456.

Problem 35.3 (RHK)

The 25-kV *electron gun in a TV tube fires an electron beam* 0.22 mm *in diameter at the screen,* 5.6×10^{14} *electrons arriving each second. We have to calculate the magnetic field produced by the beam at a point* 1.5 mm *from the axis of the beam.*

Solution:

The electron beam gives rise to a flow of current across the TV tube from the electron gun to the screen. As 5.6×10^{14} electrons arrive at the screen per second, the beam can be approximated as a long wire-like conductor in which a current is flowing. Magnitude of the current is

$$i = 5.6\times10^{14}\times1.6\times10^{-19}\ \text{A}$$
$$= 8.96\times10^{-5}\ \text{A}$$

We have to find the magnetic field produced by the beam at a point 1.5 mm from the axis of the beam. The width of the beam is 0.22 mm. Therefore, the field will be due to the current contributed by all the electrons which are flowing within the width of the beam.

From Ampere's law, the field at a distance r from a long wire carrying current i is given by the relation

$$2\pi r B(r) = \mu_0 i,$$

$$\therefore\ B(1.5\text{ mm}) = \frac{4\pi \times 10^{-7} \times 8.96 \times 10^{-5}}{2\pi \times 1.5 \times 10^{-3}}\ \text{T}$$

$$= 11.9\text{ nT}.$$