

The Generator Effect

Inducing a potential difference in a circuit

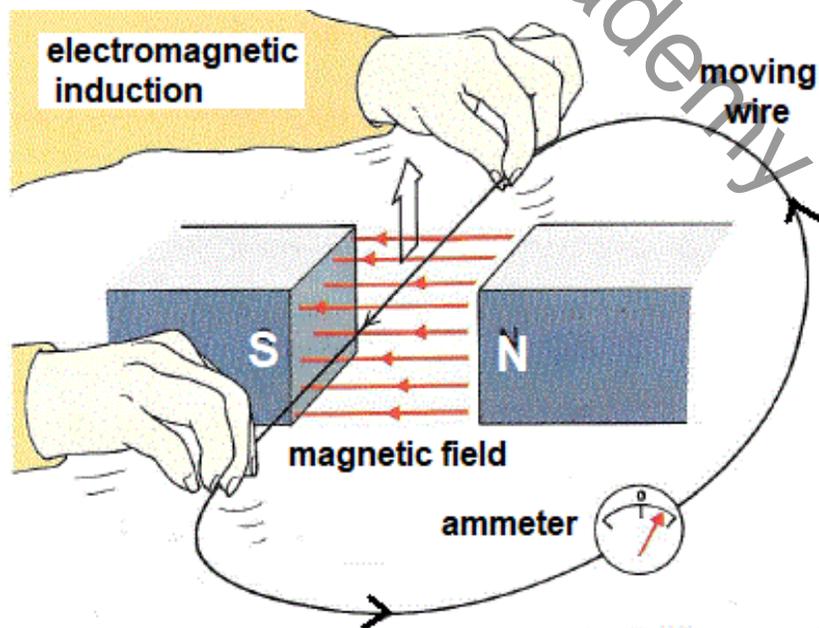
- ▶ The process of generating a **potential difference** in a conductor using a magnetic is called **electromagnetic induction**, or the **generator effect**

How the Generator Effect Works

- ▶ There are **two methods** of inducing a potential difference in a conductor:
 1. **Moving a conductor** within a fixed magnetic field
 2. Placing a conductor in a **changing magnetic field**
- ▶ If the conductor is part of a **complete circuit** then the induced potential difference produces a **current** in that circuit

1. Moving the electrical conductor

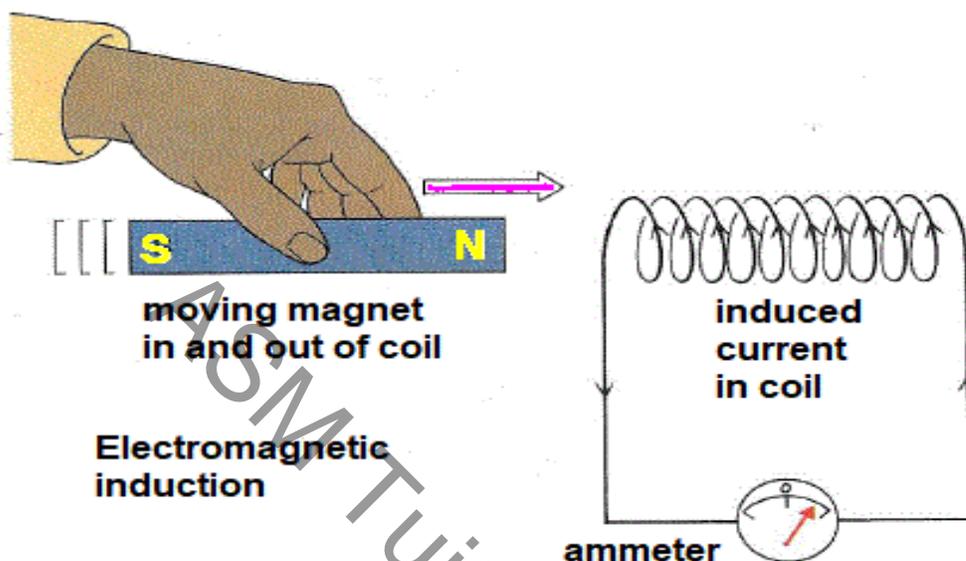
- ▶ When a conductor (such as a wire) is moved perpendicular to the direction of the field lines of a magnetic field (which are fixed) the wire **cuts** through the field lines
- ▶ A **potential difference** is induced in the circuit which creates the **current**
- ▶ An **ammeter** detects the current in the circuit



