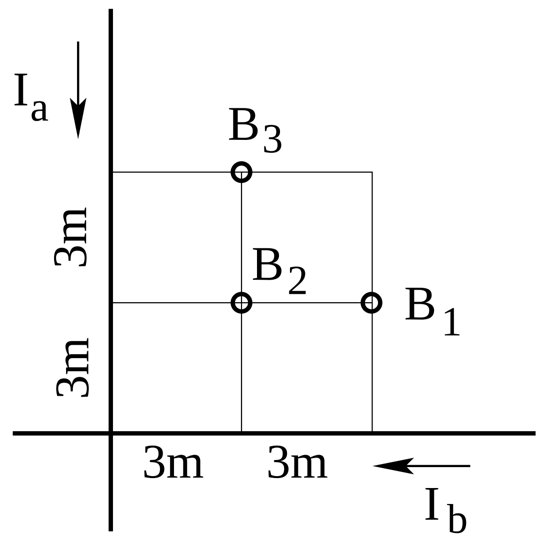
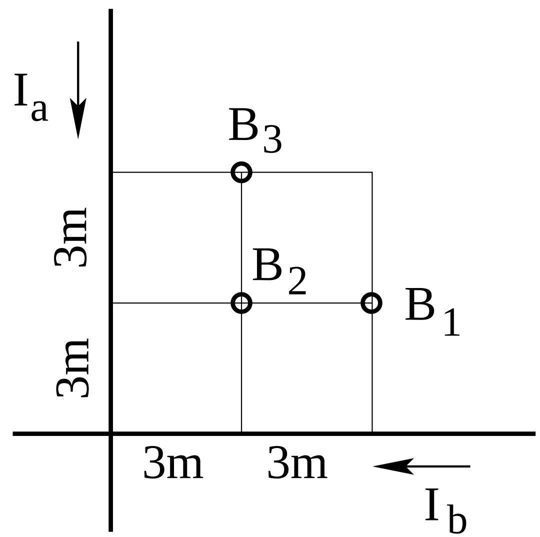
Unit Exam III: Problem #1 (Fall ’14)

Consider two infinitely long, straight wires with currents $I_a = 7$A, $I_b = 9$A in the directions shown. Find direction (in/out) and magnitude of the magnetic fields $\mathbf{B}_1$, $\mathbf{B}_2$, $\mathbf{B}_3$ at the points marked in the graph.



Consider two infinitely long, straight wires with currents $I_a = 7\text{A}$, $I_b = 9\text{A}$ in the directions shown. Find direction (in/out) and magnitude of the magnetic fields $\mathbf{B}_1$, $\mathbf{B}_2$, $\mathbf{B}_3$ at the points marked in the graph.



Solution:

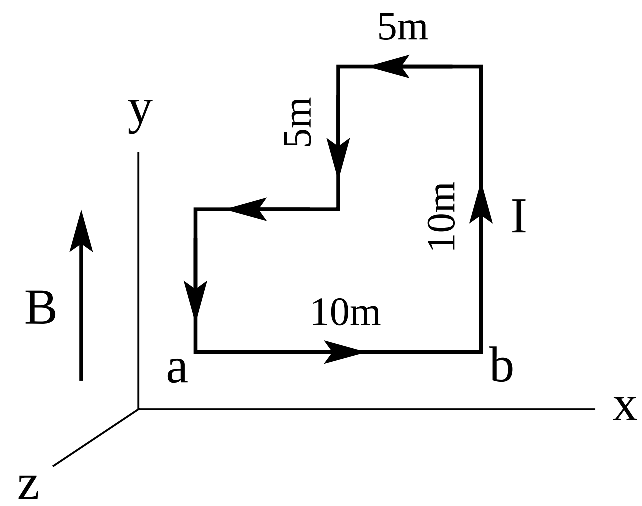
- Convention used: out = positive, in = negative
- $B_1 = \frac{\mu_0}{2\pi}\left(\frac{7\text{A}}{6\text{m}} - \frac{9\text{A}}{3\text{m}}\right) = -0.367\mu\text{T}$ (in).
- $B_2 = \frac{\mu_0}{2\pi}\left(\frac{7\text{A}}{3\text{m}} - \frac{9\text{A}}{3\text{m}}\right) = -0.133\mu\text{T}$ (in).
- $B_3 = \frac{\mu_0}{2\pi}\left(\frac{7\text{A}}{3\text{m}} - \frac{9\text{A}}{6\text{m}}\right) = +0.167\mu\text{T}$ (out).

Consider the (piecewise rectangular) conducting loop in the xy-plane as shown with a counterclockwise current $I = 4\text{A}$ in a uniform magnetic field $\vec{B} = 2\text{T}\hat{j}$.

