Chapter-28

1. At the equator, near the surface of the Earth, the magnetic field is approximately 50.0 *µ*T northward, and the electric field is about 100 N/C downward in fair weather. Find the gravitational, electric, and magnetic forces on an electron in this environment, assuming that the electron has an instantaneous velocity of 6.00 x 106 m/s directed to the east.

Ans: Gravitational force:

 

 Electric force:

 

 Magnetic force:

 

1. One electron collides elastically with a second electron initially at rest. After the collision, the radii of their trajectories are 1.00 cm and 2.40 cm. The trajectories are perpendicular to a uniform magnetic field of magnitude 0.044 0 T. Determine the energy (in keV) of the incident electron.

For each electron,  and 

 The electrons have no internal structure to absorb energy, so the collision must be perfectly elastic:

 

 

1. In his experiments on “cathode rays” during which he discovered the electron, J. J. Thomson showed that the same beam deflections resulted with tubes having cathodes made of *different* materials and containing *various* gases before evacuation. (a) Are these observations important? Explain your answer. (b) When he applied various potential differences to the deflection plates and turned on the magnetic
coils, alone or in combination with the deflection plates, Thomson observed that the fluorescent screen continued to show a *single small* glowing patch. Argue whether his observation is important. (c) Do calculations to show that the charge-to-mass ratio Thomson obtained was huge compared with that of any macroscopic object or of any ionized atom or molecule. How can one make sense of this comparison? (d) Could Thomson observe any deflection of the beam due to gravitation? Do a calculation to argue for your answer. *Note:* To obtain a visibly glowing patch on the fluorescent screen, the potential difference between the slits and the cathode must be 100 V or more.

(a) 

 (b) 

 (c) 

 (d) With kinetic energy 100 eV, an electron has speed given by

 

 from which we obtain

 

 The time interval to travel 40.0 cm is

 

 If it is fired horizontally it will fall vertically by

 

 an immeasurably small amount. An electron with higher energy falls by a smaller amount.

 

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 µT northward at 48.0° 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?

(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

 