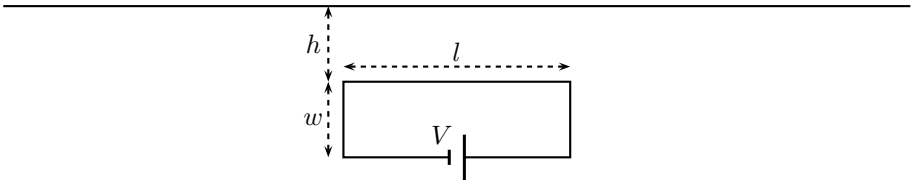
AP Physics B Problem Sheet: Spring #1

1. A long straight wire carries a constant current horizontally. A wire of diameter d and resistivity ρ is shaped into a rectangular loop with sides of lengths l and w. A small battery of voltage V is attached to the wire loop. The mass of the loop and battery together is m. This loop is placed so that the long straight wire is directly above its top by a height h and so that they lie in the same plane, as shown below. When released, the loop remains suspended in mid-air.



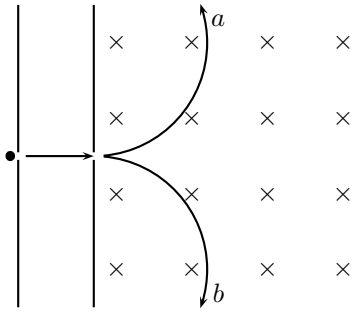
   (a) How much current flows through the loop? (4 pts)

   (b) What is the direction of the magnetic field from the long straight wire at the loop's location? (1 pt)

   (c) In what direction does current flow through the long straight wire? (1 pts)

   (d) What is the magnitude of the current in the long straight wire? (4 pts)

2. Two capacitor plates are set up to launch a proton from rest into a uniform magnetic field, as shown below. The voltage between the plates is 100 V. The magnetic field has a strength of 0.05 T and is directed into the page.



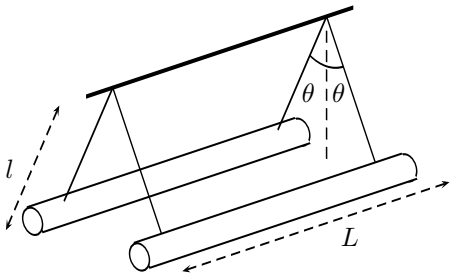
   (a) At what speed does the proton enter the magnetic field? (3 pts)

   (b) Will the proton follow path a or path b? (1 pt)

   (c) What will the radius of this path be? (3 pts)

   (d) How long after it enters the magnetic field will the proton hit the back of the capacitor plate? (3 pts)

3. Two long straight wires of length L and mass M hang side-by-side from very light strings of length l, with $l \ll L$. These wires each carry a current of the same magnitude. Each wire's strings make an angle θ to the vertical.



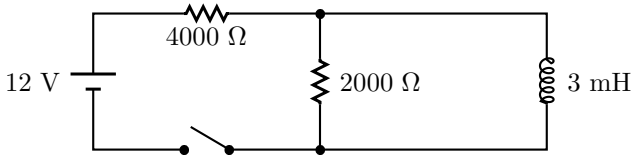
(a) Using an end-on view, draw a free body diagram for each wire. (3 pts)

(b) Find the magnitude of the magnetic force between the wires. (2 pts)

(c) Do the currents run parallel or anti-parallel? (1 pt)

(d) Find the magnitude of the current in the wires. (4 pts)

4. Two resistors and an inductor are attached to a battery, as shown below. The switch is originally open. The switch is then closed and remains closed.

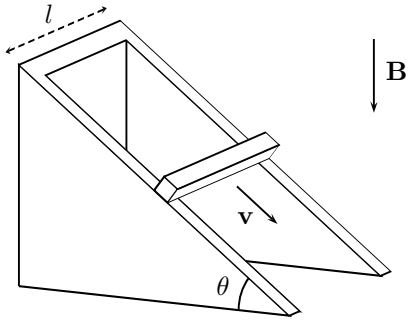


(a) How much current flows through each resistor and the inductor immediately after the switch is closed? (4 pts)

(b) How much current flows through each resistor and the inductor a long time later? (4 pts)

(c) How much energy is stored in the inductor a long time later? (2 pts)

5. An inclined plane is set up with two conductive rails running along its sides. The rails are electrically connected at the top of the incline. A bar, of mass m and length l, slides down the frictionless rails, making electrical contact with them. The net resistance of the circuit is R. The plane is inclined by an angle θ to the horizontal. There is a uniform magnetic field, of magnitude B, directed straight downward.



(a) Using an end-on view, draw a free body diagram for the bar. (2 pts)

(b) Find the current through the bar when it reaches terminal velocity. (4 pts)

(c) Determine the terminal velocity of the bar. (4 pts)