Chapter-28

1. A laboratory electromagnet produces a magnetic field of magnitude 1.50 T. A proton moves through this field with a speed of 6.00 X 106 m/s. (a) Find the magnitude of the maximum magnetic force that could be exerted on the proton. (b) What is the magnitude of the maximum acceleration of the proton? (c) Would the field exert the same magnetic force on an electron moving through the field with the same speed? (d) Would the electron experience the same acceleration? Explain.

Ans: (a) The proton experiences maximum force when it moves perpendicular to the magnetic field, and the magnitude of this maximum force is

 

 (b) From Newton’s second law,

 

 (c) Since the magnitude of the charge of an electron is the same as that of a proton, a force would be exerted on the electron that had the same magnitude as the force on a proton, but in the opposite direction because of its negative charge.

 (d) 

1. A proton (charge +e, mass mp), a deuteron (charge +e, mass 2mp), and an alpha particle (charge +2e, mass 4mp) are accelerated from rest through a common potential difference ∆V. Each of the particles enters a uniform magnetic field $\vec{B}$, with its velocity in a direction perpendicular to$\vec{B}$. The proton moves in a circular path of radius rp. In terms of rp, determine (a) the radius rd of the circular orbit for the deuteron and (b) the radius rd for the alpha particle.

Ans: An electric field changes the speed of each particle according to
(K + U)i = (K + U)f. Therefore, noting that the particles start from rest, we can write

 

 After they are fired, the particles have the magnetic field change their direction as described by 

 

 For the protons, 

 (a) For the deuterons,

 

 (b) For the alpha particles,

 

1. A cyclotron designed to accelerate protons has a magnetic field of magnitude 0.450 T over a region of radius 1.20 m. What are (a) the cyclotron frequency and (b) the maximum speed acquired by the protons?

Ans: (a) The name “cyclotron frequency” refers to the angular frequency or angular speed

 

 For protons,

 

 (b) The path radius is 

 Just before the protons escape, their speed is

 

1. A magnetized sewing needle has a magnetic moment of 9.70 mA. m2. At its location, the Earth’s magnetic field is 55.0 *μ*T northward at 48.0o below the horizontal. Identify the orientations of the needle that represent (a) the minimum potential energy and (b) the maximum potential energy of the needle–field system. (c) How much work must be done on the system to move the needle from the minimum to the maximum potential energy orientation?

Ans: (a) The field exerts torque on the needle tending to align it with the field, so the minimum energy orientation of the needle is:

 

 where its energy is

 

 (b) It has maximum energy when pointing in the opposite direction, 

 where its energy is

 

 (c) From , we have

 