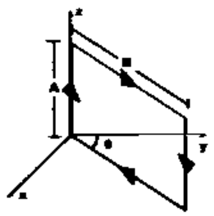
SFU Department of Physics

phys102q – Fall 2004 – Assignment 5.
Due Sun, Dec 12, 2004 at 12:12hrs. CAPA ID is **1262**

---

1. [1 pt.] The rectangular loop shown below is located in a uniform magnetic field of 0.15T pointing in the negative x direction.



DATA:
A=4.5cm
B=4.5cm
θ=32.5°
I=8.5A

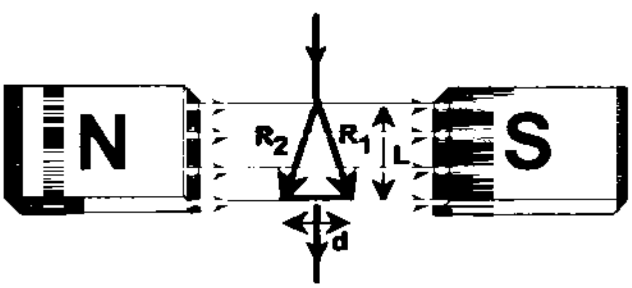
Calculate the magnitude of the torque on the loop.

---

2. [1 pt.] A narrow flat coil wound on a square frame has 140 turns and sides of 41.0cm. It carries a current of 2.45A and is positioned in a 0.220-T magnetic field. What is the maximum torque that can be exerted by the field on the coil?

---

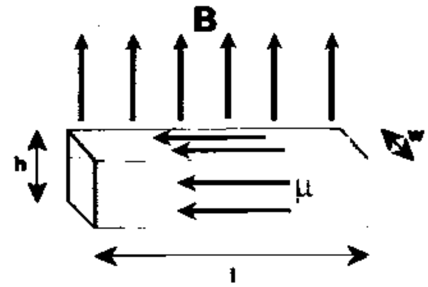
3. [1 pt.] At SFU the magnetic field due to the earth is at 15.0° to the vertical and has a magnitude of 5.70×10^{-5}T. An electron moves straight down at $7.78\times10^{5}\mathrm{ms}^{-1}$. Find the ratio of the magnitude of the magnetic force on the electron to its weight, mg.



4. [1 pt.] The diagram above depicts a wire carrying a current I=4.70A. The wire splits into two channels; of resistance R_2=7.45Ω and R_1=4.85Ω, and re-joins forming a current loop in the shape of an isosceles triangle with base distance d=7.90cm and height L=16.0cm. The loop is entered into the space between the two poles of a magnet with a uniform magnetic field, **B**=4.35×10^{-2}T, that runs from one pole to the other. The loop is placed such that the field lies in the plane of the loop. What is the torque on the circuit about the wire's axis?

---

5. [1 pt.] Calculate the magnetic dipole moment of a single atom, based on the following model: One electron travels at speed 3.90×10^{6}m/s in a circular orbit of diameter 2×10^{-10}m.



6. [1 pt.] The individual atomic magnetic dipoles of magnetic materials (such as iron) are preferentially lined up to point in the same direction. If a fraction f of the dipoles are so aligned along the long axis (with the rest oriented randomly so that their magnetic dipole moments add vectorially to zero), what is the net magnetic dipole moment of a piece of such material (as shown in the diagram above); where, w=2.65cm, h=5.55cm, l=11.0cm, and f=0.70? Note, the material may be viewed as an array of cubes, each of which contains one atom, with only the outermost electron being considered, and is 2×10^{-10}m on a side. Also assume the same speed for the electron as above.

7. [1 pt.] What is the torque experienced by the piece of material in a field of 1.10×10^{-3}T, when the magnetic field is directed at right angles to the long axis of the material as shown in the diagram? (The torque should point in a direction perpendicular to both μ and **B**.)

---

8. [1 pt.] An infinitely long wire lies along the z-axis and carries a current of I=+4.80$\hat{z}$A. A second infinitely long wire is parallel to the z-axis and lies along the plane x=+13.0cm. Find the current in the second wire if the net magnetic field at x=+6.10cm is zero.

---

9. [1 pt.] A long solenoid filled with a ferromagnetic material of permeability μ=845μ_0 is wound with wire so that there are 12 turns per cm. What current must flow through the wire to produce a magnetic field of 1.70T within the solenoid?

Baking Tip: Old fashioned rolled oats and quick cooking oats can be used interchangeably in baking recipes.

Physics 102.

