



Lesson 6: Electromagnetic Induction and Magnetic Forces

ET 332a

Dc Motors, Generators and Energy Conversion Devices

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Learning Objectives

After this presentation you will be able to:

- Explain how voltage is induced in dc generators and motors
- Explain how generators and motors develop magnetic forces
- Explain the electromechanical operation of generator and motor systems

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Electromagnetic Induction

Moving a conductor through a magnetic field induces a voltage across the conductor

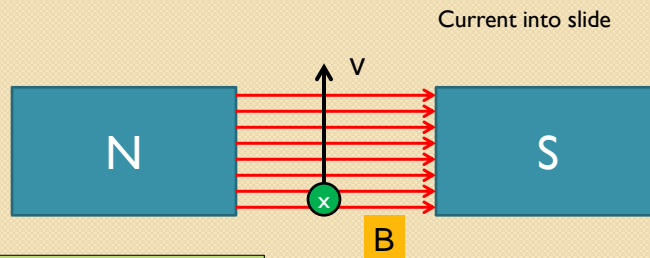
Mathematically $e = B \cdot l \cdot v$

Where e = induced voltage
 B = flux density of the magnetic field
 v = velocity of the conductor in the field
 l = active length of conductor

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Electromagnetic Induction

The maximum voltage is induced when B and v are at 90 degrees



Voltage induced when conductor cuts flux lines

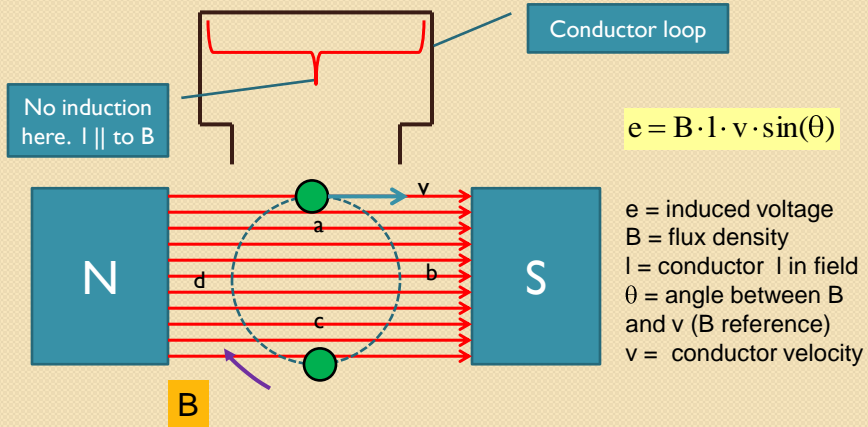
Polarity: **Right-hand Rule**
 Thumb = v -velocity
 First Finger = B – flux density
 Middle Finger = I direction

No voltage induced when velocity, v , is parallel to flux, B . **Conductor must cut B for induction**

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Induced Voltage in Rotating Conductors

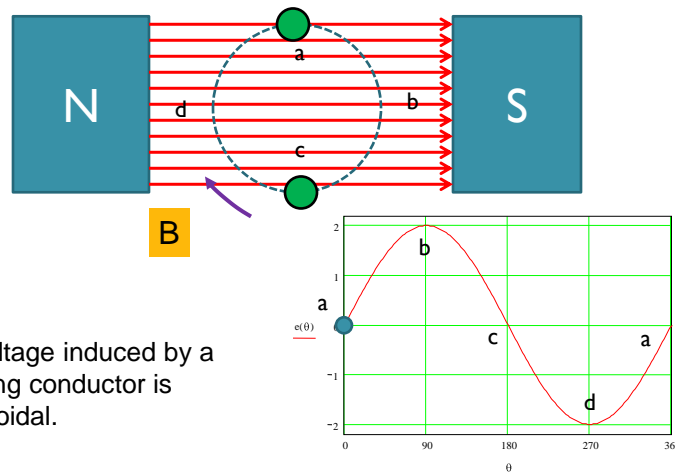
Consider a loop of conductor rotating in a magnetic flux



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Induced Voltage in Rotating Conductors

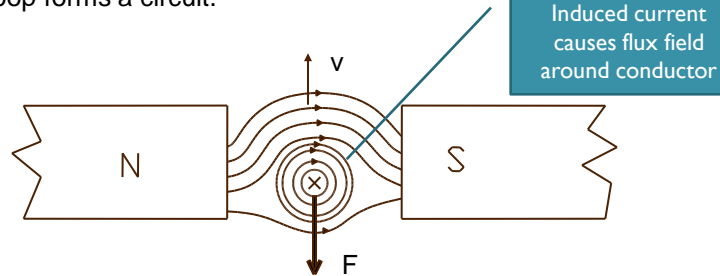
Rotating conductors produce sine wave voltages



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Electromagnetic Force

Induced voltage causes an induced current to flow when the wire loop forms a circuit.



