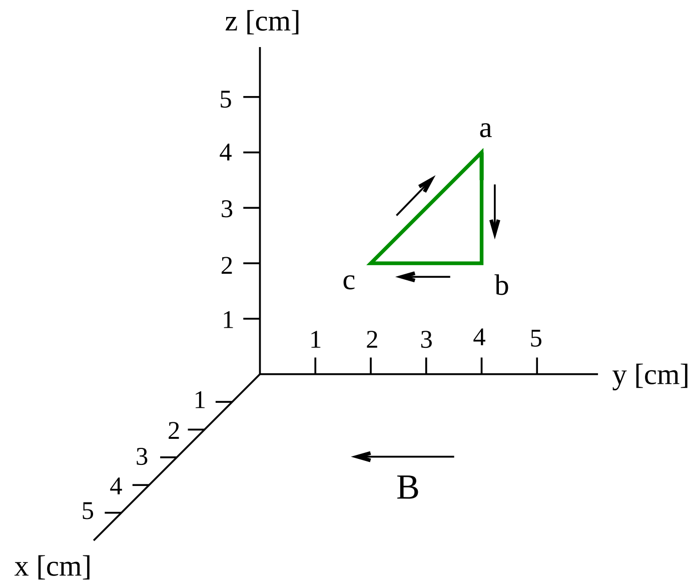
A clockwise current $I = 2.1$A is flowing around the conducting triangular frame shown in a region of uniform magnetic field $\vec{B} = -3$mT$\hat{\mathbf{j}}$.
(a) Find the force $\vec{F}_{ab}$ acting on side ab of the triangle.
(b) Find the force $\vec{F}_{bc}$ acting on side bc of the triangle.
(c) Find the magnetic moment $\vec{\mu}$ of the current loop.
(d) Find the torque $\vec{\tau}$ acting on the current loop.
Remember that vectors have components or magnitude and direction.



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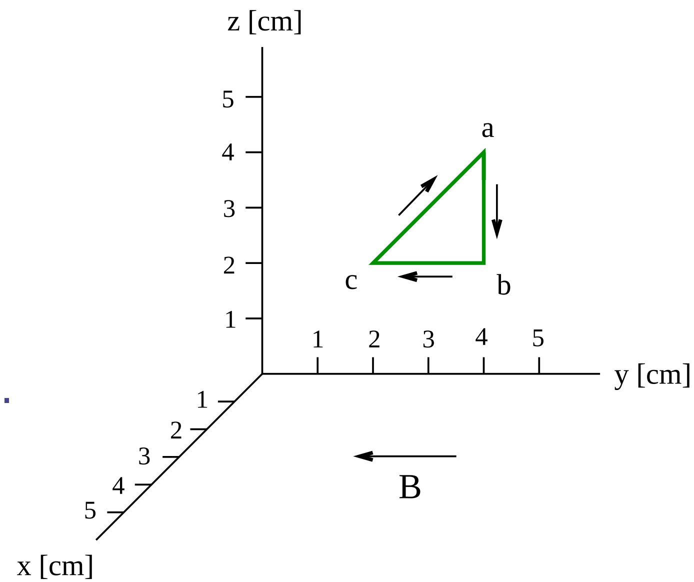


Solution:

(a) $\vec{F}_{ab} = (2.1\text{A})(-2\text{cm}\hat{\mathbf{k}}) \times (-3\text{mT}\hat{\mathbf{j}}) = -1.26 \times 10^{-4}\text{N}\hat{\mathbf{i}}.$