CAPA set #5. Solutions

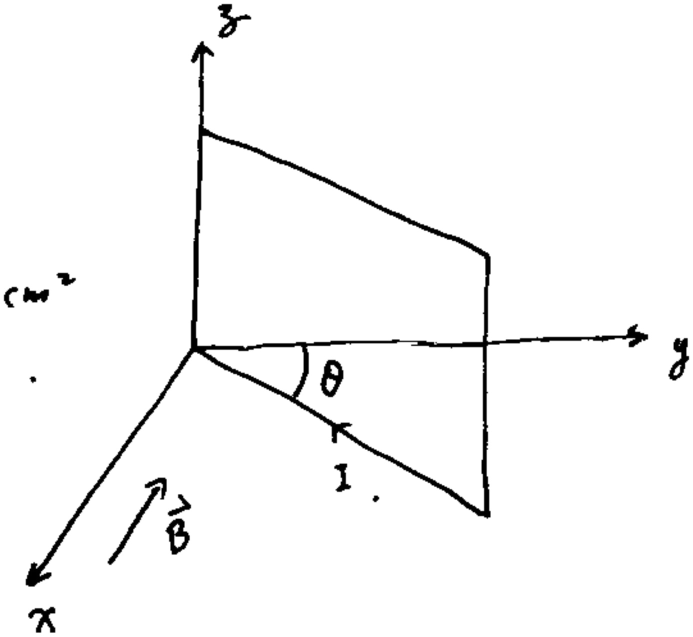
1. $B = 0.85\ T$.

$I = 8.5\ A$

$\theta = 32.5^\circ$.

area of loop $= 4.5 \times 4.5 = 20.25\ cm^2$

$A = 2.025 \times 10^{-3}\ m^2$.



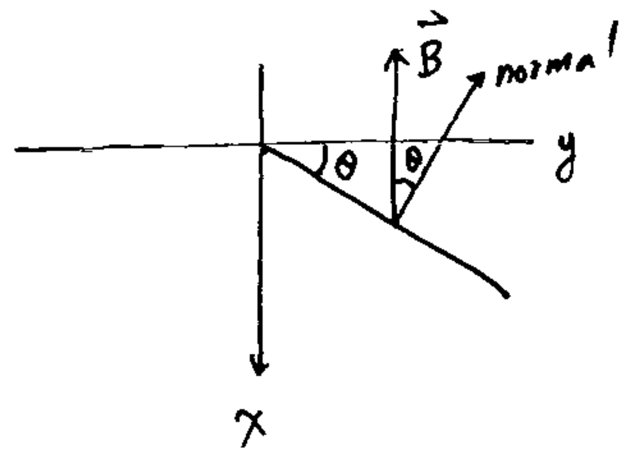
Torque:

$\tau = BIA \cdot \sin\theta$

$= 0.15 \times 8.5 \times 2.025 \times 10^{-3} \times \sin 32.5^\circ$

$= 1.39 \times 10^{-3}\ N \cdot m$.

Top View



2. $\tau = NI \cdot B \cdot A \cdot \sin\theta$.

$\tau_{max} = NIBA$

$= 140 \times 2.45 \times 0.22 \times 0.41^2$

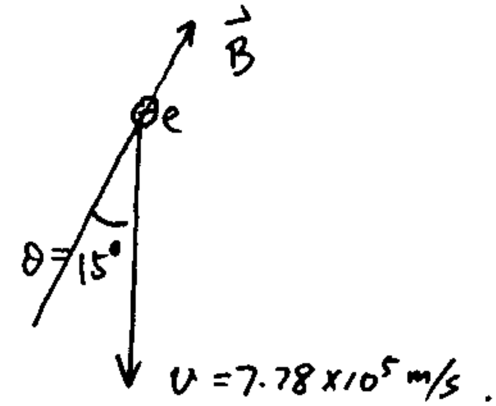
$= 12.7\ N \cdot m$.

3.

Magnetic force $\vec{F}_B = q\vec{v} \times \vec{B}$

$$F_B \Rightarrow evB \cdot \sin\theta$$

$$F_W = mg .$$



$$\frac{F_B}{F_W} = \frac{evB \cdot \sin\theta}{mg}$$

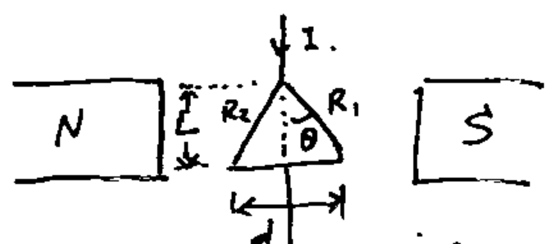
$$= \frac{1.6 \times 10^{-19} \times 7.78 \times 10^5 \times 5.7 \times 10^{-5} \times \sin 15°}{9.11 \times 10^{-31} \times 9.8}$$

$$= 2.06 \times 10^{11} .$$

4. $I = 4.7$ A , $R_1 = 4.85\,\Omega$, $R_2 = 7.45\,\Omega$.

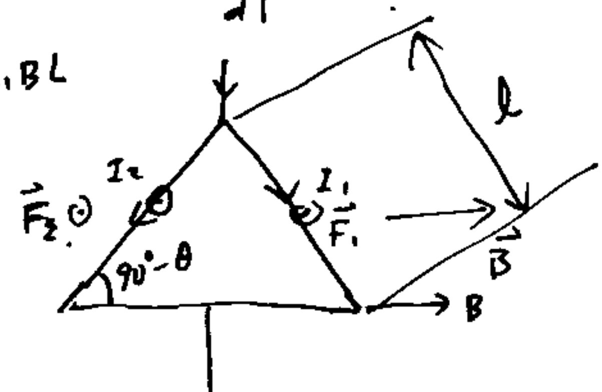
$B = 4.35 \times 10^{-2}$ T .

