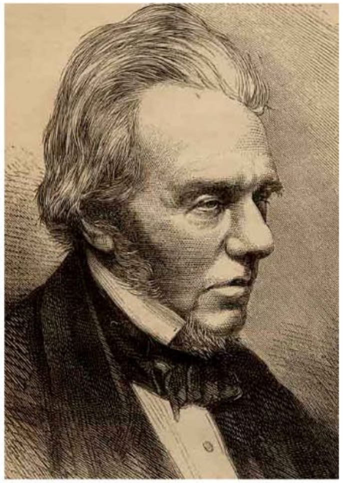
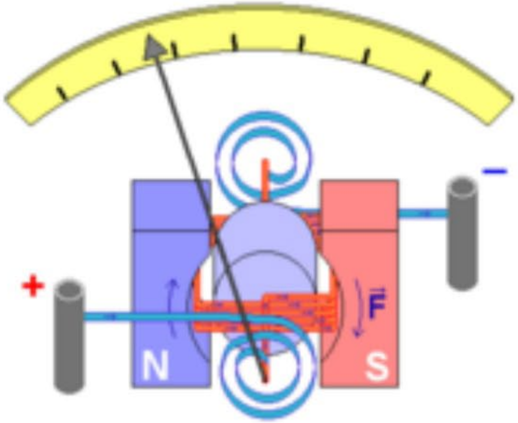
Physics 30 Unit B - Forces and Fields

Induction and Generators





Lesson 7

Objectives

- Describe, qualitatively, the effects of a moving conductor in an external magnetic field, in terms of charges in a magnetic field

Recall:

The magnitude of the force on a current carrying wire can be found using the equation:

$$\vec{F}_B = \vec{B}_{\perp} I L$$

where:

I = current (A)

L = length of wire (m)

We said this discovery led to many important inventions such as

i) The Electric Motor

and its friends...

ii) The Galvanometer

and...

iii) The ______?______

iii) The ________?__________

- recall the motor effect…a coil of current carrying wire in a magnetic field produces a force (i.e. a turning armature)

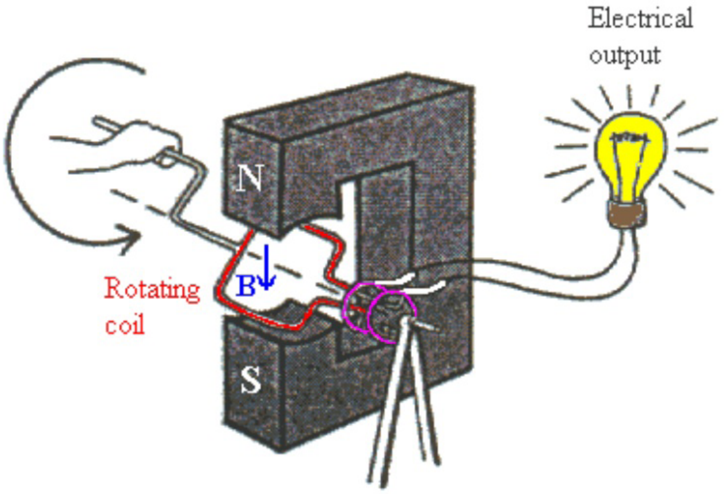
- what would happen if we supplied the energy and turned the armature ourselves?

- the result is called a ________________.

The Electric Generator

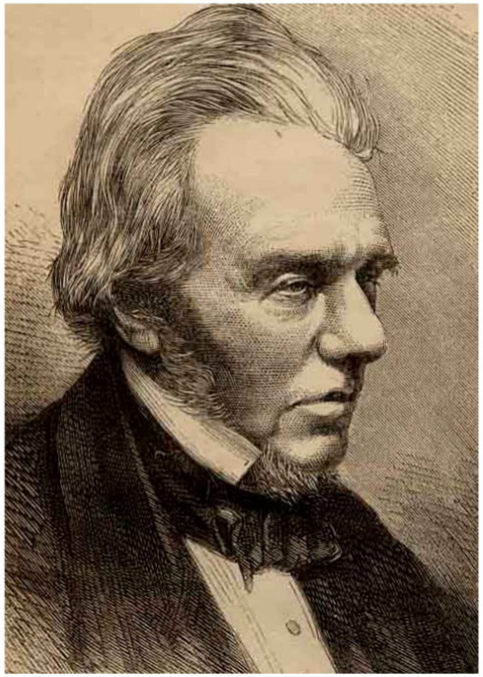
- essentially a motor in reverse

- in a generator, an outside force is applied to the armature, and mechanical energy is converted to electrical energy