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

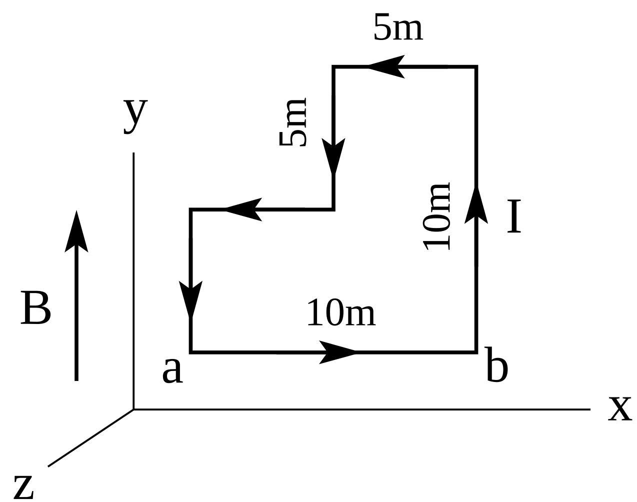
(b) Find the force $\vec{F}$ (magnitude and direction) acting on the side ab of the rectangle.

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



Unit Exam III: Problem #2 (Fall '14)

Consider the (piecewise rectangular) conducting loop in the xy-plane as shown with a counterclockwise current $I = 4$A in a uniform magnetic field $\vec{B} = 2\mathrm{T}\hat{j}$.
(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.



Solution:

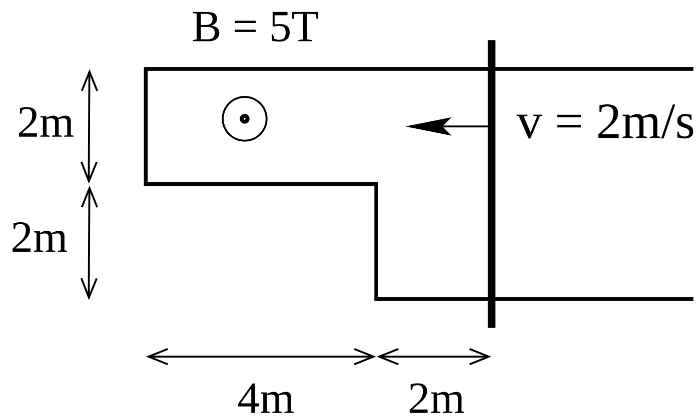
(a) $\vec{\mu} = (4\mathrm{A})(75\mathrm{m}^2)\hat{k} = 300\mathrm{Am}^2\hat{k}.$

(b) $\vec{F} = I\vec{L} \times \vec{B} = (4\mathrm{A})(10\mathrm{m}\hat{i}) \times (2\mathrm{T}\hat{j}) = 80\mathrm{N}\hat{k}.$

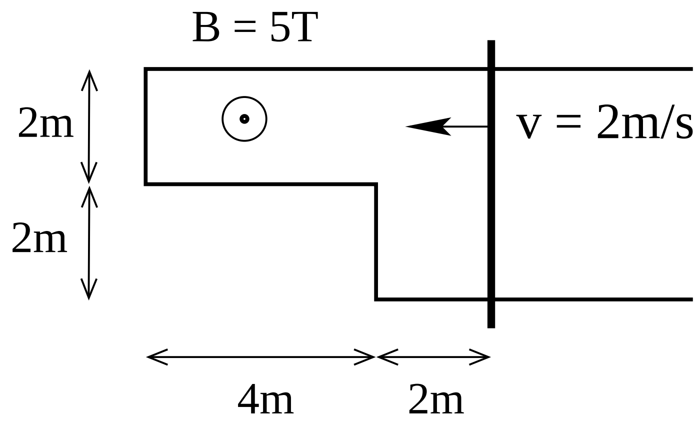
(c) $\vec{\tau} = \vec{\mu} \times \vec{B} = (300\mathrm{Am}^2\hat{k}) \times (2\mathrm{T}\hat{j}) = -600\mathrm{Nm}\hat{i}$

Unit Exam III: Problem #3 (Fall '14)

A conducting frame with a moving conducting rod is located in a uniform magnetic field directed out of the plane as shown. The rod moves at constant velocity.
(a) Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame at the instant shown.
(b) Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame two seconds later.
Write magnitudes only (in SI units), no directions.



A conducting frame with a moving conducting rod is located in a uniform magnetic field directed out of the plane as shown. The rod moves at constant velocity.
(a) Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame at the instant shown.
(b) Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame two seconds later.
Write magnitudes only (in SI units), no directions.



Solution:

(a) $\Phi_B = (16\text{m}^2)(5\text{T}) = 80\text{Wb}, \quad \mathcal{E} = (2\text{m/s})(5\text{T})(4\text{m}) = 40\text{V}.$

(b) $\Phi_B = (4\text{m}^2)(5\text{T}) = 20\text{Wb}, \quad \mathcal{E} = (2\text{m/s})(5\text{T})(2\text{m}) = 20\text{V}.$