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2. **Moving the magnetic field**

- As the magnet moves through a fixed coil, the field lines **cut** through the turns on the coil
- This generates a **potential difference** in the coil and induces a **current**



- These examples have in common is a **conductor moving through a magnetic field** or a **magnetic field moving through a conductor** - this induces the electromagnetic effect.
- The electromagnetic induction effect is used in generators, loudspeakers and transformers

Ways to increase potential difference or current

- An induced potential difference or induced current will increase if:
 1. the speed of movement is increased
 2. the magnetic field strength is increased
 3. the number of turns on the coil is increased

Rules of the Generator Effect

Rule 1:

The induced current opposes the change that made it.

This is because the **induced current** produces a **magnetic field** around the wire (a different magnetic field than the one the wire was placed in). This magnetic field acts against the original

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field created by the magnet, as if it is trying to balance things out. Therefore the induced current will always oppose the change that made it, whether that be the electrical conductor moving or a change in the original magnetic field.

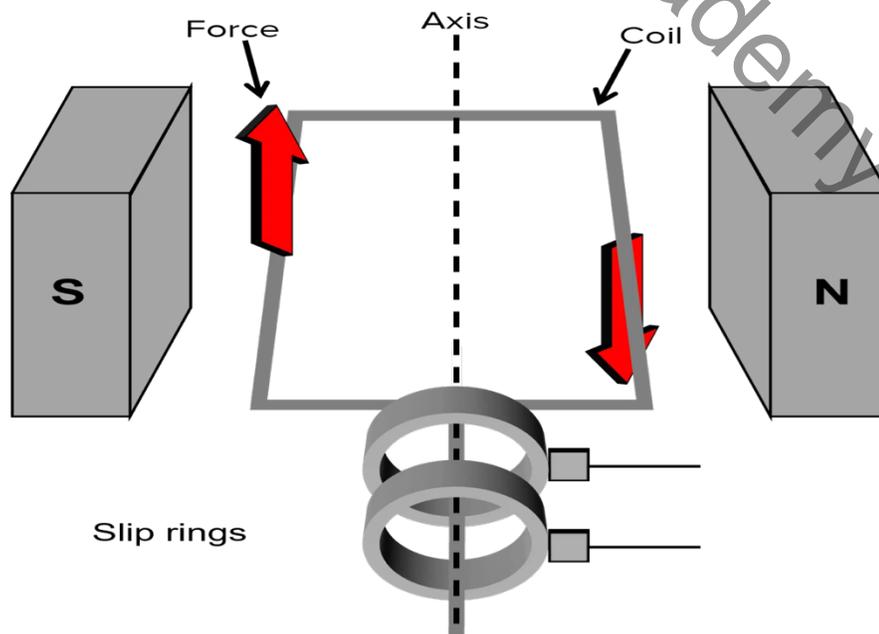
Rule 2:

The size of the induced potential difference depends on the rate that the magnetic field is changing.

- ▶ You can increase the rate that the **magnetic field** is changing and hence increase the induced potential difference by either:
 1. Increasing the speed of the movement
 2. Increasing the strength of the magnetic field

The Ac Generator : The Alternator

- ▶ An alternating current (ac) generator is a device that produces a potential difference. A simple ac generator consists of a coil of wire rotating in a magnetic field.
- ▶ Cars use a type of ac generator, called an alternator to keep the battery charged and to run the electrical system while the engine is working.
- ▶ As one side of the coil moves up through the magnetic field, a potential difference is induced in one direction.
- ▶ As the rotation continues and that side of the coil moves down, the induced potential difference reverses direction. This means that the alternator produces a current that is constantly changing. This is alternating current or ac.



