UNIVERSITY OF MARYLAND, PHYSICS DEPARTMENT

PHYS 272, HW 9 Solutions

Jonathan Echevers

April 9, 2014

1 PROBLEM I

The battery will generate a current I that will pass through the wire when the loop is closed (recall $V = IR$). The current is essentially a cascade of electrons with velocity v passing through the wire. Thus, because of the magnetic field generated by the magnet, each electron will "feel" the Lorentz force as it moves through the loop. The force component that is perpendicular to the loop at every point, will point in opposite directions at each half of the loop, this will cause the loop to rotate about the central axis. See Fig. 1.1.

2 PROBLEM II

See Fig. 2.1

$$\begin{aligned} \varepsilon &= -\frac{d}{dt}\Phi \\ &= -\frac{d}{dt}\int da N \mathbf{B}\cdot\hat{\mathbf{n}} \\ &= -\frac{d}{dt} N \int da B \cos\omega t \\ &= \omega B N A \sin\omega t \end{aligned} \tag{2.1}$$

Where A is just the area defined by the loops: $A = (0.1m)^2$, the frequency $\omega = 20\pi/s$ (since the loops move at 10 revolutions per second).

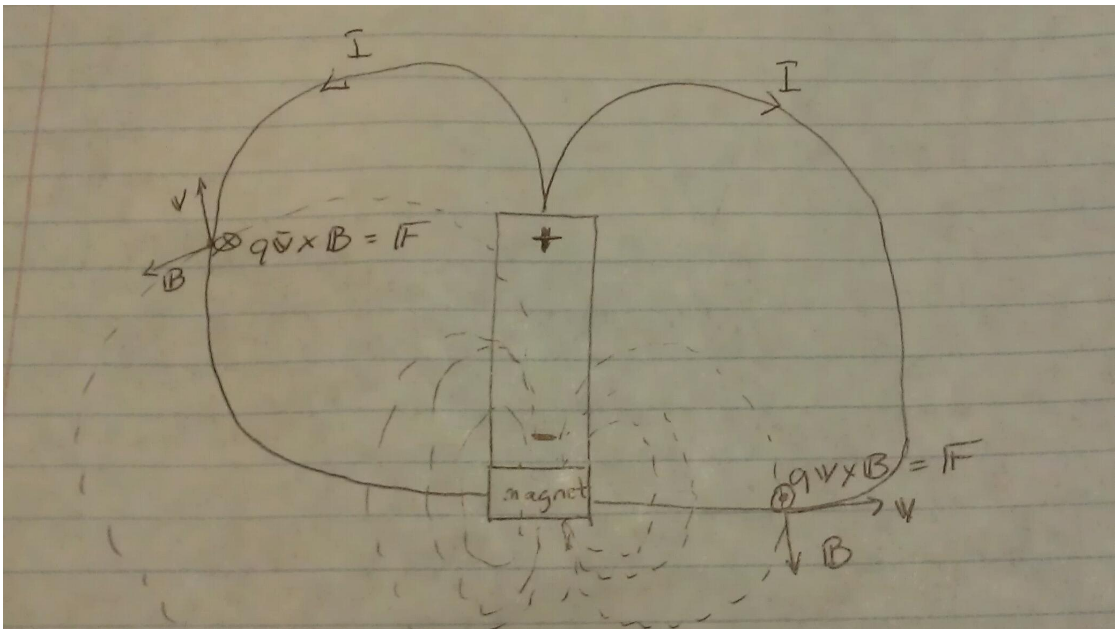

Figure 1.1: Problem 1

3 Problem III (graded)

If the inductors are connected in series, the current passing through the first inductor is the same as the one passing through the second one. Denote it by I.

$$\begin{aligned}\varepsilon &= \varepsilon_1 + \varepsilon_2 \\ &= -L_1\frac{d}{dt}I - L_2\frac{d}{dt}I \\ &= -(L_1 + L_2)\frac{d}{dt}I \\ &= -L\frac{d}{dt}I \end{aligned} \tag{3.1}$$

So: $L = L_1 + L_2$

If the inductors are connected in parallel, then the current can go in either direction, towards inductor 1 or inductor 2. By conservation of charge, we know that: $I_{total} = I_1 + I_2$

$$
\begin{aligned}
I &= I_1 + I_2 \\
\frac{d}{dt} I &= \frac{d}{dt} I_1 + \frac{d}{dt} I_2 \\
&= -\frac{\varepsilon}{L_1} - \frac{\varepsilon}{L_2} \\
&= -\varepsilon \left[\frac{1}{L_1} + \frac{1}{L_2} \right]
\end{aligned}
\tag{3.2}
$$