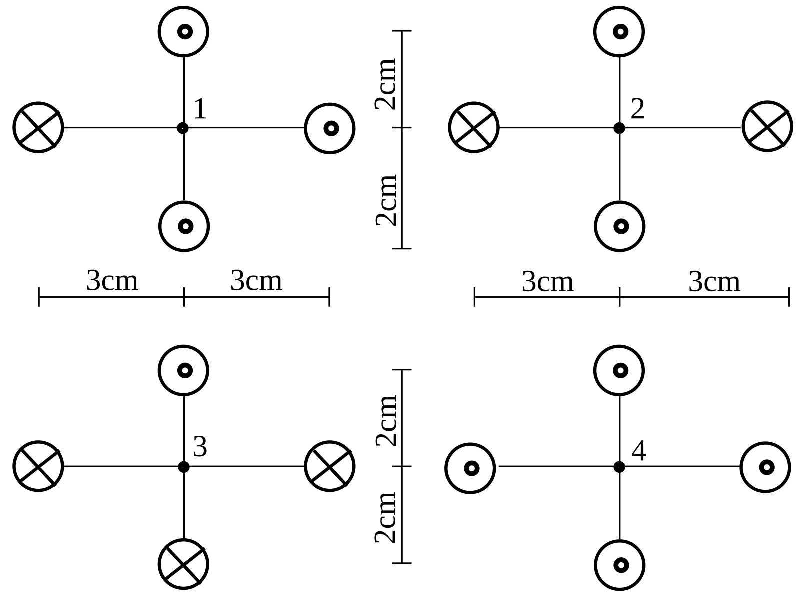
(b) $\vec{F}_{bc} = 0.$

(c) $\vec{\mu} = \left[-\frac{1}{2}(2\text{cm})(2\text{cm})\hat{\mathbf{i}}\right](2.1\text{A}) = -4.2 \times 10^{-4}\text{Am}^2\hat{\mathbf{i}}.$

(d) $\vec{\tau} = (-4.2 \times 10^{-4}\text{Am}^2\hat{\mathbf{i}}) \times (-3\text{mT}\hat{\mathbf{j}}) = 1.26 \times 10^{-6}\text{Nm}\hat{\mathbf{k}}.$

Unit Exam III: Problem #2 (Spring '15)

Consider four long, straight currents in four different configurations. All currents are $I = 4$mA in the directions shown ($\otimes =$ in, $\odot =$ out). Find the magnitude (in SI units) and the direction ($\leftarrow, \rightarrow, \uparrow, \downarrow$) of the magnetic fields $\mathbf{B}_1$, $\mathbf{B}_2$, $\mathbf{B}_3$, $\mathbf{B}_4$ generated at the points $1, \ldots, 4$, respectively.



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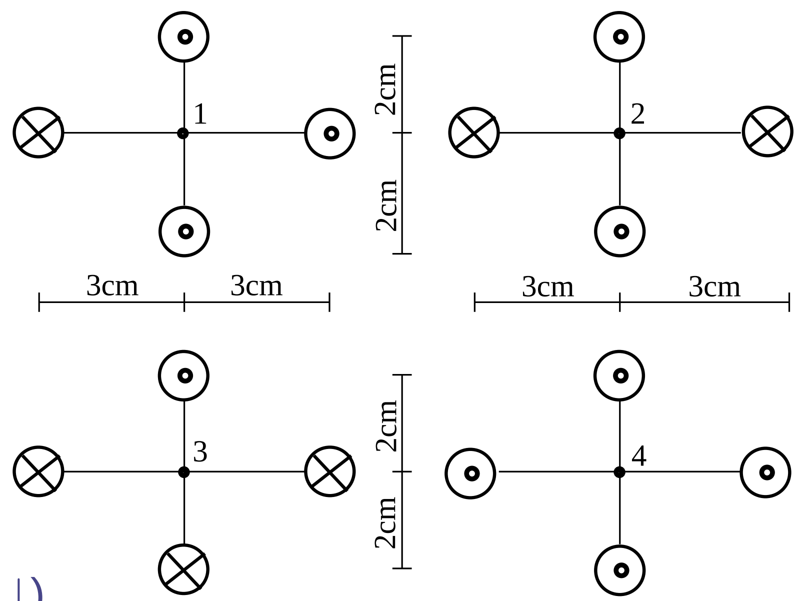


Solution:

