PHYSICS TUTOR
ONLINE

Unit 13 – Electromagnetic Induction

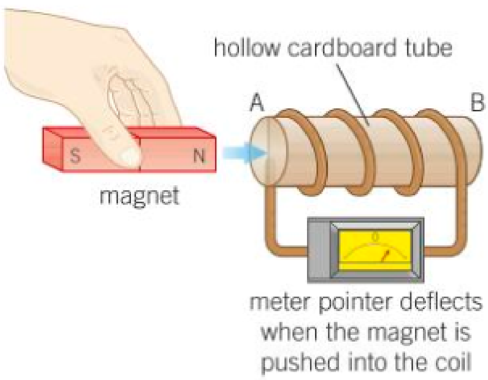
This unit explains how electrical energy can be generated without a battery, simply by moving wires in magnetic fields. You'll learn how **induced current** works, how **alternators** and **dynamos** generate electricity, and the differences between **AC and DC**. We explore how this applies to real-life systems like microphones, loudspeakers, and the National Grid. You'll also understand how **transformers** work and why stepping voltage up and down is essential for efficient power transmission.

Inducing Current

When a **conductor (wire)** moves through a **magnetic field**, a **potential difference** is generated. This can cause a **current to flow** if the wire is part of a complete circuit.

Key Ideas:

- Moving a wire in a magnetic field causes electrons to shift → **potential difference**
- If connected in a circuit → **current flows**
- The new current produces its own magnetic field in the **opposite direction** to oppose the change (Lenz's Law)



Generating Electricity

Small-Scale Generation

- Spin a coil between two magnets → small current (measured with a **sensitive ammeter**)
- Move a wire manually through a magnetic field → deflection seen on an ammeter

Large-Scale Generation

Process	Description
Steam Production	Water heated by fossil fuels or nuclear energy
Turbine Rotation	Steam pressure spins turbine blades
Generator Action	Turbine connected to a coil in a magnetic field
Result	Spinning coil generates current in wires

Factors Affecting Current/Voltage Size:

- Number of wire coils
- Speed of rotation
- Strength of magnetic field

Alternators vs Dynamos

Alternator

- A coil spins in a magnetic field
- Every **half-turn**, the current switches direction
- Produces **Alternating Current (AC)**
- Use **Fleming's Left Hand Rule** to predict current direction

Dynamo

- Similar to an alternator, but with a **commutator**:
  - A split metal ring that keeps the current output in the same direction
  - Every half turn, it switches contact, ensuring the **Direct Current (DC)** output remains positive

Feature	Alternator	Dynamo
Output Type	AC	DC
Current Flips	Yes, naturally	No, commutator corrects it
Uses	Power stations	Bicycle lights, old radios

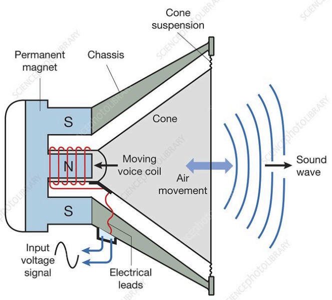
Microphones & Loudspeakers

Microphones (Input Device)

- **Sound waves** move a **coil** placed in a magnetic field
- This movement induces a current
- Current is **proportional to pressure variations**

Loudspeakers (Output Device)

- The **induced current** flows into a coil
- The coil interacts with a **fixed magnet**
- This makes the coil (and the **attached cone**) move
- Movement creates **sound waves**



Transformers

Transformers use electromagnetic induction to change the potential difference (voltage).

How They Work:

- AC current in primary coil → changing magnetic field
- This field cuts through the secondary coil
- Induces an AC voltage in the secondary coil

⚠️ **DC doesn't work in transformers (no changing field → no induction)**

Types of Transformers:

Transformer Type	**Coils**	**Effect on Voltage**
Step-up	More coils on secondary	Increases voltage
Step-down	Fewer coils on secondary	Decreases voltage

Transformer Equation:

$$\frac{N_{\text{primary}}}{N_{\text{secondary}}} = \frac{V_{\text{primary}}}{V_{\text{secondary}}}$$

Where:

- N = number of turns (coils)
- V= potential difference (voltage)

⚠️ **Assumes 100% efficiency unless told otherwise.**

The National Grid

A system that transfers energy from power stations to homes and businesses.

Why High Voltage?

- Power = Current × Voltage ($P = IV$)
- To reduce energy loss:
  - Increase voltage → reduce current
  - Lower current = less heat loss in cables

💡 **High voltage = efficient transmission**
⚠️ **High voltage = dangerous, so step it down near towns**

Stage	**Voltage Change**	**Purpose**
Power Station	Voltage increased (step-up)	Efficient long-distance travel
Towns/Homes	Voltage reduced (step-down)	Safe for domestic use

Power Balance Equation:

$$V_{\text{primary}} \times I_{\text{primary}} = V_{\text{secondary}} \times I_{\text{secondary}}$$