But $\varepsilon = L \frac{d}{dt} I$, so we can rewrite Eq. 3.2 as:

$$
\varepsilon = -\frac{d}{dt} I \left[\frac{1}{L_1} + \frac{1}{L_2} \right]^{-1} \tag{3.3}
$$

Therefore:

$$
L = \left[\frac{1}{L_1} + \frac{1}{L_2} \right]^{-1}
$$

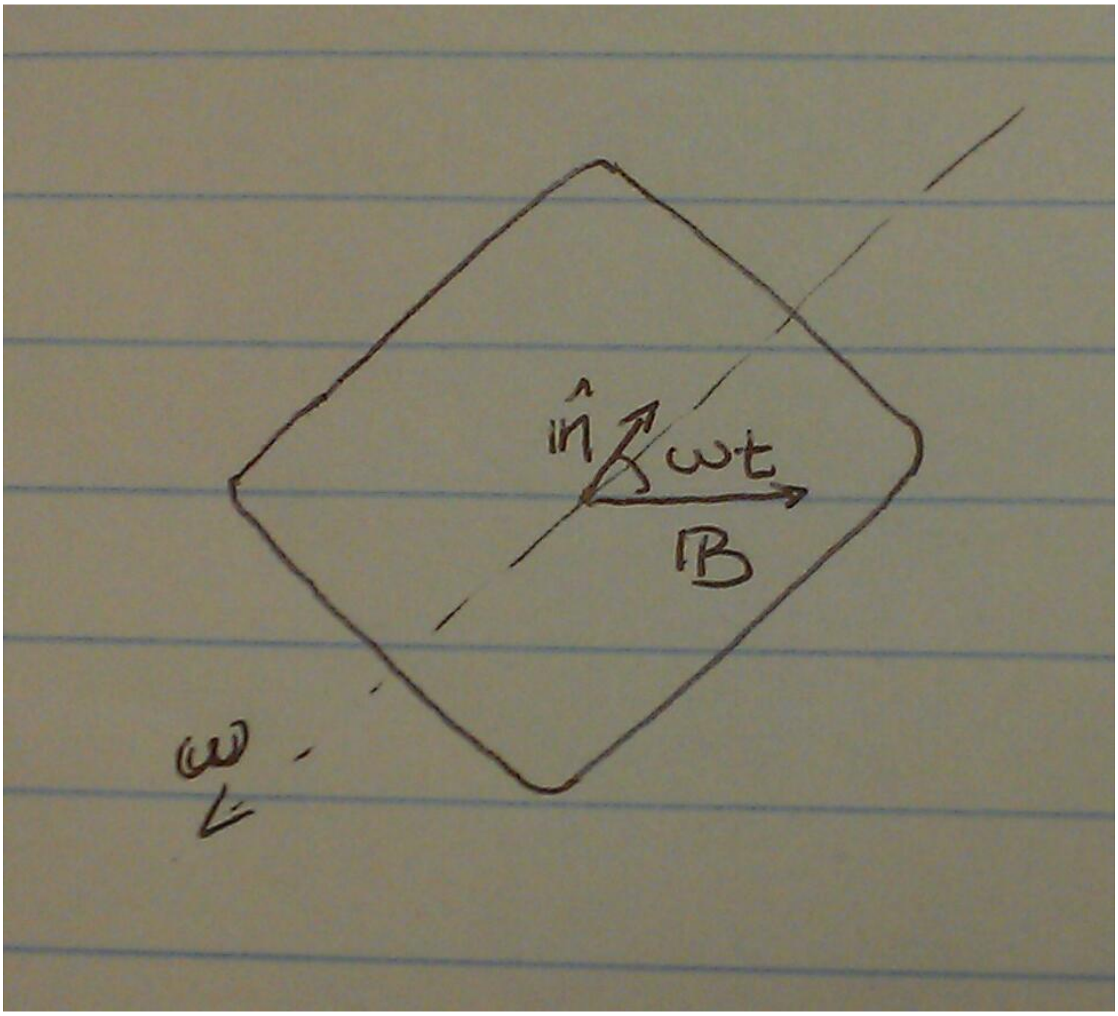

Figure 2.1: Problem 2