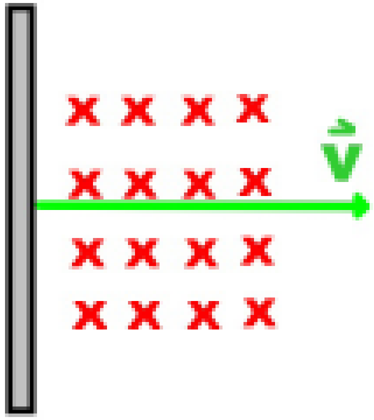
The principle a generator works on is called induction.

Faraday discovered that just as a current carrying wire in a magnetic field produced movement (a force), a moving wire with no current in a magnetic field will produce its own current.



Note: induction (a moving wire in a magnetic field produces current) is the OPPOSITE of what we have learned before (a wire with a current in a magnetic field will produce movement).

ex) Consider a conductive rod moving through a magnetic field...



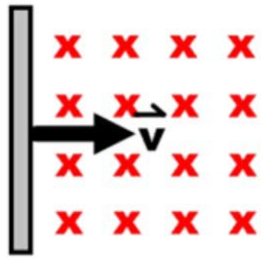
What is the direction of the current in the wire?

To determine the direction, we must use another LHR!

4th Left Hand Rule

- Rule for current-carrying **wire** that is moved through a magnetic field.
- Where:
  - Fingers are B-field
  - Thumb is direction of force/velocity on wire
  - Palm is direction of induced current within the wire
- Remember that you would use your right hand for conventional current!

ex) What is the direction of the current induced in each wire?



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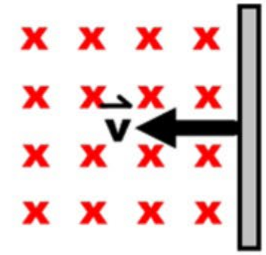

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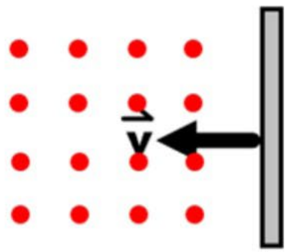

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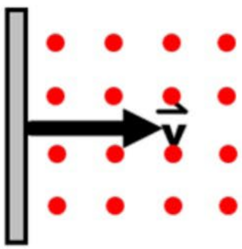

