454.

Problem 34.60 (RHK)

A circular loop of wire having a radius of 8.0 cm *carries a current of* 0.20 A. *A unit vector parallel to the dipole moment* $\vec{\mu}$ *of the loop is given by* $\hat{n} = 0.60\hat{i} - 0.80\hat{j}$. *If the loop is located in a magnetic field given in* T *by* $\vec{B} = 0.25\hat{i} + 0.30\hat{k}$, *we have to find* (a) *torque on the loop and* (b) *the magnetic potential energy of the loop.*

Solution:

(a)

The unit vector parallel to the dipole moment $\vec{\mu}$ of the loop is

$\hat{n} = 0.60\hat{i} - 0.80\hat{j}$.

Loop is a circular wire of radius 8.0 cm. The area of the loop is

$A = \pi\left(8.0\times10^{-2}\right)\ \text{m}^2$.

Current flowing in the loop

$i = 0.20\ \text{A}$.

Therefore, the magnitude of the magnetic dipole moment of the current carrying loop is

$$\mu = iA = 0.2 \times \pi \left(8.0 \times 10^{-2}\right) \text{ A m}^2$$

$$= 4.02 \times 10^{-3} \text{ A m}^2.$$

The magnetic dipole moment is

$$\vec{\mu} = 4.02 \times 10^{3} \left(0.60\hat{i} - 0.80\,\hat{j}\right) \text{ A m}^2.$$

The current carrying loop is placed in a magnetic field

$$\vec{B} = \left(0.25\hat{i} + 0.30\hat{k}\right) \text{ T}.$$

Therefore, the torque on the loop will be

$$\vec{\tau} = \vec{\mu} \times \vec{B} = 4.02 \times 10^{-3} \left(0.60\hat{i} - 0.80\,\hat{j}\right) \times \left(0.25\hat{i} + 0.30\hat{k}\right) \text{ N m}$$

$$= 4.02 \times 10^{-3} \left(-0.18\,\hat{j} + 0.20\hat{k} - 0.24\hat{i}\right) \text{ N m}.$$

(b)

The magnetic potential energy of the loop

$$U = -\vec{\mu}.\vec{B} = -4.02 \times 10^{-3} \left(0.60\hat{i} - 0.80\,\hat{j}\right).\left(0.25\hat{i} + 0.30\hat{k}\right) \text{ J}$$

$$= -4.02 \times 10^{-3} \left(0.15\right) \text{ J} = -0.60 \text{ mJ}.$$