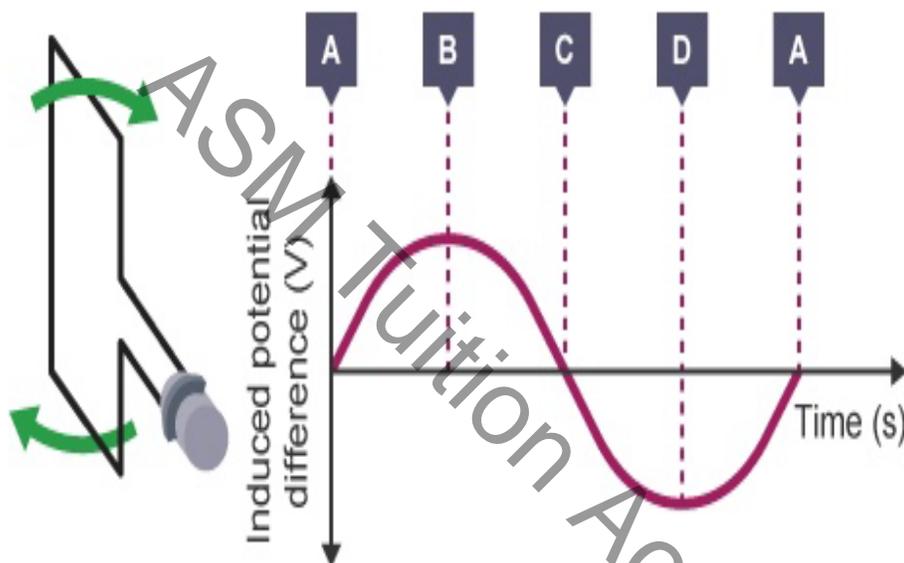
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Alternator output on a graph

- The output of an alternator as it rotates can be represented on a potential difference-time graph with potential difference (voltage) on the vertical axis and time on the horizontal axis.
- The graph shows an alternating sine curve. The maximum potential difference or current can be increased by:
 - increasing the rate of rotation
 - increasing the strength of the magnetic field
 - increasing the number of turns on the coil



- The diagram shows four different positions of the coil in an alternator, and the corresponding potential difference produced.

A - The coil is at 0° . The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

B - The coil is at 90° . The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum.

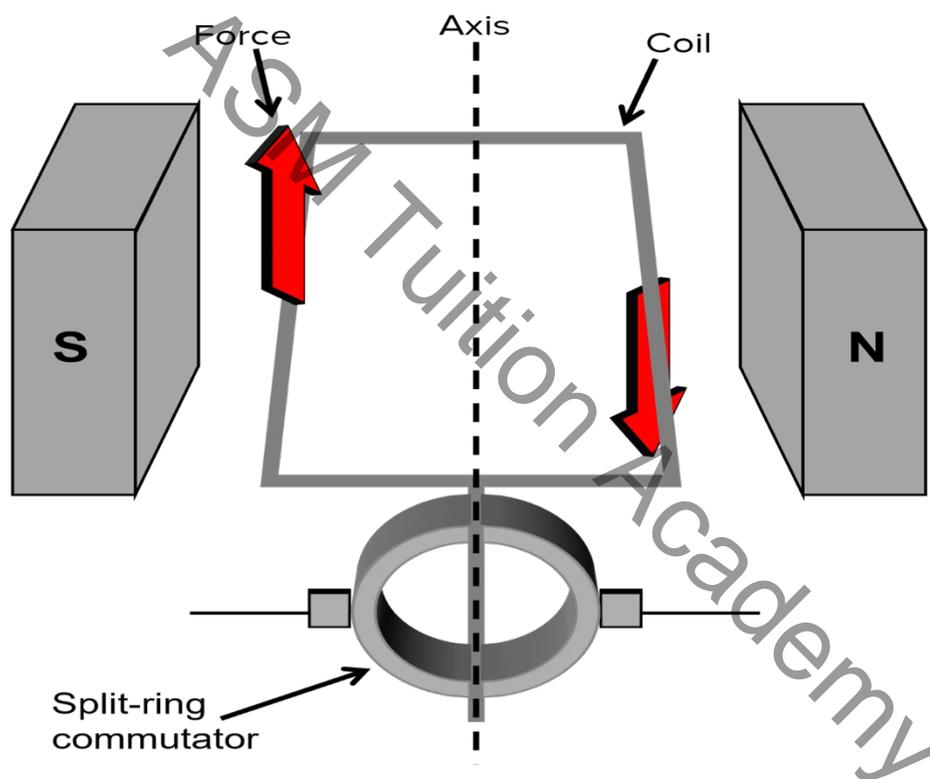
C - The coil is at 180° . The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

