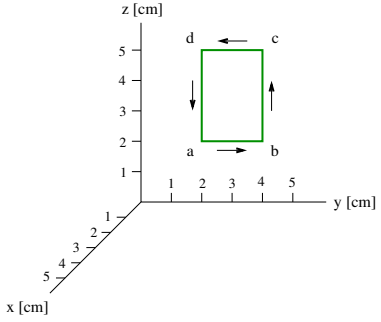
Unit Exam III: Problem #1 (Spring '14)

A counterclockwise current $I = 1.7\text{A}$ [$I = 1.3\text{A}$] is flowing through the conducting rectangular frame shown in a region of magnetic field $\mathbf{B} = 6\text{mT}\hat{\mathbf{j}}$ [$\mathbf{B} = 6\text{mT}\hat{\mathbf{k}}$].

(a) Find the force $\mathbf{F}_{bc}$ [$\mathbf{F}_{ab}$] (magnitude and direction) acting on side bc [ab] of the rectangle.

(b) Find the magnetic moment $\vec{\mu}$ (magnitude and direction) of the current loop.

(c) Find the torque $\vec{\tau}$ (magnitude and direction) acting on the current loop.



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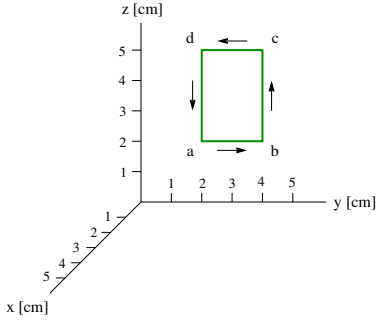

Solution:

(a) $\mathbf{F}_{bc} = (1.7\text{A})(3\text{cm}\hat{\mathbf{k}}) \times (6\text{mT}\hat{\mathbf{j}}) = -3.06 \times 10^{-4}\text{N}\hat{\mathbf{i}}$
$[\mathbf{F}_{ab} = (1.3\text{A})(2\text{cm}\hat{\mathbf{j}}) \times (6\text{mT}\hat{\mathbf{k}}) = 1.56 \times 10^{-4}\text{N}\hat{\mathbf{i}}]$

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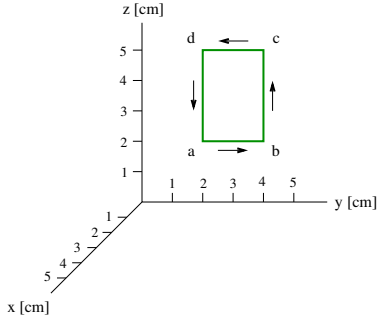

Solution:

(a) $\mathbf{F}_{bc} = (1.7\text{A})(3\text{cm}\hat{\mathbf{k}}) \times (6\text{mT}\hat{\mathbf{j}}) = -3.06 \times 10^{-4}\text{N}\hat{\mathbf{i}}$
$[\mathbf{F}_{ab} = (1.3\text{A})(2\text{cm}\hat{\mathbf{j}}) \times (6\text{mT}\hat{\mathbf{k}}) = 1.56 \times 10^{-4}\text{N}\hat{\mathbf{i}}]$

(b) $\vec{\mu} = [(2\text{cm})(3\text{cm})\hat{\mathbf{i}}](1.7\text{A}) = 1.02 \times 10^{-3}\text{Am}^2\hat{\mathbf{i}}$
$[\vec{\mu} = [(2\text{cm})(3\text{cm})\hat{\mathbf{i}}](1.3\text{A}) = 7.8 \times 10^{-4}\text{Am}^2\hat{\mathbf{i}}]$

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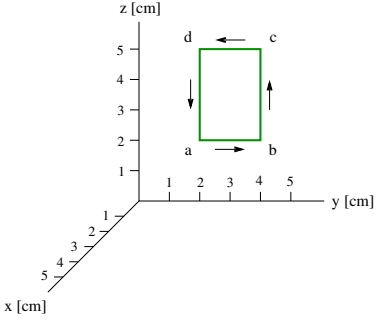

Solution:

(a) $\mathbf{F}_{bc} = (1.7\text{A})(3\text{cm}\hat{\mathbf{k}}) \times (6\text{mT}\hat{\mathbf{j}}) = -3.06 \times 10^{-4}\text{N}\hat{\mathbf{i}}$
$[\mathbf{F}_{ab} = (1.3\text{A})(2\text{cm}\hat{\mathbf{j}}) \times (6\text{mT}\hat{\mathbf{k}}) = 1.56 \times 10^{-4}\text{N}\hat{\mathbf{i}}]$

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$[\vec{\mu} = [(2\text{cm})(3\text{cm})\hat{\mathbf{i}}](1.3\text{A}) = 7.8 \times 10^{-4}\text{Am}^2\hat{\mathbf{i}}]$

(c) $\vec{\tau} = (1.02 \times 10^{-3}\text{Am}^2\hat{\mathbf{i}}) \times (6\text{mT}\hat{\mathbf{j}}) = 6.12 \times 10^{-6}\text{Nm}\hat{\mathbf{k}}$
$[\vec{\tau} = (7.8 \times 10^{-4}\text{Am}^2\hat{\mathbf{i}}) \times (6\text{mT}\hat{\mathbf{k}}) = -4.68 \times 10^{-6}\text{Nm}\hat{\mathbf{j}}]$