Flux fields follow the rules of magnetic attraction.

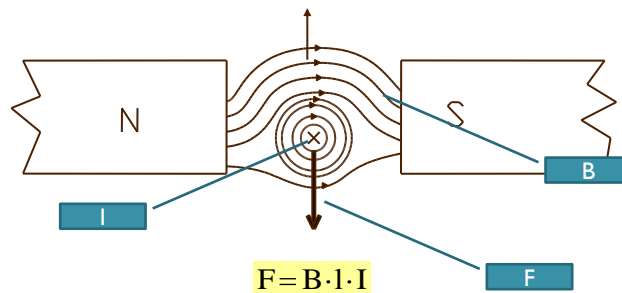
Direction of force on conductor depends on:

- 1.) magnetic polarity of stationary magnetic field
- 2.) direction of induced current in conductor.

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Electromagnetic Force

Mathematical definition of electromagnetic force

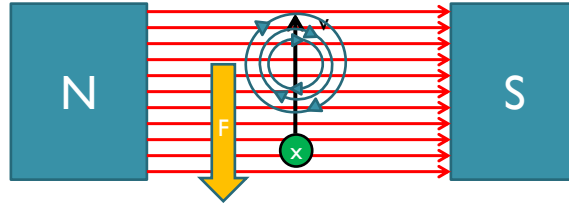


Where: F = force
 B = flux density
 I = current in conductor
 l = length of conductor in field

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Induced Voltage & Electromagnetic Force in Generators

Generator Action



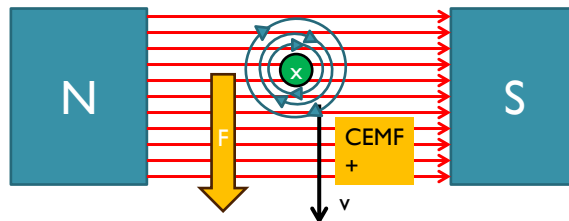
1. External force moves conductor at velocity v , induces emf
2. Induced emf produces flux around conductor
3. Conductor field interacts with stationary field to produce opposing force.

Force producing velocity must work against F

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Induced Voltage & Electromagnetic Force in Motors

Motor Action



1. Applied voltage produces flux around conductor
2. Field interaction causes force (torque)
3. Motion causes induced voltage of opposite polarity in conductor

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Summary of Generator and Motor Electromagnetic Actions

Generator

F opposes driving torque that produces emf

Motor

Input I produces force. Force produces v (rpm) v produces CEMF

All generators develop an opposing force (torque) when generating a voltage

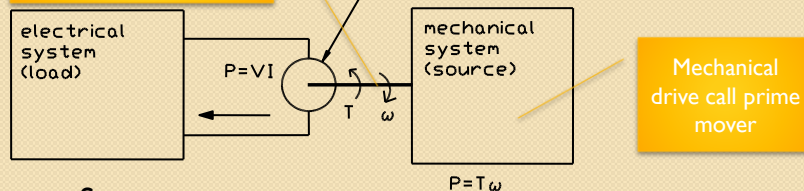
All motors generate an internal voltage (counter emf) when producing a force (torque)

Motor and generator action occur simultaneously in rotating machines. Therefore they can be operated as either.

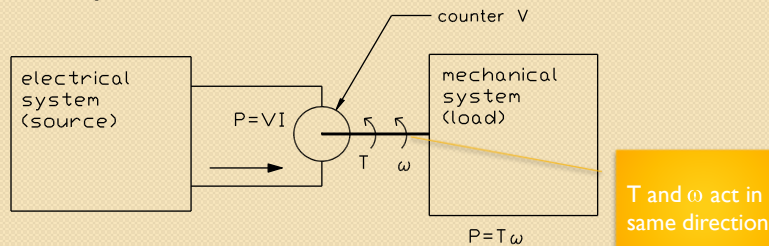
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Motor /Generator Systems

Torque and speed act opposite




Generator System



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 **END LESSON 6:
ELECTROMAGNETIC
INDUCTION AND
MAGNETIC FORCES**