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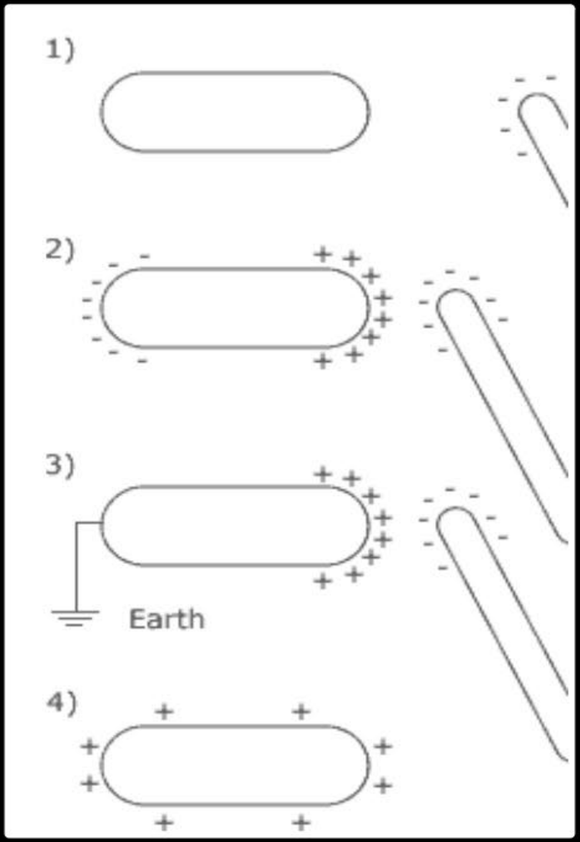
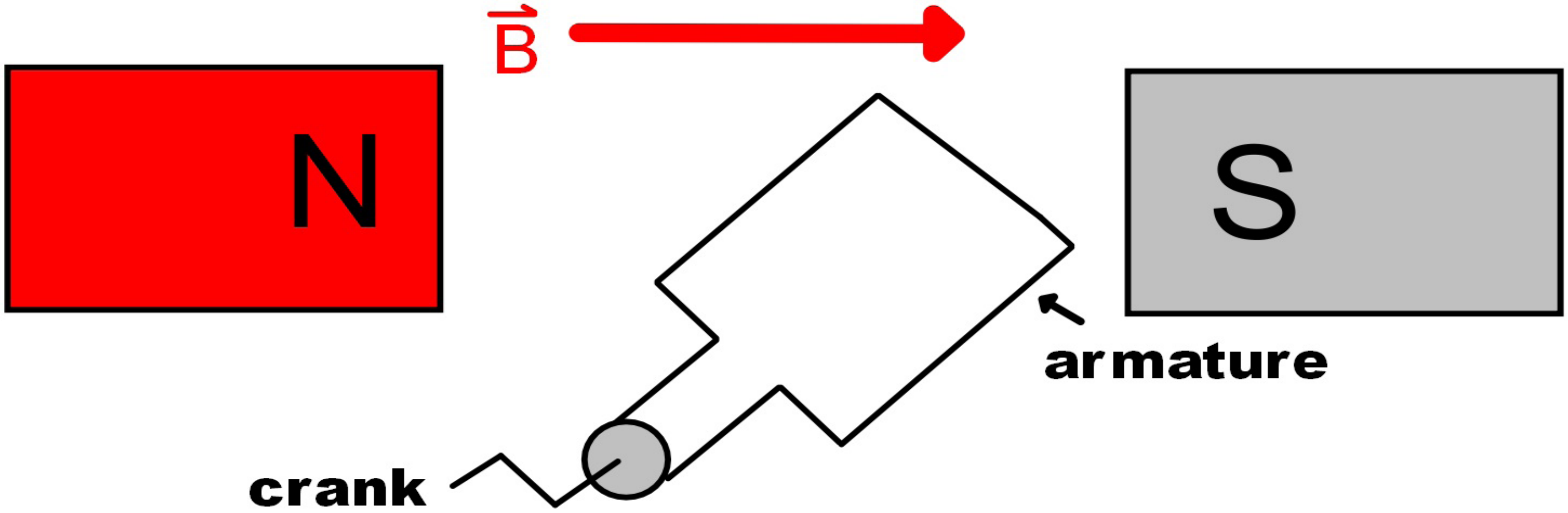
WARNING!

DO NOT confuse this type of induction with charging by induction like we studied earlier in the unit!



THEY ARE DIFFERENT!

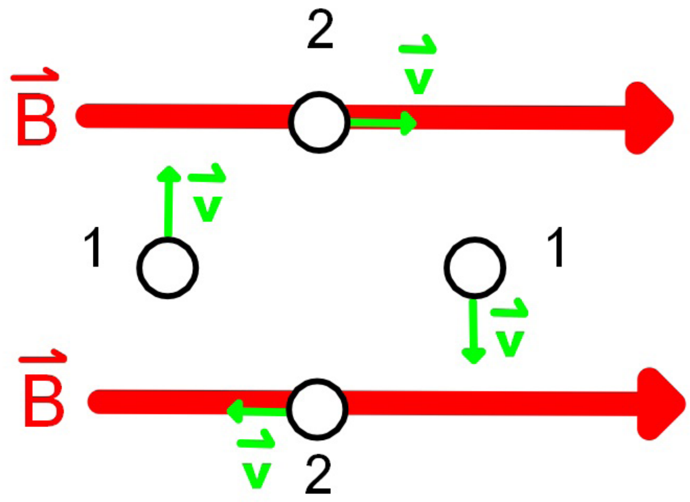
Electromagnetic induction is also sometimes called the generator effect as this is what is going on in a generator.



- where an electric motor turned current into motion, a generator turns motion into current

- the current is induced by Faraday's principle of induction

- lets take a closer look at the armature as it rotates in the B-field. Assume we look at a cross-section of the wire as it rotates:



- at position 1, the wire $\vec{v}$ is $\perp$ to the B-field, so there is max current

