Physics 152

Lecture 37

Monday, April 30, 2007

- Inductors
- LR Circuits
- LC Circuits
- Motors & Generators

Announcements

- Help sessions
  - W 9 - 10 pm in NSC 119
- MasteringPhysics
  - Hwk #5 due Fri., May 4
- Final Exam available Friday, May 4 from Mrs. Wellsand.

Announcements

- Available Friday, May 4
  - Due by our scheduled exam period
    - Monday, May 14 (10:30 am - 12:30 pm)

Hint: Be able to do the homework (graded AND recommended) and you’ll do fine on the exam!

You may bring one 8.5”X11” sheet (handwritten on both sides), a pencil or pen, and a scientific calculator with you.

I will put any constants and mathematical formulas that you might need on a single page attached to the back of the exam.

Ch. 33: Electromagnetic Induction

What is the induced EMF through such a coil?

where $L$ is the inductance and is defined to be

TRUE ONLY FOR A SOLENOID!!!!

We can derive another definition by combining

AND

That is, equate these two statements of the relationship of EMF to changing fluxes and changing currents.
Two solenoids have the same cross-sectional area. Solenoid B, however, is twice as long and has twice the number of turns as Solenoid A. The ratio of the self-inductance of Solenoid B to that of Solenoid A is

1. 1/4
2. 1/2
3. 1/1
4. 2/1
5. 4/1

Worksheet Problem #1

Inductors set up a back-EMF in a circuit as the current in the circuit changes. The magnitude of that EMF is given by

As a circuit element, therefore, inductors affect the rate at which the current in a circuit changes.

In some respects, their effect on a circuit is analogous to the role of a capacitor.

Recall, capacitors are circuit elements which store energy in an electric field between a positively charged plate and a negatively charged plate.

Inductors store energy in a magnetic field.

The amount of energy stored in the magnetic field of an inductor is given by

How do we go about deriving this?

The power consumed by a circuit element is given by

Plugging in the voltage across an inductor

Power is energy per time, so we have

Now, integrating both sides
Let's set up Kirchhoff's loop equation:
\[ V + V_L + V_R = 0 \]
This differential equation has a known solution given by
\[ \tau = \text{the time constant} = \frac{L}{R} \]

We can use the loop rule and Ohm's law to determine the potential difference across the inductor:
\[ V = V_L + V_R \]

In the circuit below, \( L = 7.00 \, \text{H}, \, R = 9.00 \, \Omega, \) and \( V = 120 \, \text{V}. \) What is the self-induced emf in the inductor 0.200 s after the switch is closed?
If we now open switch S₁ and simultaneously close switch S₂, we once again have a changing current in our circuit, inducing an EMF across our inductor.

This time, the loop rule says:

\[ V_L + V_R = 0 \]

with solution

\[ \tau = \text{the time constant} = \frac{L}{R} \]

If we allowed our previous circuit to reach its stable state...

Using Ohm's Law and the loop rule we know

\[ V_R = I R \]

\[ V_L + V_R = 0 \]

Describe what will happen in this circuit when the switch is thrown from position 1 to position 2. Assume that the capacitor was fully charged before the switch is thrown.
The water causes the paddle wheel to spin. Non-conducting rod connected to our electrical circuit.

The magnetic force on the ends of the loop will be either toward or away from the center of the loop, resulting in no net force on the loop.

However, a net force will exist on the charges in the segments on the top and bottom of the loop. In this case, an emf will be induced in the loop of wire of magnitude:

If the loop is rotating at a rate \( \omega \), then the EMF will oscillate:

Hey! It's AC Power!

A motor is simply a generator in reverse. In a motor, we drive the current through the wire. The torque on the loop causes an axel to rotate.

By timing the reversal of the current with the rotation of the loop (i.e., every time the loop normal is parallel to \( B \), reverse the current), we can keep the loop rotating in the same direction.