Physics 3B Week 10: Faraday's Law

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Date: March 12, 2008 Day: Wednesday Hour: 8:00 - 12:50

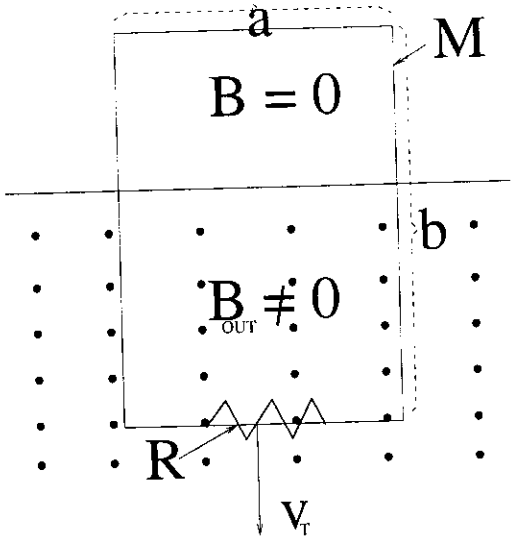
1. Problem 1

A rectangular loop (dimensions a, b), with mass M, and resistance R, enters a uniform magnetic field **B**. a) Which direction does the current flow? b) Show that the terminal velocity v_T of the loop can be expressed as:

$$v_T = \frac{Mg\,R}{B^2\,a^2} \tag{1}$$

where a is the width of the loop.

a) the current I is clockwise due to Lenz's law



b) Since $Mg = F_B$; and $F_B = I\,a\,B$

the induced current is:

$$I = \frac{\mathcal{E}}{R} = \frac{B\,a\,V_T}{R}$$

therefore

$$F_B = \left(\frac{B\,a\,V_T}{R}\right) a\,B = Mg$$

Solving for V_T:

$$\boxed{V_T = \frac{MgR}{B^2a^2}}$$

Q.E.D.

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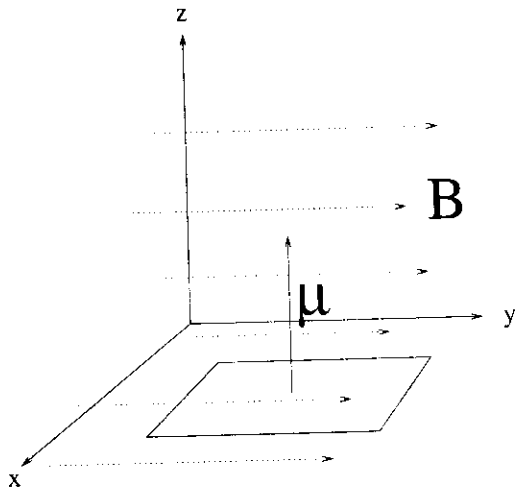
2. Problem 2

A current loop lies in the $x - y$ plane. The magnetic moment μ points in the +z direction.
a) If you look down on the loop, which way is the current flowing? (Choose only one):

1 Clockwise

→ (2) Counterclockwise

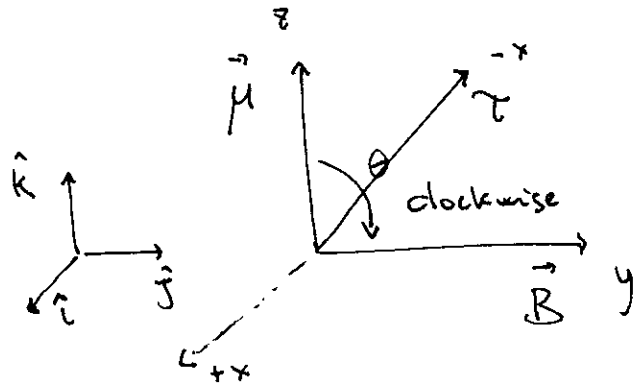
b) A uniform **B** field points in the +y direction. Which way is the torque τ on the loop? What is the formula describing this?



a) the current I is counterclockwise, since $\vec{\mu}$ points to the $+z$ direction

b) Since $\vec{\tau} = \vec{\mu} \times \vec{B}$

the torque $\vec{\tau}$ points to the negative X-direction:



$$\vec{\tau} = -\hat{\imath}\,\tau$$