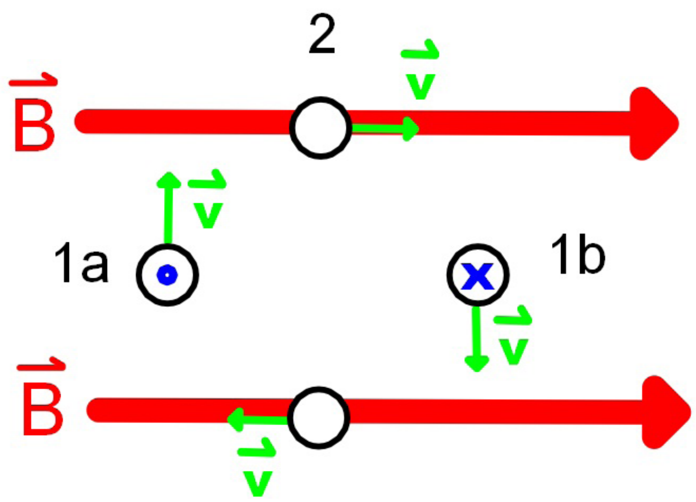
- at position 2, the wire $\vec{v}$ is parallel to the B-field, so there is no current

- at a position between 1 and 2, there must be a partial amount of current (as there is only a vector component of the $\vec{v}$ to the $\vec{B}$-field)

Interesting thing #1:

- when a generator turns, the current is not constant, but fluctuates between a maximum value and zero

- also note from this diagram the direction of the current:



- at 1a, current is moving out of the board (3rd RHR)

-at the 1b, the current is into the board (3rd RHR)

Interesting thing #2

- when a generator turns, the current direction alternates

AC

We call this kind of current alternating current or AC - generators produce AC

- we have seen this alternating nature before:

- in a motor, the split ring was used to alternate the direction of current every half turn to keep the armature rotating

AC vs. DC

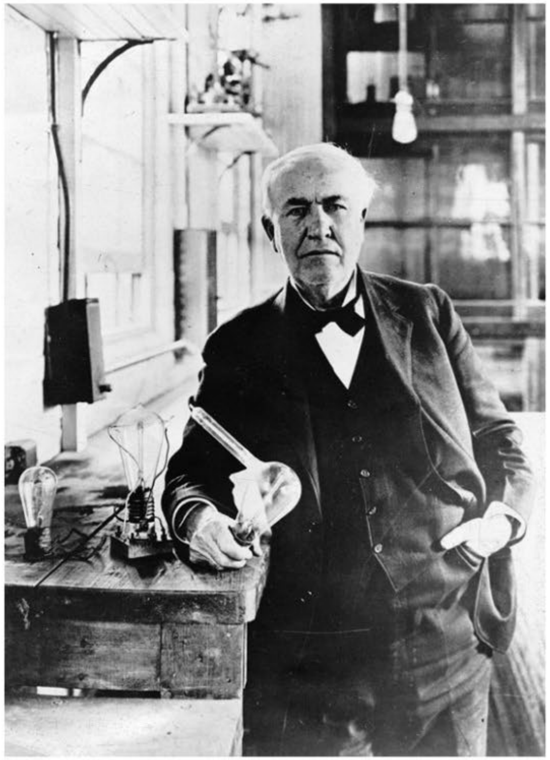
- we know the difference between AC and DC

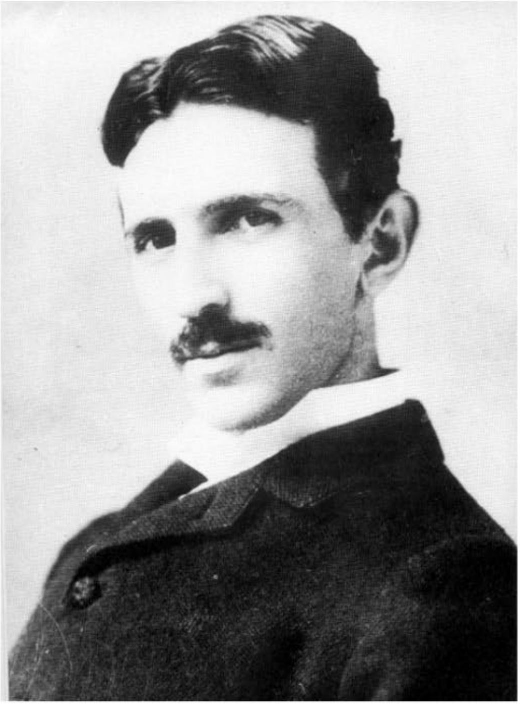
DC - current and voltage are constant

AC - current and voltage constantly varying

- so why would we use one over the other?

