479.

Problem 35.53 (RHK)

A long solenoid has 100 *turns per centimetre. An electron moves within the solenoid in a circle of radius* 2.30 cm *perpendicular to the solenoid axis. The speed of the electron is* 0.0460 c (c = *speed of light*). *We have to find the current in the solenoid.*

Solution:

Let the magnetic field inside the solenoid parallel to its axis be B. Let the radius of the electron moving with speed v in the magnetic field of the solenoid be r. The centripetal force for circular motion of the electron is provided by the action of the magnetic field of the solenoid on the moving electron. We have

$$\frac{mv^2}{r} = evB.$$

This gives

$$B = \frac{mv}{er}.$$

Data relevant to the problem are

mass of the electron, $m = 9.11\times10^{-31}$ kg, charge of the electron, $e = 1.6 \times 10^{-19}$ C,

radius of the circular orbit, $r = 2.30 \times 10^{-2}$ m,

and the speed of the electron, $v = 0.0460 \times 3 \times 10^{8}$ m s^{-1}.

The field inside the solenoid will, therefore, have to be

$$B = \frac{9.11 \times 10^{-31} \times 4.6 \times 3 \times 10^{6}}{1.6 \times 10^{-19} \times 2.3 \times 10^{-2}} \text{ T} = 3.416 \times 10^{-3} \text{ T}.$$

The magnetic field in a solenoid is determined by the current, i, flowing in the solenoid and the number of turns of the coil per unit length, n. It is given that

$n = 100$ per cm $= 10^{4}$ per meter.

The field inside a solenoid is given by

$$B = \mu_0 n i.$$

Therefore,

$$i = \frac{B}{\mu_0 n} = \frac{3.416 \times 10^{-3}}{4\pi \times 10^{-7} \times 10^{4}} \text{ A} = 272 \text{ mA}.$$