448.

Problem 34.47 (RHK)

A long, rigid conductor, lying along the x axis, carries a current of 5.0 A *in the –x direction. A magnetic field* $\vec{B}$ *is present, given by* $\vec{B} = 3\hat{i} + 8x^2\hat{j}$, *with x in meters and B in* mT. *We have to calculate the force on the* 2.0-m *segment of the conductor that lies between* $x = 1.2$ m *and* $x = 3.2$ m.

Solution:

The force in a magnetic field $\vec{B}$ on a segment of conductor of length $d\vec{s}$ carrying current i is

$$d\vec{F} = id\vec{s} \times \vec{B}.$$

Let us consider an infinitesimal section of the conductor of length dx ,with current $i = 5.0$ A, flowing in the –*x* direction. Force on this element in the magnetic field, $\vec{B} = 3\hat{i} + 8x^2\hat{j}$, where *x* is in meters and B is in mT, will be

$$d\vec{F} = -5.0dx\left(\hat{i} \times \left(3\hat{i} + 8x^2\hat{j}\right)\right) \times 10^{-3} \text{ N}$$

$$= -40 \times 10^{-3} \times x^2 \times dx\,\hat{k} \text{ N}.$$

Therefore, the total force on a 2.0-m segment of the conductor that lies between $x = 1.2\text{ m}$ and $x = 3.2\text{ m}$ will be

$$\vec{F} = -4.0\times10^{-2}\left(\int_{1.2}^{3.2} x^2 dx\right)\hat{k}\text{ N}$$

$$= \frac{-4.0\times10^{-2}}{3}\left(3.2^3 - 1.2^3\right)\hat{k}\text{ N} = -0.414\hat{k}\text{ N}.$$