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Exam 3 (Solutions)

PHY 204: Elementary Physics II

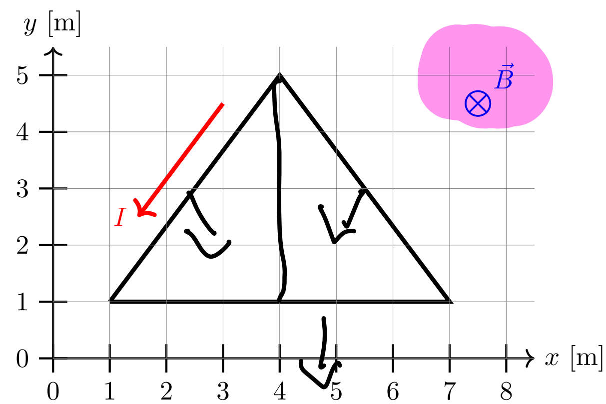
You have 50 minutes to complete this exam. Show your work, explain your reasoning, include sketches where appropriate, and clearly indicate your final answer. All vectors must be written in unit-vector notation for full credit. All final answers must have units for full credit.

1. The conducting loop shown in the figure to the right has $N = 2$ turns and carries a counterclockwise current $I = 1\,\mathrm{A}$. A constant magnetic field $\vec{B} = -1\,\mathrm{T}\,\hat{k}$ is present throughout the region, as shown.

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

   (b) Calculate the magnitude of the force $\vec{F}$ on each of the three sides of the loop. Specify the direction for each force by drawing an arrow on the figure.

   (c) Calculate the net force $\vec{F}_{\mathrm{net}}$ and the net torque $\vec{\tau}_{\mathrm{net}}$ on the loop. Show your work and/or explain your answer.



a). $\vec{\mu} = NIA$

$= 2(1)(12)$

$= 24\hat{k}$

b). $|F| = NILB\sin\theta$

$= 2(1)(6)(-1)\sin 90$

$= 12$

$|F| = 2(1)(5)(\cancel{1})\sin 90$

$= 10$

$|F| = 2(1)(5)(-1)\sin 90$

$= 10$

c). $\vec{F}_{net} = 0$ closed shape

$\vec{\tau}_{net} = 24\hat{k} \times -1\hat{k}$

$= 0$

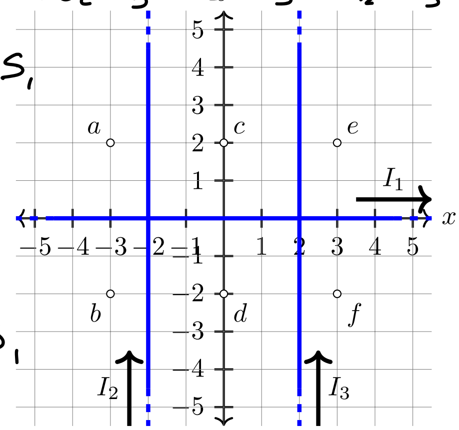
$B = \frac{\mu_0 I}{2\pi r}$ (Inf. wire)

2. There are three infinite wires arranged in a plane as shown in the figure to the right, where x and y are measured in meters. Each wire carries a current $I = 6\,\text{A}$, $I_2 = 10\,\text{A}$, $I_3 = 20\,\text{A}$ in the directions shown. Calculate the magnitude and direction of the total magnetic field ($\vec{B}_a$, $\vec{B}_b$, $\vec{B}_c$, $\vec{B}_d$, $\vec{B}_e$, $\vec{B}_f$) at each the indicated points a, b, c, d, e, f shown.

$+S_2+S_3$ $-S_2+S_3$ $-S_2-S_3$

$+S_1$

$-S_1$



out = pos

$$\vec{B}_a = \frac{(\cancel{4\pi}\times 10^{-7})(6)}{\cancel{2\pi}(\cancel{2})} + \frac{\cancel{4\pi}\times 10^{-7}(10)}{\cancel{2\pi}} + \frac{(\cancel{4\pi}\times 10^{-7})(\cancel{20})}{\cancel{2\pi}(\cancel{5})}$$

$$6\times 10^{-7} + 20\times 10^{-7} + 8\times 10^{-7}$$

$$\boxed{34\times 10^{-7}\ \text{T}\ \hat{k}}$$

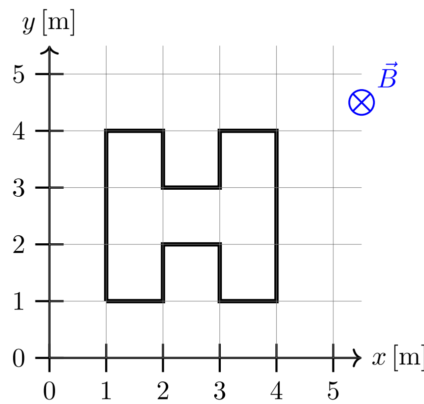
$$\vec{B}_b = -\frac{(4\pi\times 10^{-7})(6)}{2\pi(2)} + \frac{(4\times 10^{-7})(10)}{2\pi} + \frac{(4\pi\times 10^{-7})(20)}{2\pi(5)}$$

$$-6\times 10^{-7} + 20\times 10^{-7} + 8\times 10^{-7}$$

$$22\times 10^{-7}\ \text{T}\ \hat{k}$$

$$\vec{B}_e = \frac{(4\pi\times 10^{-7})(6)}{2\pi(2)} + \frac{(4\pi\times 10^{-7})(10)}{2\pi(5)} + \frac{(4\pi\times 10^{-7})(20)}{2\pi(1)}$$

3. A conducting loop with $N = 2$ turns is bent into the shape of the letter "H" as shown in the figure to the right. A time-dependent magnetic field is present throughout the region. The field has a magnitude given by the equation $B(t) = B_0 t^2 - B_1$, where $B_0 = 1\,\mathrm{T/s^2}$ and $B_1 = 1\,\mathrm{T}$, and is directed into the plane.



(a) Calculate the area of the loop, and specify the direction of its normal vector ($\odot$, $\otimes$).

(b) Find the magnetic flux Φ_B through the loop at $t = 0$ and $t = 1\,\mathrm{s}$.

(c) Find the magnitude and direction (cw/ccw) of the induced emf $\mathcal{E}$ at $t = 0$ and $t = 1\,\mathrm{s}$.

a). $7\ m^2$ $\quad \odot$

b). $\Phi_B = \vec{B} \cdot \vec{A}$

$$N \cdot (B_0 t^2 - B_1)(7)$$

$$(1t^2 - 1)(7) = -7\ Tm^2 = \boxed{-14\ Tm^2}$$

$$(B_0 t^2 - B_1)(7)$$

$$(1(1)^2 - 1)(7) = 0$$

c) $$\mathcal{E} = -\frac{d\,\Phi_B}{dt} \cdot N \qquad \Phi_B = B \cdot A$$

$$B = B_0 t^2 - \cancel{B_1}$$
$$B' = 2B_0 t$$

$$\mathcal{E} = -\left(\frac{dB}{dt}\right) A \cdot N$$

$$\mathcal{E} = -N(2B_0 t)A$$

t=0

$$-2(2(1)(0)) \cdot (7) = 0$$

t=1

$$-2(2(1)(1)) \cdot (7) = \boxed{-28\ V}$$ ccw

Grade: __________ / 100