PHYS1022 Electricity and Magnetism

Problem Sheet 7 – workshop

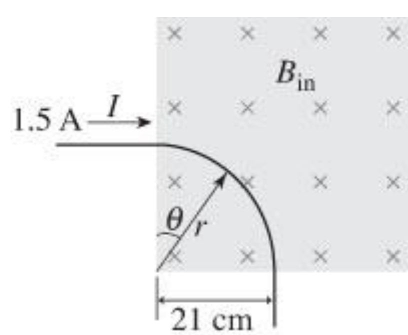
1. A certain cyclotron with a magnetic field of 1.8 T is designed to accelerate protons to 25 MeV.
   (a) What is the cyclotron frequency?
   (b) What must the minimum radius of the magnet be to achieve an emergence energy of 25 MeV?
   (c) If the alternating potential applied to the dees has a maximum value of 50 kV, how many revolutions must the protons make before emerging with an energy of 25 MeV?

2. A straight, stiff, horizontal wire of length 25 cm and mass 50 g is connected to a source of emf by light, flexible leads. A magnetic field of 1.33 T is horizontal and perpendicular to the wire. Find the current necessary to float the wire; that is, find the current so the magnetic force balances the weight of the wire.

3. A wire carrying 1.5 A passes through a region containing a 48 mT magnetic field. The wire is perpendicular to the field and makes a quarter-circle turn of radius 21 cm as it passes through the field region, as shown in the figure. Find the magnitude and direction of the force on this section of the wire.

   Some clues to get started:

   Divide the wire into current elements *Idl*,
   find the force *dF* on such an element,
   use symmetry ideas,
   integrate one component of the force, changing the variable of integration to suit.



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Problem Sheet 6: tutorials

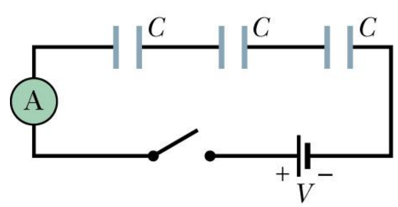
1. Figure 25.2 (W p 332) illustrates a mechanical analogue of a resistance in a simple electric circuit – balls rolling down a hill interact with spikes before "a battery" lifts them back to the top. Devise another mechanical analogue in which the current is represented by a flow of water instead of balls rolling down a hill.

2. A constant electric field generally produces a constant drift velocity in a conduction wire. How is this consistent with Newton's third law, i.e. that force results in acceleration, not velocity?

3. The figure shows an open switch, a battery of potential difference V, a current-measuring meter A, and three identical uncharged capacitors of capacitance C. When the switch is closed and the circuit reaches equilibrium, what are

   (a) the potential difference across each capacitor and
   (b) the charge on the left-hand plate of each capacitor?

   Give your answers in terms of C and V.



   Discuss what would happen to answers (a) and (b) if the middle capacitor was now $2C$.

4. One capacitor is charged until its stored energy is 4.0 J. A second identical but uncharged capacitor is then connected to it in parallel.
   (a) If the charge distributes equally, what is now the total energy stored in the electric fields?
   (b) Where did the excess energy go?