PHYS 102 Midterm examination #2 (Version 2A)

November 19, 2004 Name Key

Time: 50 minutes Student No.

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Constants:

$\mu_0 = 4\pi \times 10^{-7}$ Tm/A

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2

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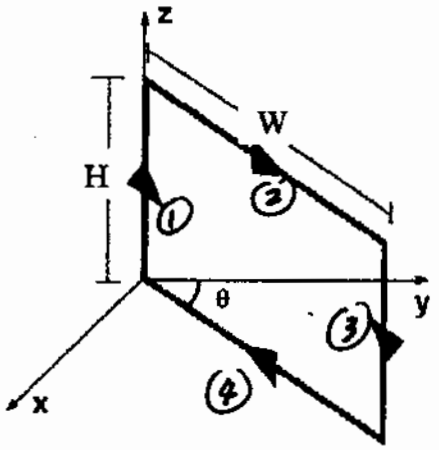
1(5/20 marks). The rectangular loop shown below is located in a uniform magnetic field of 0.15T pointing in the positive y direction.
(a) Find the magnetic force (both the magnitude and direction) on each side of the loop.
(b) Calculate the magnitude of the torque on the loop.

DATA:
H=2.0cm
W=4.0cm
θ=30.0°
I=8.5A
N = 1



(a) $\vec{F}_1$: along $-\hat{x}$

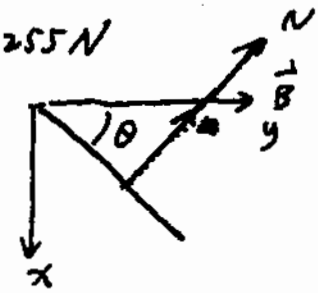
$|\vec{F}_1| = F_1 = BIH$

$= (0.15)(8.5)(0.02)$

$= 0.0255\ N$

$\vec{F}_2$: along $\hat{j}$

$F_2 = BIW\sin\theta = (0.15)(8.5)(0.04)\sin 30^\circ = 0.0255\ N$



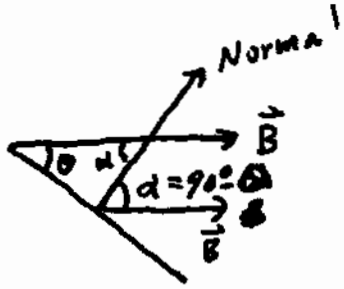
$\vec{F}_3$: along $\hat{x}$, $F_3 = F_1 = 0.0255\ N$

$\vec{F}_4$: along $-\hat{j}$, $F_4 = F_2 = 0.0255\ N$

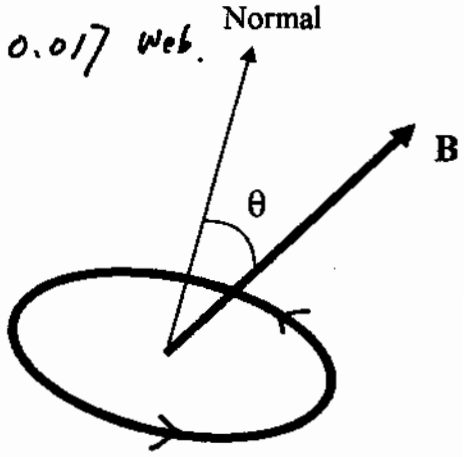
(b) $\tau = BIA\sin(90^\circ - \theta)$ $(N = 1)$

$= (0.15)(8.5)(0.02)(0.04)\cdot\sin 60^\circ$

$= 8.83 \times 10^{-4}\ N\cdot m$.



2(5/20 marks). A piece of wire is formed into a circular loop of radius 25cm. The loop is immersed in a uniform magnetic field. The angle between the magnetic field and the normal of the loop is 30°, as shown in the figure below. Initially B=0.10T. The magnetic field is then decreased at a constant rate to zero in a time of 0.4s.
(a) What is the initial value of the magnetic flux?
(b) What is the induced emf in the loop at t=0.2s?
(c) Indicate the direction of induced current in the loop.



(a) $\Phi_0 = BA\cos\theta = (0.1)\pi(0.25)^2 \cdot \cos 30° = 0.017$ Wb.

