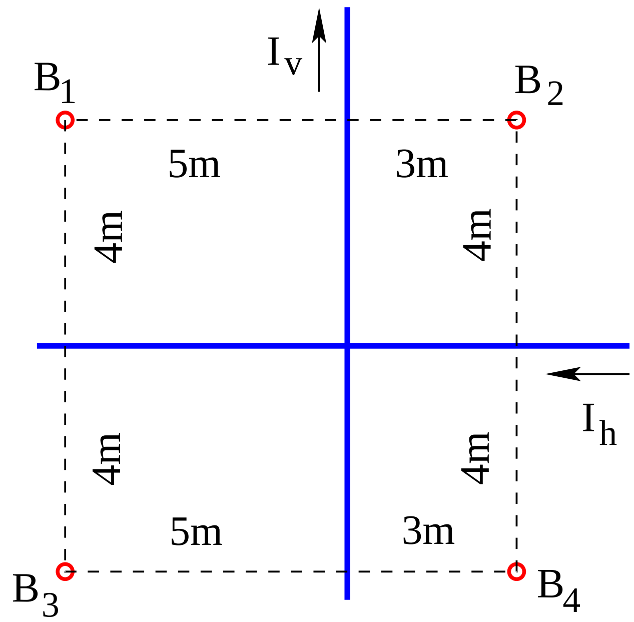
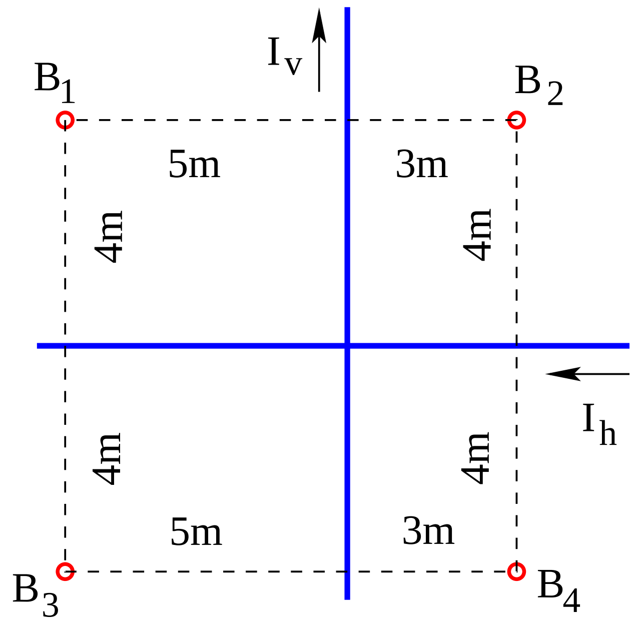
Unit Exam III: Problem #1 (Spring '17)

Consider two infinitely long, straight wires with currents $I_v = 6.9$A, $I_h = 7.2$A in the directions shown. Find direction (in/out) and magnitude of the magnetic fields $\mathbf{B}_1$, $\mathbf{B}_2$, $\mathbf{B}_3$, $\mathbf{B}_4$, at the points marked in the graph.



Consider two infinitely long, straight wires with currents $I_v = 6.9$A, $I_h = 7.2$A in the directions shown. Find direction (in/out) and magnitude of the magnetic fields $\mathbf{B}_1$, $\mathbf{B}_2$, $\mathbf{B}_3$, $\mathbf{B}_4$, at the points marked in the graph.



Solution:

- Convention used: out = positive, in = negative
- $B_1 = \frac{\mu_0}{2\pi}\left(\frac{6.9\text{A}}{5\text{m}} - \frac{7.2\text{A}}{4\text{m}}\right) = -0.84 \times 10^{-7}\text{T}$ (in).
- $B_2 = \frac{\mu_0}{2\pi}\left(-\frac{6.9\text{A}}{3\text{m}} - \frac{7.2\text{A}}{4\text{m}}\right) = -8.20 \times 10^{-7}\text{T}$ (in).
- $B_3 = \frac{\mu_0}{2\pi}\left(\frac{6.9\text{A}}{5\text{m}} + \frac{7.2\text{A}}{4\text{m}}\right) = 6.36 \times 10^{-7}\text{T}$ (out).
- $B_4 = \frac{\mu_0}{2\pi}\left(-\frac{6.9\text{A}}{3\text{m}} + \frac{7.2\text{A}}{4\text{m}}\right) = -1.00 \times 10^{-7}\text{T}$ (in).