D - The coil is at 270° . The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum. Here, the induced potential difference travels in the **opposite** direction to what it did at B.

A - The coil is at 360° , ie it is back at its starting point, having done a full rotation. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

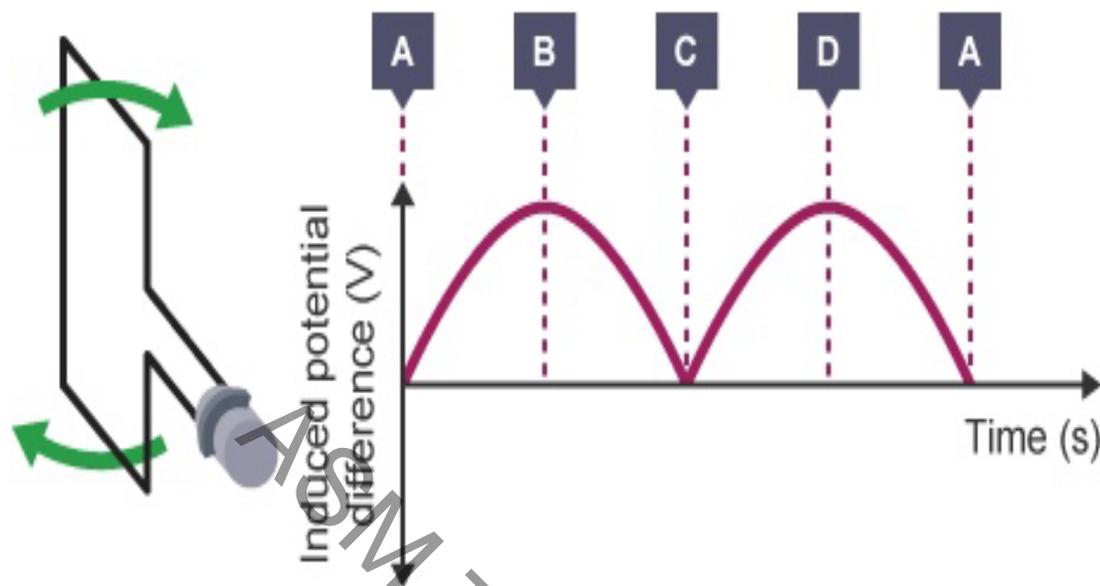
The Dc Generator: The Dynamo

- A direct current (dc) generator is another device that produces a potential difference. A simple dc generator consists of a coil of wire rotating in a magnetic field. However, it uses a split ring commutator rather than the two slip rings found in alternating current (ac) generators.
- Some bike lights use a type of dc generator called a dynamo to run the lamps while the wheels are turning.
- In a dynamo, a split ring commutator changes the coil connections every half turn. As the induced potential difference is about to change direction, the connections are reversed. This means that the current to the external circuit always flows in the same direction.



Dynamo output on a graph

- The output of a rotating dynamo can be shown on a potential difference-time graph. The graph shows a sine curve that stays in the same direction all the time.
- The maximum potential difference or current can be increased by:
 - increasing the rate of rotation
 - increasing the strength of the magnetic field
 - increasing the number of turns on the coil



- The diagram shows four different positions of the coil in a dynamo, and the corresponding potential difference produced.

A - The coil is at 0° . The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

B - The coil is at 90° . The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum.

C - The coil is at 180° . The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

D - The coil is at 270° . The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum. Here, the induced potential difference travels in the **same** direction as at B.

A - The coil is at 360° , ie it is back at its starting point, having done a full rotation. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

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