Both $\vec{F}_1$ and $\vec{F}_2$ point up.



$$F_1 = I_1 \ell B \sin(90° - \theta) = I_1 B \ell \cos\theta = I_1 BL$$

$$F_2 = I_2 \ell B = I_2 BL$$



Net torque :

$$\tau = F_2 \cdot \frac{d}{4} - F_1 \frac{d}{4} .$$

$$= \frac{BLd}{4}(I_2 - I_1)$$

$$= \frac{BLd \cdot I}{4(R_1 + R_2)}(R_1 - R_2)$$

$$= 1.37 \times 10^{-4} \text{ N} \cdot \text{m} .$$

$$I_1 = \frac{V}{R_1} = \frac{I \cdot \frac{R_1 R_2}{R_1 + R_2}}{R_1} = \frac{R_2 I}{R_1 + R_2} .$$

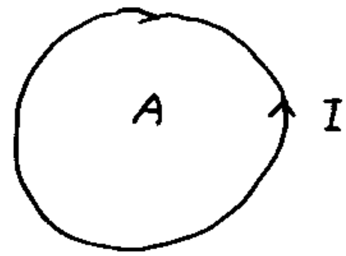
$$I_2 = \frac{R_1 I}{R_1 + R_2}$$

$L = 16$ cm $= 0.16$ m .

$(= \ell \cdot \cos\theta)$

5. Magnetic dipole moment of a current loop.

$\mu = A \cdot I$.



For the electron:

$I = \frac{\Delta q}{\Delta t} = \frac{e}{T}$ T — period.

$T = \frac{2\pi r}{v}$, $A = \pi r^2$.

$\therefore \mu = \frac{e \cdot v}{2\pi r} \cdot \pi r^2 = \frac{evr}{2} = \frac{evd}{4} = 3.12 \times 10^{-23}\ A \cdot m^2$

---

6. Total magnetic moment:

$M = N \cdot \mu$ where $N = \frac{w l \cdot h}{d^3} \cdot f$

$\mu = \frac{evd}{4} = 3.12 \times 10^{-23}\ A \cdot m^2$.

$\therefore M = \frac{w \cdot l \cdot h \cdot f}{d^3} \mu$

$= \frac{2.65 \times 10^{-2} \times 5.55 \times 10^{-2} \times 1.1 \times 10^{-1} \times 0.7}{(2 \times 10^{-10})^3} \times 3.12 \times 10^{-23}$

$= 442\ A \cdot m^2$.

---

7. $\tau = B \cdot M = 1.1 \times 10^{-3} \times 442 = 0.486\ N \cdot m$.

8. $\vec{B}$ - field at $x = 6.10$

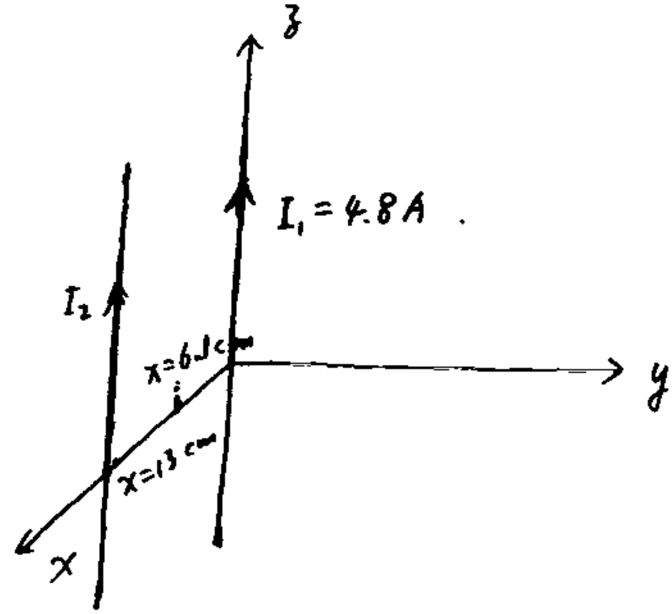
due to current I_1:

$$B_1 = \frac{\mu_0 I_1}{2\pi x} \quad (\text{along } +y)$$

$\vec{B}$ - field at $x = 6.10$

due to current I_2:

$$B_2 = \frac{\mu_0 I_2}{2\pi (13-x)} \quad (\text{along } -y).$$



But, $\vec{B}_1 + \vec{B}_2 = 0$

$$\therefore \quad \frac{I_1}{x} = \frac{I_2}{13-x}. \qquad I_2 = \frac{13-x}{x} I_1$$

$$= \frac{13-6.1}{6.1} \times 4.8$$

$$= 5.43 \text{ A}.$$

---

9. $n = 12$. Turns/cm $= 1200$ Turns/m .

$$B = \mu n I$$

$$I = \frac{B}{\mu n} = \frac{B}{845 \mu_0 n} = \frac{1.70}{845 \times 4\pi \times 10^{-7} \times 1200}$$

$$= 1.33 \text{ A}.$$