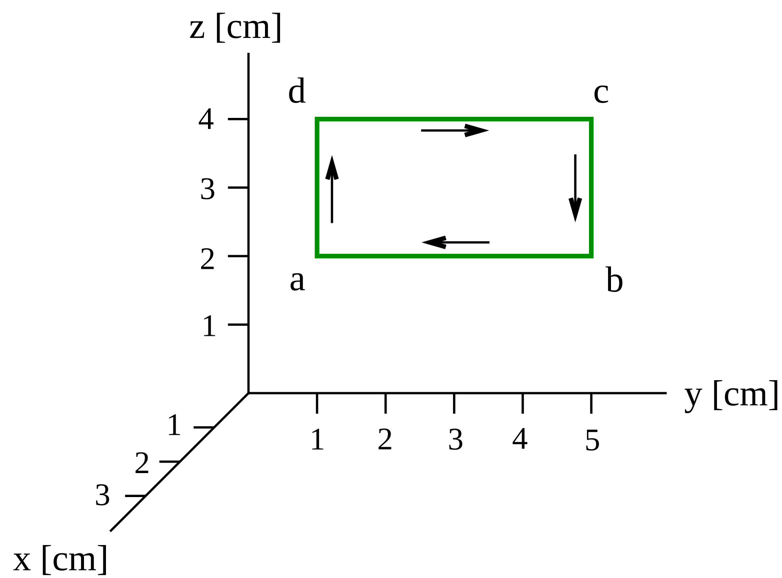
Unit Exam III: Problem #2 (Spring '17)

In a region of uniform magnetic field $\mathbf{B} = 4\text{mT}\hat{\mathbf{k}}$ [$\mathbf{B} = 5\text{mT}\hat{\mathbf{j}}$] a clockwise current $I = 1.4$A [$I = 1.5$A] is flowing through the conducting rectangular frame.

(i) Find the force $\mathbf{F}_{dc}$ (magnitude and direction) acting on side dc of the rectangle. (ii) Find the force $\mathbf{F}_{ad}$ (magnitude and direction) acting on side ad of the rectangle.

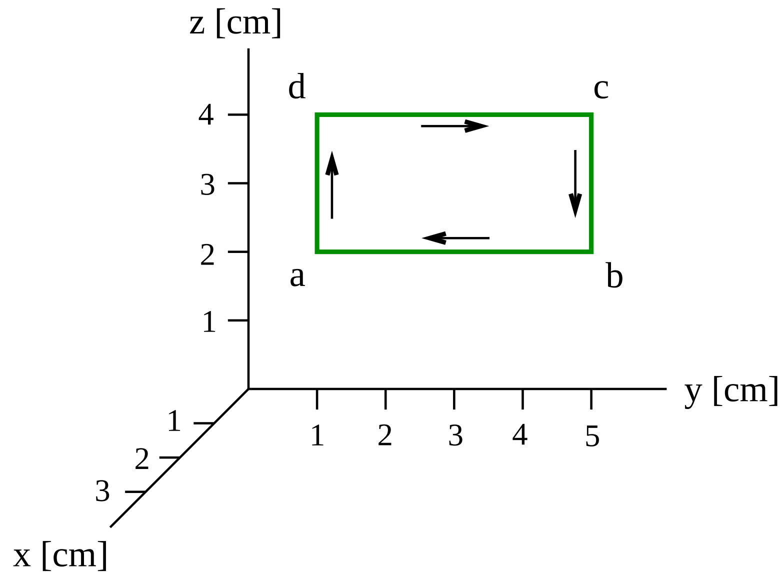
(iii) Find the magnetic moment $\vec{\mu}$ (magnitude and direction) of the current loop.

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



Unit Exam III: Problem #2 (Spring '17)

In a region of uniform magnetic field $\mathbf{B} = 4\text{mT}\hat{\mathbf{k}}$ [$\mathbf{B} = 5\text{mT}\hat{\mathbf{j}}$] a clockwise current $I = 1.4$A [$I = 1.5$A] is flowing through the conducting rectangular frame.
(i) Find the force $\mathbf{F}_{dc}$ (magnitude and direction) acting on side dc of the rectangle. (ii) Find the force $\mathbf{F}_{ad}$ (magnitude and direction) acting on side ad of the rectangle.
(iii) Find the magnetic moment $\vec{\mu}$ (magnitude and direction) of the current loop.
(iv) Find the torque $\vec{\tau}$ (magnitude and direction) acting on the current loop.



Solution:

(i) $\mathbf{F}_{dc} = (1.4\text{A})(4\text{cm}\hat{\mathbf{j}}) \times (4\text{mT}\hat{\mathbf{k}}) = 2.24 \times 10^{-4}\text{N}\hat{\mathbf{i}}.$

$[\mathbf{F}_{dc} = (1.5\text{A})(4\text{cm}\hat{\mathbf{j}}) \times (5\text{mT}\hat{\mathbf{j}}) = 0.]$

(ii) $\mathbf{F}_{ad} = (1.4\text{A})(2\text{cm}\hat{\mathbf{k}}) \times (4\text{mT}\hat{\mathbf{k}}) = 0.$

$[\mathbf{F}_{ad} = (1.5\text{A})(2\text{cm}\hat{\mathbf{k}}) \times (5\text{mT}\hat{\mathbf{j}}) = -1.50 \times 10^{-4}\text{N}\hat{\mathbf{i}}.]$

(iii) $\vec{\mu} = [-(4\text{cm})(2\text{cm})\hat{\mathbf{i}}](1.4\text{A}) = -1.12 \times 10^{-3}\text{Am}^2\hat{\mathbf{i}}.$

