Physics 12 Date: ____________________

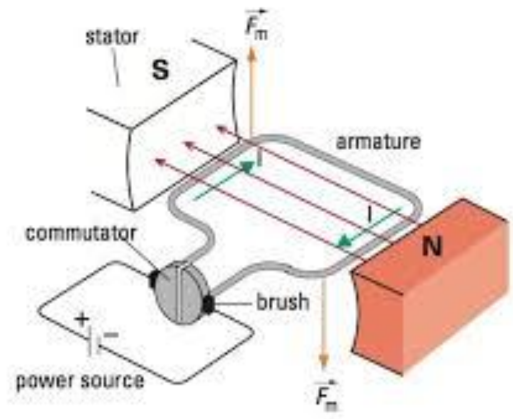
Lesson 8.3 - Generators and Back EMF

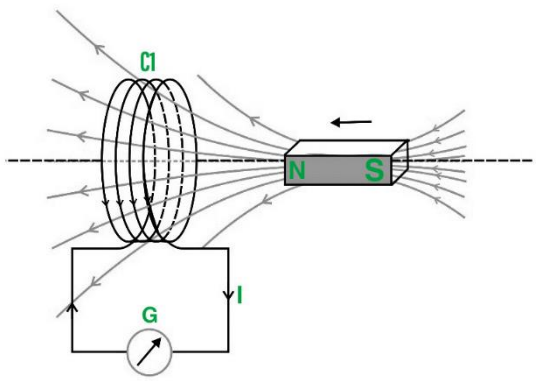
Unit 8: Electromagnetic Induction

Transitioning into the Generator:

Recall:

- A **current** in a wire produces a **magnetic** field.
- In a motor, this magnetic field interacts with an **external** field to create a **force** and cause **rotation**.





- Conversely, if we mechanically move a conductor (**armature**) in a magnetic field, an EMF is induced (**Faraday's Law**).

$$\mathcal{E} = -N\frac{\Delta\phi}{\Delta t}$$

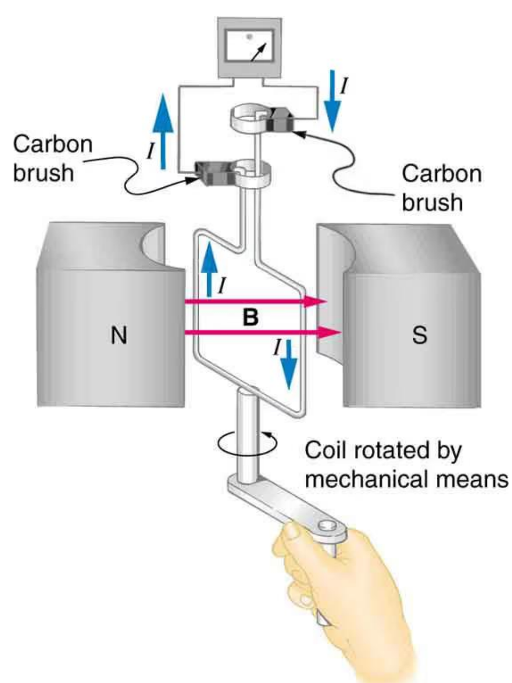
The Generator:

Electric motors and generators act on the same principles from different perspectives.

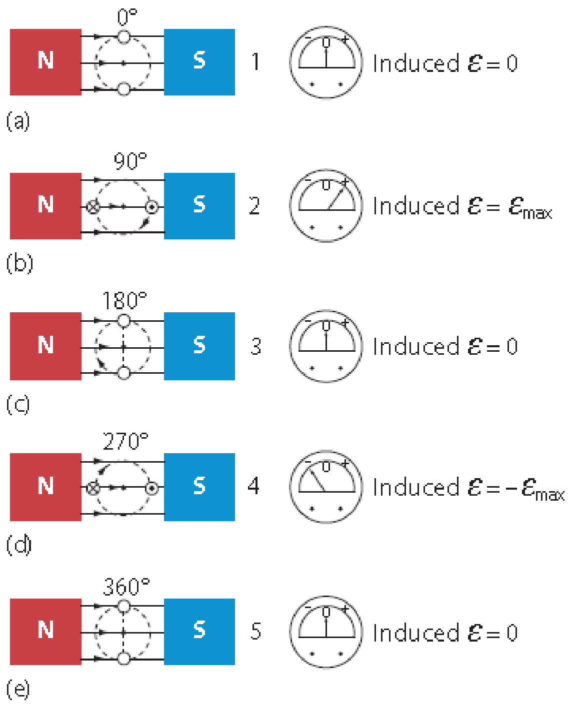
Electric motor: **electrical** energy ---------> **mechanical** energy

