Topics: Faraday's Law
Related Reading:
      Course Notes (Liao et al):   Chapter 10
      Serway & Jewett: Chapter 31
      Giancoli: Chapter 29
Experiments: None

Topic Introduction

Today we practice using Faraday's Law to calculate the current in and force on a loop falling through a magnetic field.

Faraday's Law & Lenz's Law

Remember that Faraday's Law tells us that a changing magnetic flux generates an EMF (electromotive force):

$$\mathcal{E} = -\frac{d\Phi_B}{dt}, \text{ where } \Phi_B = \iint \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}} \text{ is the magnetic flux, and } \mathcal{E} = \oint \vec{\mathbf{E}}' \cdot d\vec{\mathbf{s}} \text{ is the EMF}$$

In the formula above, $\vec{\mathbf{E}}'$ is the electric field measured in the rest frame of the circuit, if the circuit is moving.   The sign indicates that the EMF opposes the change in flux – I suggest you use Lenz's Law to get the direction and just report the magnitude of the EMF (i.e. drop the minus sign). As is usual, the flux integral nearly always turns into a simple multiplication: *BA*.

Lenz's Law tells us that the direction of that EMF is so as to oppose the change in magnetic flux. That is, if there were a physical loop of wire where you are trying to determine the direction of the EMF, a current would be induced in it that creates a flux to either supplement a decreasing flux or decrease an increasing flux. Remember that, in general, *opposing* a change in flux means *opposing* what is happening to change the flux (e.g. forces or torques *oppose* the change).

Important Equations

Faraday's Law (in a coil of N turns): $\mathcal{E} = -N\frac{d\Phi_B}{dt}$

Magnetic Flux (through a single loop): $\Phi_B = \iint \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}}$

EMF: $\mathcal{E} = \oint \vec{\mathbf{E}}' \cdot d\vec{\mathbf{s}}$ where $\vec{\mathbf{E}}'$ is the electric field
                                          measured in the rest frame of the circuit, if the circuit is moving.