 7B
Spring 1999
Final Exam
R. Packard

Name:_____SID_____

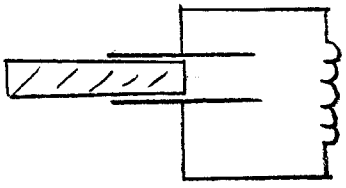
All the problems are weighted the same. Do not perform any numerical calculations until you have a final algebraic answer with a box drawn around it. Any symbol not given in the problem statement should be defined by you. Cross out work you do not wish to be graded. The neater you work, the more partial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

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.

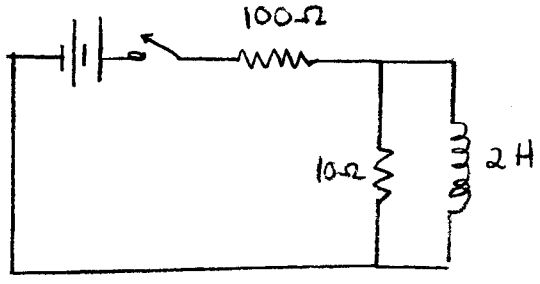
1. Two circular 3.0m diameter capacitor plates are spaced 2.0mm apart and filled with a fluid of dielectric constant k=1.8 . An oscillating voltage of amplitude V_0=60V and frequency f=90MHz is applied across the plates. A 12 turn pick-up coil of 1mm diameter is placed at a radius r=1m from the center with the plane of the coil oriented perpendicular to the plane of the plates. Find the voltage induced across the coil due to the magnetic field within the plates. Assume the magnetic field is uniform across the coil.



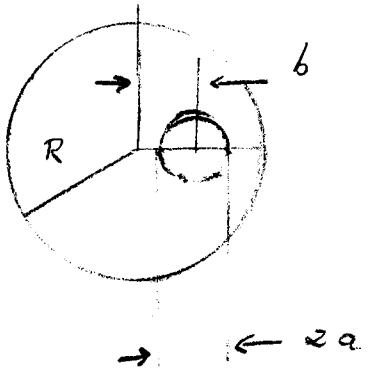
2. An inductor L=2mH is connected in series with a rectangular parallel plate capacitor of width w=0.3m and gap d=2mm. A dielectric slab (k=4.8) of thickness d can be slid in to fractionally fill the space. When the slab is slid halfway into the gap the resonant frequency is 90MHz. What is the capacitance of the capacitor without the dielectric?



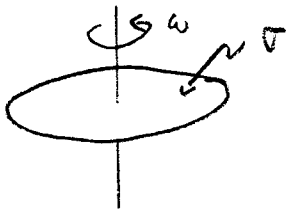
3. In the circuit shown below assume the switch has been closed for a long time and the inductor is superconducting, i.e. has no resistance. A. Find the battery current, the current in each resistor and the current in the inductor. B. Find the current in the inductor as a function of time measured from the instant of opening the switch.



4. A very long straight conductor with a circular cross section of radius R carries a current I. Inside the conductor there is a circular hole of radius a<R whose axis is parallel to the axis of the conductor, a distance b from it. Let the z axis be the axis of the conductor and let the axis of the hole be at x=b. Find the magnetic field on the x axis at x=2R.

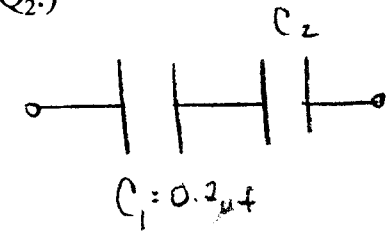


5. A non-conducting disk has a surface charge density σ and rotates with angular velocity ω about the symmetry axis. Find the magnetic moment.

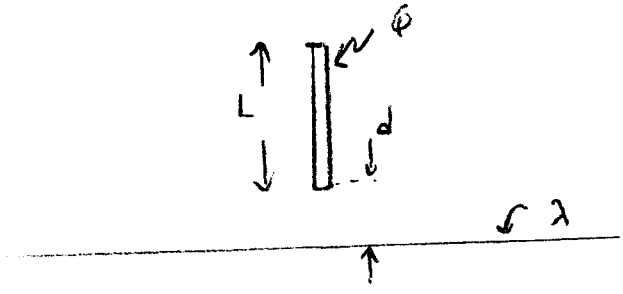


6. Large electromagnets use water cooling to prevent excessive heating of the magnet coils. A large laboratory magnet draws current I=100A when a voltage V= 240V is applied across the terminals. To cool the coils, water at an initial temperature of 15°C is circulated through the coils. How many liters per second must circulate through the coils if the exiting water temperature should not exceed 50°C?

7. 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. (Hint: There is a net charge on the two inner plates, i.e. $Q_1 \neq Q_2$.)



8. A rod of length L lies perpendicular to an infinitely long uniform line charge of charge density λ. The near end of the rod lies a distance d from the line charge and carries a total charge Q, uniformly distributed along its length. Find the force that the infinitely long line charge exerts on the rod.



9. A heat engine that does the work of blowing up a balloon at a pressure of 1atm. Extracts 4kJ from a hot reservoir at 120°C. The volume of the balloon increases by 4L and heat is exhausted to a cold reservoir at a temperature T_c. If the efficiency of the heat engine is 50% of the Carnot engine working between the same reservoirs, find the temperature T_c.