Physics 5C **Midterm 2** May 19, 2008

PRINT YOUR NAME ____

You have an hour and ten minutes to do this exam. You may use two pages of formulas.

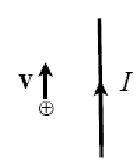
1. True or False Questions (30 points). You will get 3 points for each correct answer and 2 additional points if you also give a correct brief explanation.

a. ____ In an RC circuit, current flows from a battery until the capacitor is fully charged. The total energy supplied by the battery then equals the energy stored in the capacitor.

b. ____In a certain region of space, there is an electric field in the x-direction and a magnetic field in the y-direction such that an electron moving with a certain speed v in the z-direction travels through the region moving in a straight line. A proton with the same speed v in the z-direction will also move through this region in a straight line.

c. ____ Ferromagnetic hysteresis is the basis of data storage on computer hard disks.

d. ____ A positive charge moves parallel to a wire, in which the current *I* is suddenly turned on. The moving charge is attracted toward the wire.

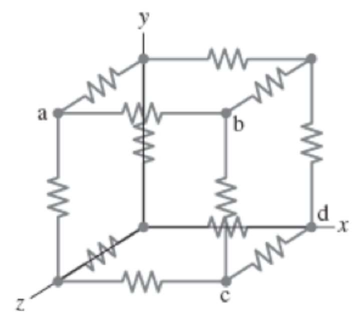


e. ____ In the drawing at the right, a clockwise current is induced in the loop.

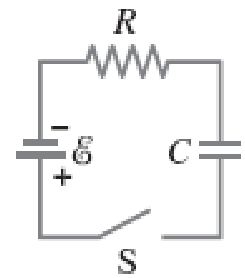
f. _____ If you double the current through a solenoid, you double the magnetic field inside it and you increase the energy stored by a factor of four.

Calculation problems (70 points). Show all your work and make your method clear in order to get full credit. If you need additional paper, print your name and the problem number on each sheet.

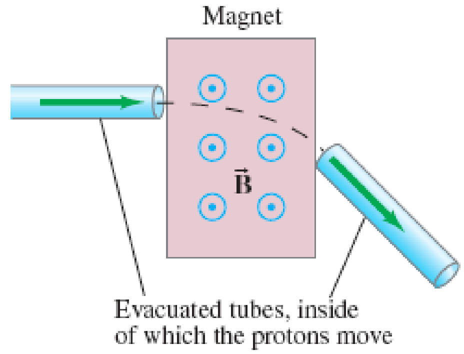
2. (10 points) Twelve resistors, each of resistance *R*, are connected as the edges of a cube as shown. Determine the equivalent resistance between points a and d, the ends of the volume diagonal. [Hint: use symmetry.]



3. (15 points) How long does it take after the switch S is closed for the energy stored in the capacitor in the *RC* circuit at the right to reach 75% of its maximum value?



4. (15 points) Magnetic fields are very useful in particle accelerators for "beam steering"; that is, the magnetic fields can be used to change the beam's direction without altering its speed (see the figure). Show how this could work with a beam of protons.

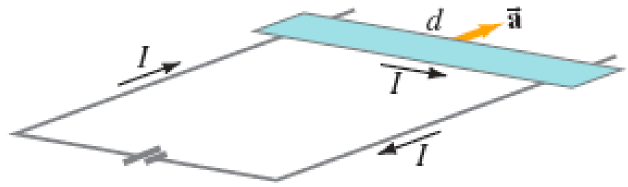


(a) What is the radius of curvature of the protons?

(b) What happens to protons that are not moving with the speed that the magnetic field is designed for?

(c) If the field extends over a region 5.0 cm wide and has a magnitude of 0.38 T, by approximately what angle will a beam of protons traveling at $v = 8.5\times10^{6}$ m/s be bent? (Note: the mass of a proton is $m_p = 1.67\times10^{-27}$ kg and its charge is $e = 1.60\times10^{-19}$ C.)

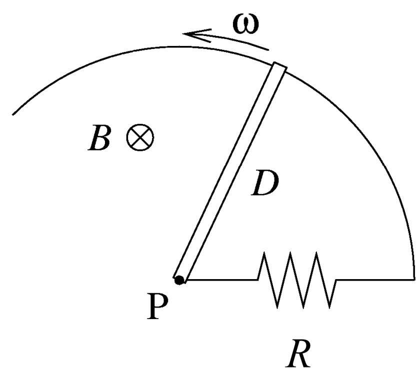
5. (15 points) A “rail gun projectile launcher” is shown at right. A large current moves in a closed loop composed of fixed rails, a power supply, and a very light, almost frictionless bar touching the rails. A magnetic field is perpendicular to the plane of the circuit.



(a) If the bar has a length d = 24 cm, a mass of 1.5 g, and is placed in a field of 1.8 T, what constant current flow is needed to accelerate the bar from rest to a speed of 25 m/s in a distance of 1.0 m?

(b) In what direction must the field point?

6. (15 points) A conducting bar of length D rotates with angular frequency ω about a pivot P at one end of the bar (see the figure at right). The other end of the bar is in slipping contact with a stationary conducting wire in the shape of a circle (we only show part of that circle to keep the drawing simple). Between point P and the circular wire there is a resistor R as shown. Thus the bar, the resistor, and the wire form a closed conducting loop. The resistance of the bar and the circular wire are negligibly small.



There is a uniform magnetic field B perpendicular to the plane of the conducting wire, as shown. What is the induced current in the loop? Express your answer in terms of D, ω, R, and B.