Edison vs. Tesla





http://en.wikipedia.org/wiki/War_of_Currents

http://www.badassoftheweek.com/tesla.html

Transformers

- one advantage to AC is it has the ability to be transformed

- a transformer is a device that raises or lowers voltage

- some devices require a small voltage (i.e. iPod, electric tooth-brush), while others require a high voltage (TVs require thousands of volts)

Transformers are everywhere…

…big green boxes on street-corners…

…on power poles…

…in 'wall warts'

When electrical energy is produced, it is produced at high voltages. It is transmitted at extremely high voltages. We use the energy mostly at 110 V (usual plug in) or 220 V (large oven/dryer plug in).

So how do we *transform* voltage?

All transformers work on the principle of *induction*:

Induction: a wire moving in a magnetic field will produce a current.

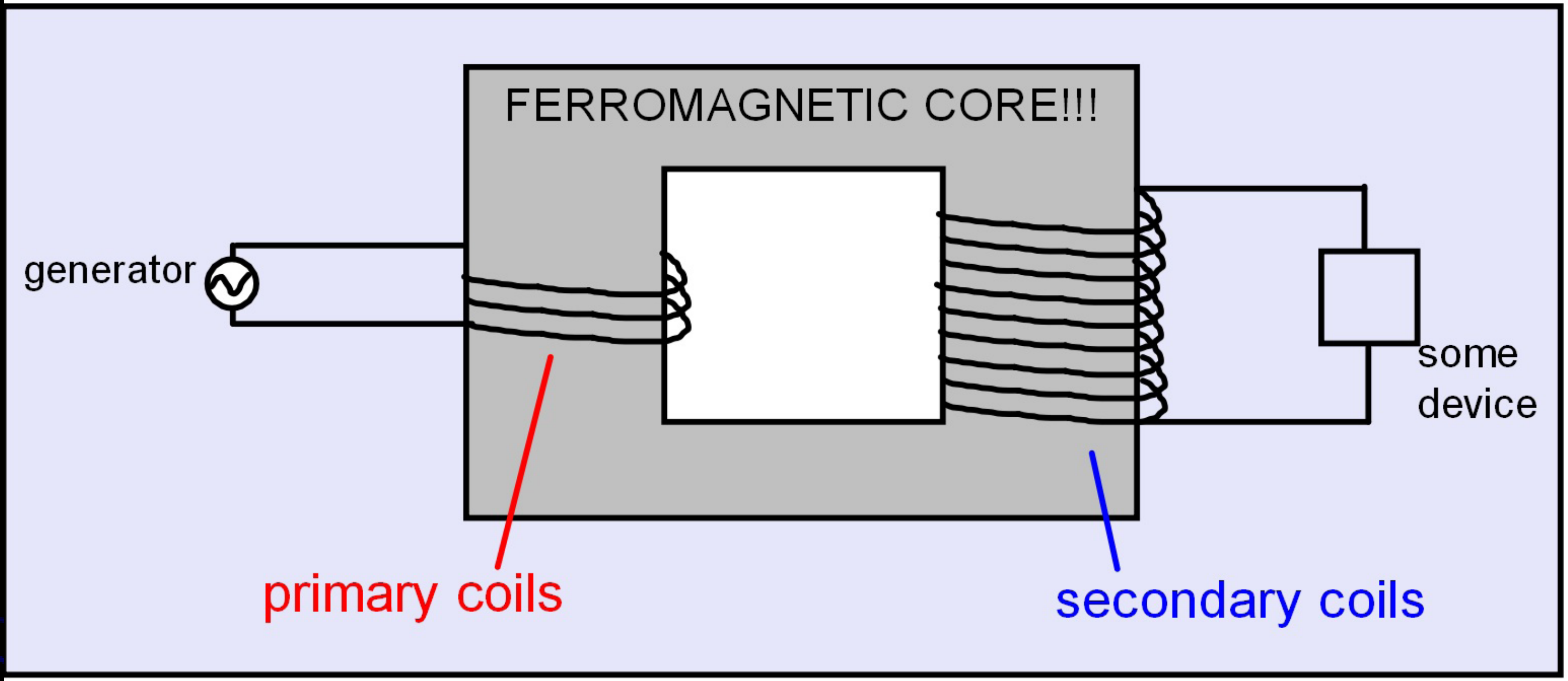
Another way of thinking of this is…

A wire with changing position in a magnetic field produces a current.

The opposite is also true:

A changing magnetic field surrounding a wire will produce a current.

A basic transformer looks like this:



Electricity transmission looks like this: