Magnetic Torque

- Equations:

$$\bar{\tau} = \bar{r} \times \bar{F}$$

$$\tau = r F \sin\theta$$

- Magnetic fields can cause a shape of wire to rotate.

- Magnetic dipole moment

$\bar{\mu}$ → vector pointing in the direction of the magnetic field that the loop makes along its axis

(usually $\mu = IA$)

$$\bar{\tau} = \bar{\mu} \times \bar{B}$$

Potential Energy of Magnetic Dipole:

$$U_m = -\vec{\mu} \cdot \vec{B}$$

$$U_m = -\mu B \cos\theta$$

Electric Motors and Generators

- Electric Motor

  Electrical energy → mechanical energy

- Generator

  Mechanical energy → electrical energy

A rectangular coil of dimensions 5.4 cm x 8.5 cm consists of 25 turns of wire and carries a current of 15.0 mA. A 0.35-T magnetic field is applied parallel to the plane of the coil.

a) Calculate the magnitude of the magnetic dipole moment of the coil.

b) What is the magnitude of the torque acting on the loop?

a) $\mu = nIA$

$= (25)(0.015\,A)(0.054\,m)(0.084\,m)$

$= 1.72E-3\ A \cdot m^2$

b) $\tau = \mu B \sin\theta$

$= (1.72E-3\ A \cdot m^2)(0.35\,T)$

$= 6.02E-4\ N \cdot m$

A 50-turn circular coil of radius 5.00 cm can be oriented in any direction in a uniform magnetic field having a magnitude of 0.50 T. If the coil carries a current of 25 mA, find the magnitude of the maximum possible torque exerted on the coil.

$$\tau = \mu B \sin\theta \quad \theta = 1$$

$$= nIAB$$

$$= (50)(0.025\,A)[\pi (0.05m)^2](0.5T)$$

$$= 4.91E-3\ N\cdot m$$

A current of 17 mA is maintained in a single circular loop of 2.0 m in circumference. A magnetic field of 0.80 T is directed parallel to the plane of the loop.

a) Calculate the magnetic moment of the loop.

b) What is the magnitude of the torque exerted by the magnetic field on the loop?

$r = \frac{C}{2\pi} = \frac{2m}{2\pi} = \frac{1}{\pi} m$

a) $\mu = nIA$

$= (1)(0.017\,A)\left[\pi\left(\frac{1}{\pi} m\right)^2\right]$

$= 5.41\,E\text{-}3\ A \cdot m^2$

b) $\tau = \mu B \sin\theta$

$= (5.41\,E\text{-}3\ A \cdot m^2)(0.80\ T)$

$= 4.33\,E\text{-}3\ N \cdot m$

$$\bar{r} = a\hat{i} + b\hat{j} + c\hat{k}$$

$$\bar{r} = \langle a, b, c \rangle$$

Matter and Interactions

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