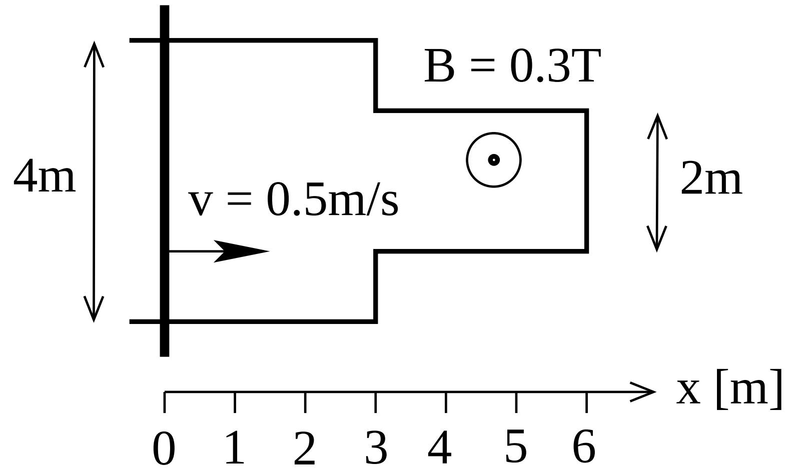
$[\vec{\mu} = [-(4\text{cm})(2\text{cm})\hat{\mathbf{i}}](1.5\text{A}) = -1.20 \times 10^{-3}\text{Am}^2\hat{\mathbf{i}}.]$

(iv) $\vec{\tau} = (-1.12 \times 10^{-3}\text{Am}^2\hat{\mathbf{i}}) \times (4\text{mT}\hat{\mathbf{k}}) = 4.48 \times 10^{-6}\text{Nm}\hat{\mathbf{j}}.$

$[\vec{\tau} = (-1.20 \times 10^{-3}\text{Am}^2\hat{\mathbf{i}}) \times (5\text{mT}\hat{\mathbf{j}}) = -6.00 \times 10^{-6}\text{Nm}\hat{\mathbf{k}}.]$

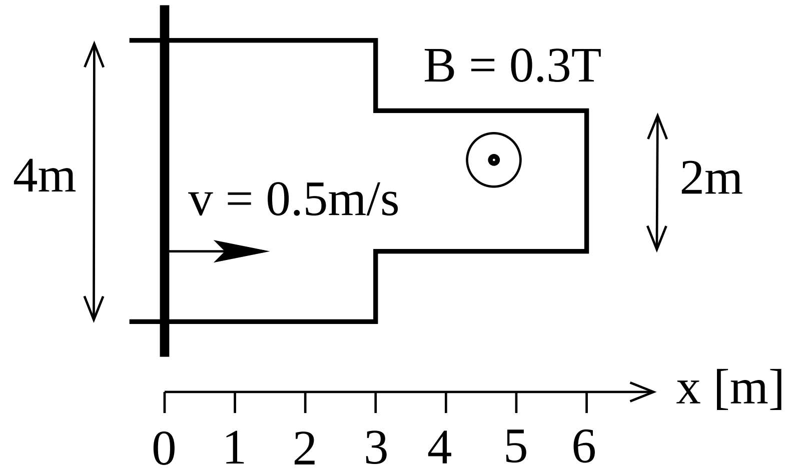
Unit Exam III: Problem #3 (Spring ’17)

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.
Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame when the rod is
(a) at position $x = 1$m,
(b) at position $x = 4$m.
(c) at position $x = 2$m,
(d) at position $x = 5$m.
Write magnitudes only (in SI units), no directions.



Unit Exam III: Problem #3 (Spring '17)

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.
Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame when the rod is
(a) at position $x = 1$m,
(b) at position $x = 4$m.
(c) at position $x = 2$m,
(d) at position $x = 5$m.
Write magnitudes only (in SI units), no directions.



Solution:

(a) $\Phi_B = (8+6)\mathrm{m}^2(0.3\mathrm{T}) = 4.2\mathrm{Wb}, \quad \mathcal{E} = (0.5\mathrm{m/s})(0.3\mathrm{T})(4\mathrm{m}) = 0.6\mathrm{V}.$

(b) $\Phi_B = (4\mathrm{m}^2)(0.3\mathrm{T}) = 1.2\mathrm{Wb}, \quad \mathcal{E} = (0.5\mathrm{m/s})(0.3\mathrm{T})(2\mathrm{m}) = 0.3\mathrm{V}.$

(c) $\Phi_B = (4+6)\mathrm{m}^2(0.3\mathrm{T}) = 3.0\mathrm{Wb}, \quad \mathcal{E} = (0.5\mathrm{m/s})(0.3\mathrm{T})(4\mathrm{m}) = 0.6\mathrm{V}.$

(d) $\Phi_B = (2\mathrm{m}^2)(0.3\mathrm{T}) = 0.6\mathrm{Wb}, \quad \mathcal{E} = (0.5\mathrm{m/s})(0.3\mathrm{T})(2\mathrm{m}) = 0.3\mathrm{V}.$