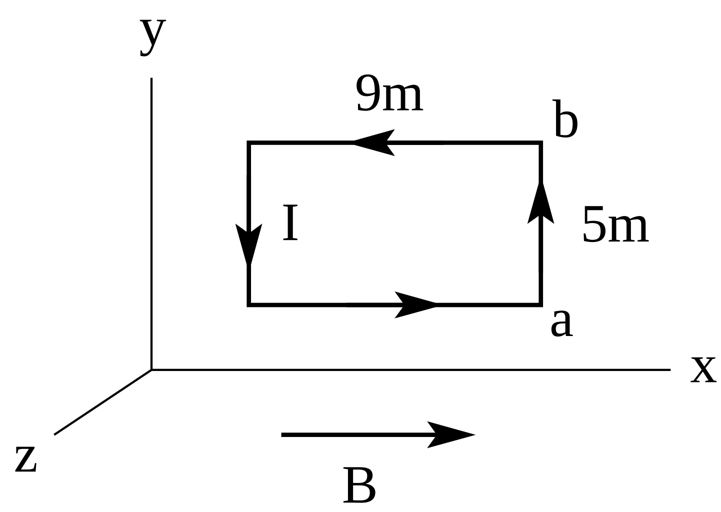
Intermediate Exam III: Problem #1 (Spring '07)

Consider a rectangular conducting loop in the xy-plane with a counterclockwise current $I = 7\text{A}$ in a uniform magnetic field $\vec{B} = 3\text{T}\hat{i}$.

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

(b) Find the force $\vec{F}$ (magnitude and direction) acting on the side ab of the rectangle.

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



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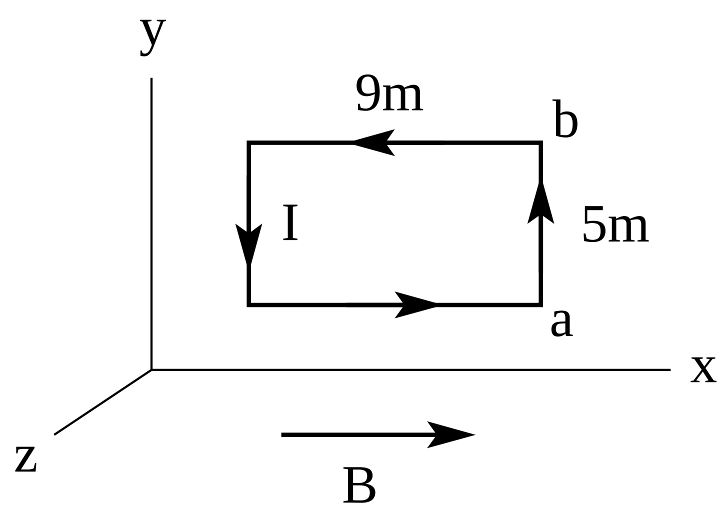


Solution:

(a) $\vec{\mu} = (7\text{A})(45\text{m}^2)\hat{k} = 315\text{Am}^2\hat{k}$.

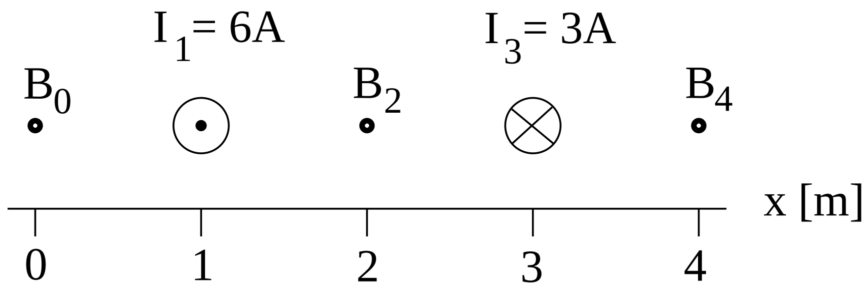
(b) $\vec{F} = I\vec{L} \times \vec{B} = (7\text{A})(5\text{m}\hat{j}) \times (3\text{T}\hat{i}) = -105\text{N}\hat{k}$.

(c) $\vec{\tau} = \vec{\mu} \times \vec{B} = (315\text{Am}^2\hat{k}) \times (3\text{T}\hat{i}) = 945\text{Nm}\hat{j}$

Intermediate Exam III: Problem #2 (Spring '07)

Consider two very long, straight wires with currents $I_1 = 6$A at $x = 1$m and $I_3 = 3$A at $x = 3$m in the directions shown. Find magnitude and direction (up/down) of the magnetic field

(a) B_0 at $x = 0$,
(b) B_2 at $x = 2$m,
(c) B_4 at $x = 4$m.