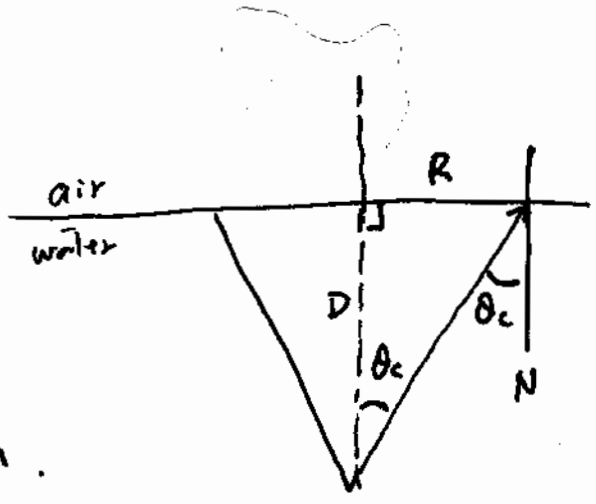
(b) $|\mathcal{E}| = \left| \frac{d\Phi}{dt} \right|$.

$= + \frac{\Delta\Phi}{\Delta t} = + A \cdot \cos\theta \cdot \frac{\Delta B}{\Delta t}$.

$= \frac{+[(0.10) - 0] \cdot \pi(0.25)^2 \cdot \cos 30°}{0.4}$

$= 4.25 \times 10^{-3}$ V.

3(5/20 marks). A point source of light is located 5.00m below the surface of a large lake of clear toxic fluid (Lake Ontario, where n=1.60.) Find the area of the largest circle on the pool's surface through which light coming directly from the source can emerge.



$R = D \cdot \tan\theta_c$.

$\theta_c = \sin^{-1}\left(\frac{n_a}{n_w}\right)$

$= \sin^{-1}\left(\frac{1.00}{1.60}\right)$

$= 38.68°$

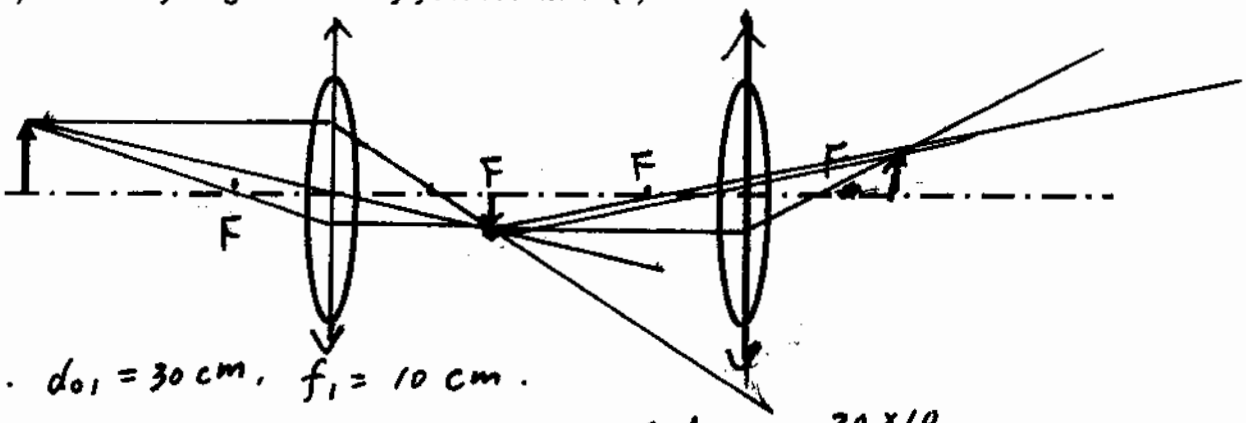
$R = (5.00)\tan(38.68°) = 4.00$ m.

$A = \pi R^2 = 50.3$ m^2.

4(5/20 marks). Two converging lenses, each with a focal length f=10.0cm, are placed 40.0cm apart, as shown in the figure below. An object is placed 30.0cm in front of the first lens as shown.

(a) Calculate the location and magnification of the final image formed by the combination of the two lenses.

(b) Use a ray diagram to verify your results of (a).



(a). $d_{o1} = 30\ cm$, $f_1 = 10\ cm$.

$$\frac{1}{d_{o1}} + \frac{1}{d_{i1}} = \frac{1}{f_1} \qquad d_{i1} = \frac{f_1 d_{o1}}{d_{o1} - f_1} = \frac{30 \times 10}{30 - 10} = 15\ cm$$

$$d_{o2} = 40 - 15 = 25\ cm.$$

$$d_{i2} = \frac{f_2 d_{o2}}{d_{o2} - f_2} = \frac{(10)(25)}{25 - 10} = 16.7\ cm$$

$$m = m_1 m_2. \qquad m_1 = -\frac{d_{i1}}{d_{o1}} = -\frac{15}{30} = -\frac{1}{2}$$

$$m_2 = -\frac{d_{i2}}{d_{o2}} = -\frac{16.7}{25} = -0.668$$

$$m = \left(-\frac{1}{2}\right)(-0.668) = 0.334$$