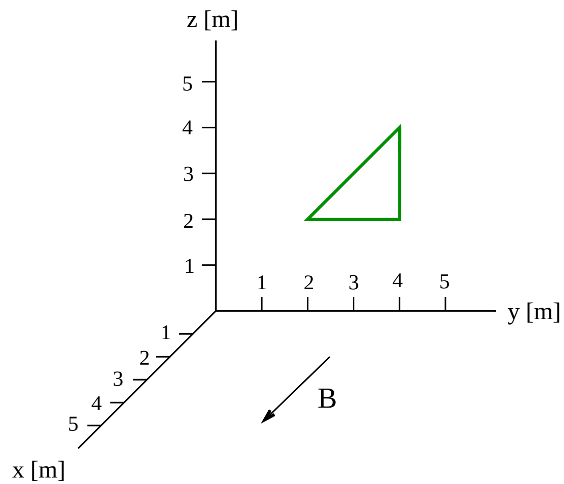
- $B_1 = 2\,\dfrac{\mu_0(4\text{mA})}{2\pi(3\text{cm})} = 5.33 \times 10^{-8}\text{T}$ (directed $\downarrow$).
- $B_2 = 0$ (no direction).
- $B_3 = 2\,\dfrac{\mu_0(4\text{mA})}{2\pi(2\text{cm})} = 8.00 \times 10^{-8}\text{T}$ (directed $\rightarrow$).
- $B_4 = 0$ (no direction).

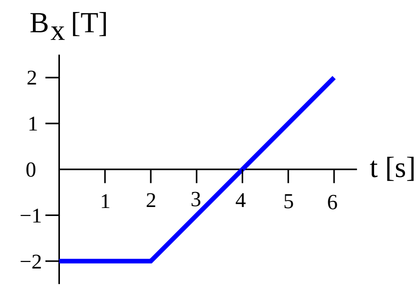
Unit Exam III: Problem #3 (Spring '15)

A wire shaped into a triangle has resistance $R = 3.5\Omega$ and is placed in the yz-plane as shown. A uniform time-dependent magnetic field $\mathbf{B} = B_x(t)\hat{\mathbf{i}}$ is present. The dependence of B_x on time is shown graphically.

(a) Find magnitude $|\Phi_B^{(1)}|$ and $|\Phi_B^{(4)}|$ of the magnetic flux through the triangle at times $t = 1$s and $t = 4$s, respectively.

(b) Find magnitude I_1, I_4 and direction (cw/ccw) of the induced current at times $t = 1$s and $t = 4$s, respectively.





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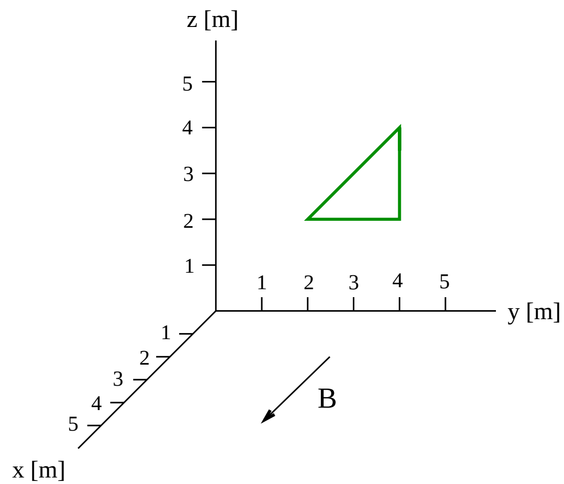

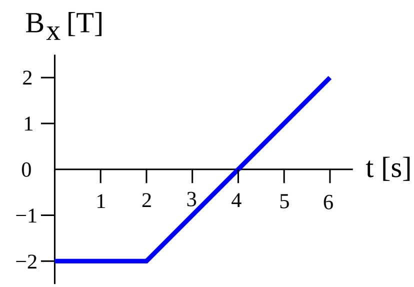

Solution:

(a) $$|\Phi_B^{(1)}| = |(2\mathrm{m}^2)(-2\mathrm{T})| = 4.0\,\mathrm{Wb},$$

$$|\Phi_B^{(4)}| = |(2\mathrm{m}^2)(0\mathrm{T}) = 0.$$

(b) $$\left|\frac{d\Phi_B^{(1)}}{dt}\right| = \left|A\frac{dB}{dt}\right| = |(2\mathrm{m}^2)(0\mathrm{T/s}) = 0$$

$$\Rightarrow\; I_1 = 0,$$

$$\left|\frac{d\Phi_B^{(4)}}{dt}\right| = \left|A\frac{dB}{dt}\right| = |(2\mathrm{m}^2)(1\mathrm{T/s})| = 2.0\mathrm{V}$$

$$\Rightarrow\; I_4 = \frac{2.0\mathrm{V}}{3.5\Omega} = 0.571\mathrm{A}$$ (cw).