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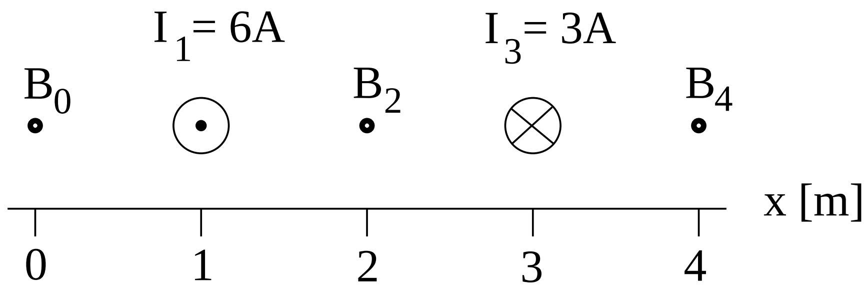


Solution:

(a) $B_0 = -\dfrac{\mu_0(6\text{A})}{2\pi(1\text{m})} + \dfrac{\mu_0(3\text{A})}{2\pi(3\text{m})} = -1.2\mu\text{T} + 0.2\mu\text{T} = -1.0\mu\text{T}$ (down),

(b) $B_2 = \dfrac{\mu_0(6\text{A})}{2\pi(1\text{m})} + \dfrac{\mu_0(3\text{A})}{2\pi(1\text{m})} = 1.2\mu\text{T} + 0.6\mu\text{T} = 1.8\mu\text{T}$ (up),

(c) $B_4 = \dfrac{\mu_0(6\text{A})}{2\pi(3\text{m})} - \dfrac{\mu_0(3\text{A})}{2\pi(1\text{m})} = 0.4\mu\text{T} - 0.6\mu\text{T} = -0.2\mu\text{T}$ (down).

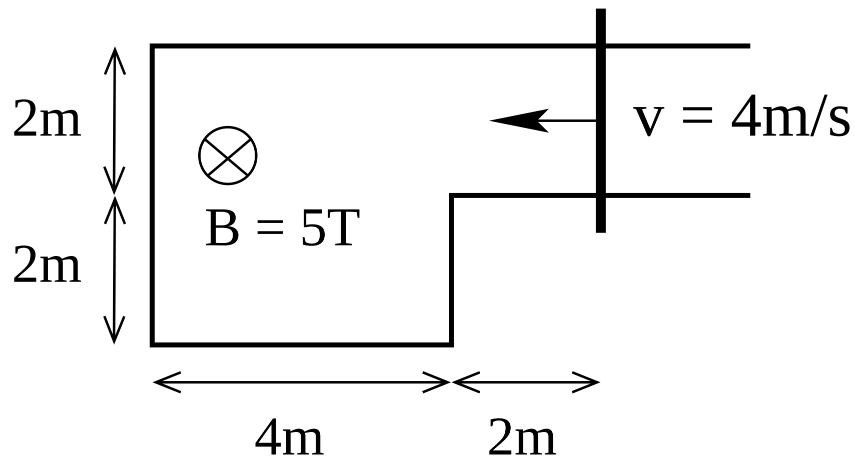
Intermediate Exam III: Problem #3 (Spring ’07)

A conducting frame with a moving conducting rod is located in a uniform magnetic field as shown.

(a) Find the magnetic flux Φ_B through the frame at the instant shown.

(b) Find the induced emf $\mathcal{E}$ at the instant shown.

(c) Find the direction (cw/ccw) of the induced current.



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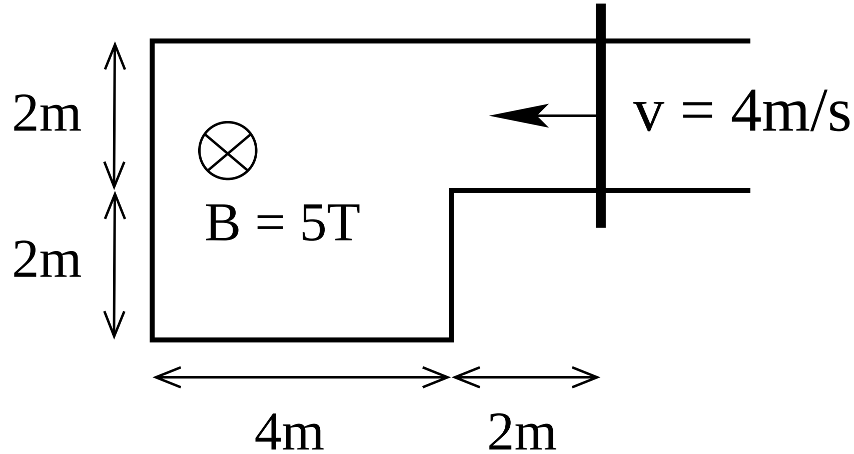

Solution:

(a) $\Phi_B = \vec{A} \cdot \vec{B} = \pm(20\text{m}^2)(5\text{T}) = \pm 100\text{Wb}.$

(b) $\mathcal{E} = -\dfrac{d\Phi_B}{dt} = \pm(5\text{T})(2\text{m})(4\text{m/s}) = \pm 40\text{V}.$

(c) clockwise.