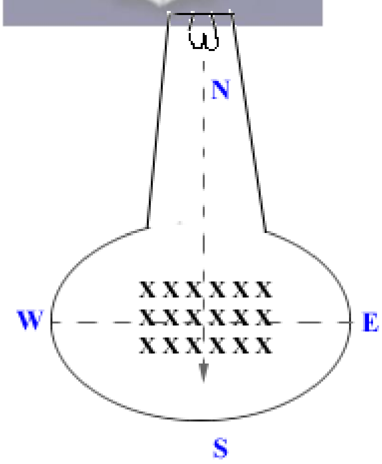
427.

<u>Problem 34.9 (RHK)</u>

The electrons in the beam of a television tube have a kinetic energy of 12.0 keV. *The tube is oriented so that the electrons move horizontally from magnetic south to magnetic north. The vertical component of the Earth's magnetic field points down and has a magnitude of* $55.0\ \mu\text{T}$. (a) *We have to find the direction in which the beam will deflect;* (b) *the acceleration of a given electron due to the magnetic field;* (c) *the distance the beam will deflect in moving 20.0 cm through the television tube.*



<u>Solution:</u>

(a)

Magnetic south is in the same direction as the geographical north. Therefore, the television tube has been kept in the north-south direction. As the electrons are negatively charged and the Earth's magnetic field points vertically downward, they will be deflected in the westward direction.

(b)

We recall that

mass of electron, $m_e = 9.11\times10^{-31}$ kg.

Kinetic energy of the electron beam,

$$\text{KE} = \frac{m_e v^2}{2} = 12.0 \text{ keV} = 12\times10^3\times1.6\times10^{-19} \text{ J} = 1.92\times10^{-15} \text{ J}.$$

Therefore, the velocity of electrons will be

$$v = \sqrt{\frac{2KE}{m_e}} = \sqrt{\frac{2\times1.92\times10^{-15}}{9.11\times10^{-31}}} \text{ m s}^{-1} = 6.49\times10^7 \text{ m s}^{-1}.$$

Magnitude of the force on an electron moving with speed v in magnetic field, $B = 55\times10^{-6}$ T, is

$$F = evB = 1.6\times10^{-19}\times6.49\times10^7\times55\times10^{-6} \text{ N} = 5.71\times10^{-16} \text{ N}.$$

Therefore, acceleration of an electron due to the magnetic field will be

$$a = \frac{F}{m_e} = \frac{5.71\times10^{-16} \text{ N}}{9.11\times10^{-31} \text{ kg}} = 0.627\times10^{15} \text{ m s}^{-2}.$$

(b)

Time, t, taken by the beam in travelling 20.0 cm through the television tube will be

$$t = \frac{20 \times 10^{-2}\ \text{m}}{6.49 \times 10^{7}\ \text{m s}^{-1}} = 3.08 \times 10^{-9}\ \text{s}.$$

Deflection of the beam in travelling 20.0 cm of the television tube will, therefore, be

$$d = \frac{1}{2} a t^{2} = \frac{0.627 \times 10^{15} \times \left(3.08 \times 10^{-9}\right)^{2}}{2}\ \text{m} = 0.297\ \text{cm}.$$