Electric Generator: **mechanical** energy ---------> **electrical** energy

Simulation 1 and Simulation 2



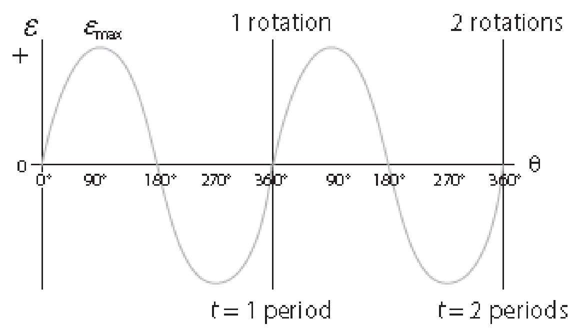
- **Mechanical** source rotates the **armature** (coil) in external magnetic field.
- The change in **flux** produces an **induced** **EMF**
- Direction of induced current follows **Lenz's Law** (opposes the change).
    - **Use 2nd right-hand rule**



EMF (voltage) is **maximum** when the armature arms are **horizontal** because their motion is **perpendicular** to the magnetic field

EMF is **zero** when they are **parallel**

****think about a swing where parallel is the highest you go and stop for a split second (=0)*



Induced EMF of one "arm" of the armature:

$$\varepsilon = \vec{B}l\vec{v}sin\theta$$

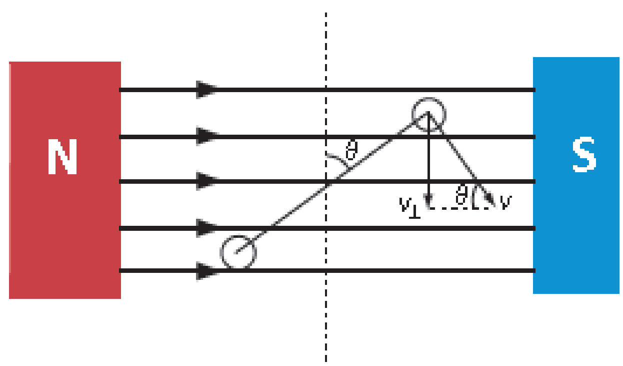
Induced EMF of two "arms" of the armature:

$$\varepsilon = 2\vec{B}l\vec{v}sin\theta$$

With N loops of wire:

$$\varepsilon = 2N\vec{B}l\vec{v}sin\theta$$

$$\mathcal{E} = \mathcal{E}_{max}\sin\theta$$



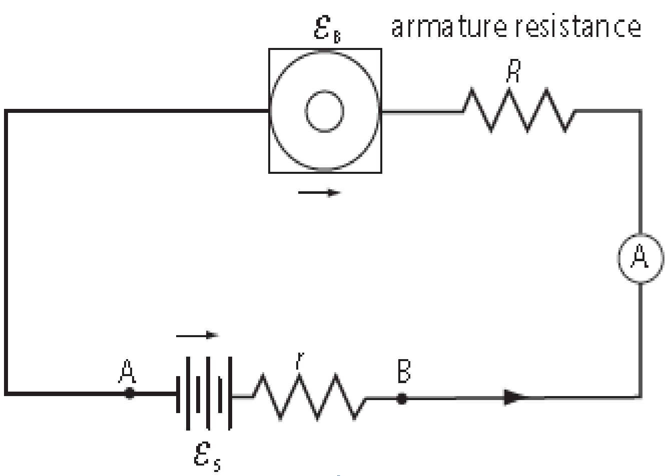
List all the generators you can think of that turn mechanical rotation into electrical energy:

Back EMF:

Consider what know:

- A **current** in the armature produces **motion** (motor effect).
- Changing **flux** or moving a **conductor** induces an EMF (**Faraday's Law**).
- The induced EMF creates a **magnetic** field that **opposes** the change (**Lenz's Law**).

Back EMF: Since motion induces an **opposing** EMF (Lenz's Law), the induced EMF in a motor must oppose the **current** that drives it.



$\mathcal{E}_s$ = EMF source to motor

r = internal resistance of the source

$\mathcal{E}_B$ = Back EMF

R = resistance of armature (coil).

We can apply Kirchhoff's Law to consider net voltage:

$$\mathcal{E}_s - Ir - IR - \mathcal{E}_B = 0$$

$$\mathcal{E}_B = \underbrace{\mathcal{E}_s - Ir}_{\text{Terminal Voltage between A and B} = V_{AB} \text{ or } V_T \text{ or } \mathcal{E}} - IR$$

$$\mathcal{E}_B = V_{AB} - IR$$

or on your formula sheet

$$V_{back} = \mathcal{E} - Ir$$

Show this video

Example 1: The armature windings of a DC motor have resistance of 10 Ω. The motor is connected to a 120 V battery (no internal resistance). At full speed the back EMF is 108 V. Find the start up and full speed currents.

Start-Up:

$\mathcal{E}_B = 0$

$\therefore V = IR$

$I = \frac{V}{R}$

$I = \frac{120V}{10\Omega}$

$\boxed{I = 12A}$

Full Speed:

$\mathcal{E}_B = V_{AB} - IR$

$I = \frac{V_{AB} - \mathcal{E}_B}{R}$

$= \frac{120V - 108V}{10\Omega}$

$\boxed{I = 1.2A}$