# Faraday's Law

Presented by

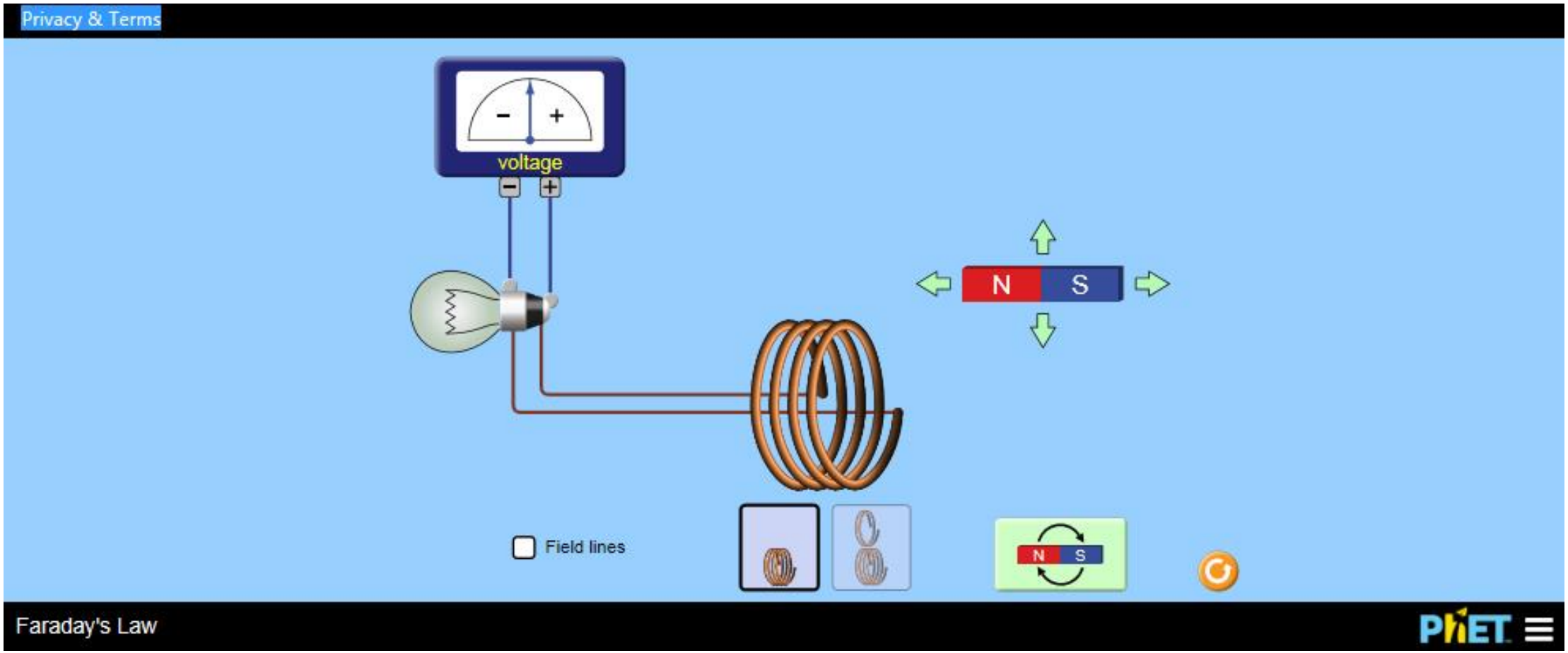
Ragav VU3VWR

# Jargon

- **Magnetic Flux** is a measurement of the total magnetic field which passes through a given area; it tells how much magnetic field has been “cut” by a coil or a plate
- **Flux Linkage** is the product of magnetic flux and number of turns in a coil
- Electromotive Force, or EMF, is the electrical action produced by a non-electric force; for example: EMF produced by a battery through chemical reaction, or, by a generator through mechanical action
- In Electromagnetism, it is the work done by an electron, travelling around a closed loop of wire; it is given in Volts (V)
- Voltage is the difference in potential between two points; EMF is the energy supplied to a charge – Voltage is the “height difference” and EMF is “driving force” which pushes things down

# Faraday's law on Electromagnetic Induction

- In 1831, Michael Faraday, an English physicist, theorized one of the most basic laws of electromagnetism that defines the relationship between an electric field and a magnetic field in a conductor
- In his experiments, he used a coil of wire, connected to a galvanometer, a device to measure the flow of electric current, and a magnet
- He found that the magnet, when held stationary above the coil had no effect; as the magnet moves towards the coil, the galvanometer needle deflected in one direction and the meter returned to zero when the magnet was stopped near the coil; as the magnet was being withdrawn away from the coil, the galvanometer needle deflected in the opposite direction
- Whenever there is relative motion between a conductor and a magnetic field, the flux linkage with a coil changes, and this change in flux induces a voltage across a coil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# Faraday's First law

Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced; If the conductor circuit is closed, a current is induced which is called induced current

This can be done by:

- moving the magnet towards or away from the coil
- moving the coil towards or away from the coil
- changing the area of the coil placed in the magnetic field
- rotating the coil relative to the magnet

# Faraday's Second law

The induced emf in a coil is equal to the rate of change of flux linkage

According to this law, the induced EMF in a coil can be varied by changing the rate of change of the interaction between the magnetic flux and the coil

To get increase induced EMF, one can:

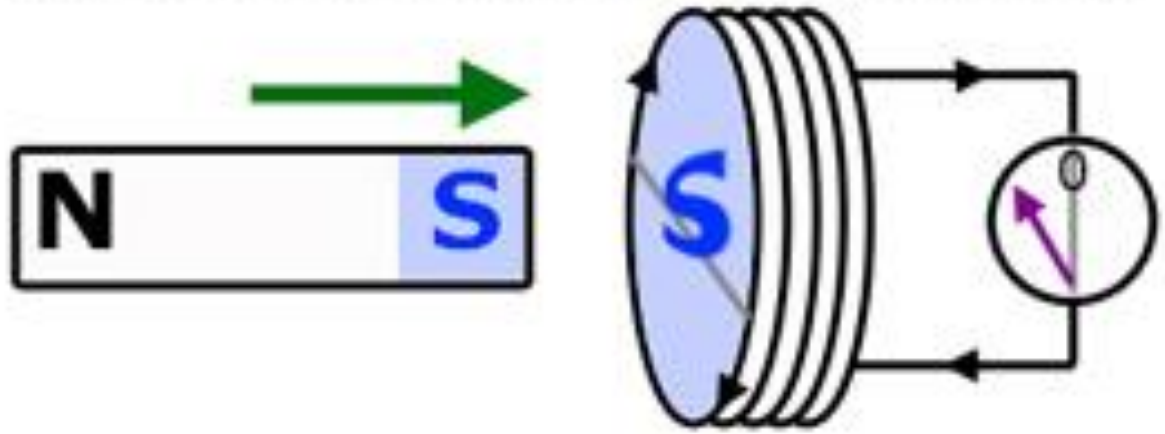
- increase number of turns in the coil
- increase magnetic field strength
- Increase speed of the relative motion between the coil and magnet

# Lenz’s Law

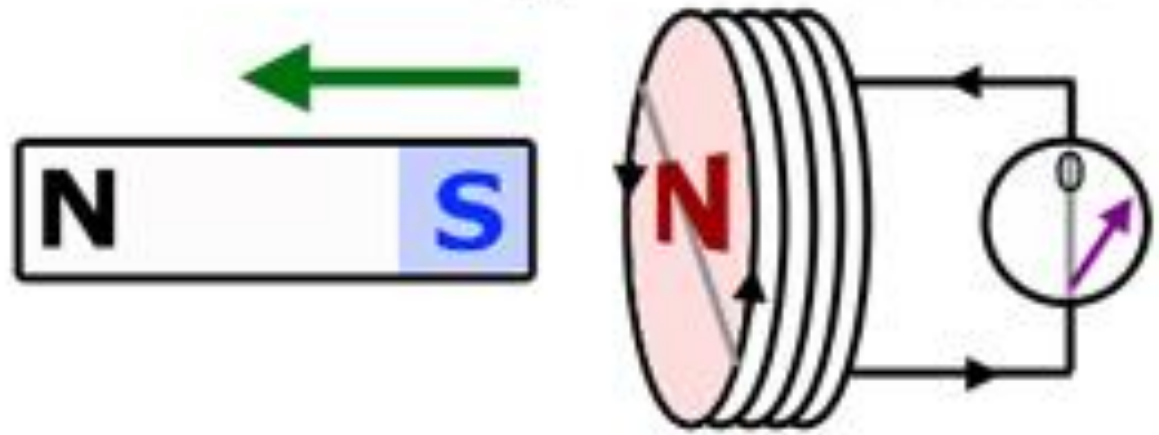
In 1833, Russian physicist Heinrich Lenz stated that, an induced electric current flows in a direction, such that the current opposes the change that induced it.

Thrusting a magnet into a coil of wire induces an electric current through the coil, making it an electromagnet; According to Lenz, when the north pole of the magnet approaches the coil, the induced current flows in such a way to make the end of the coil, nearest to the magnet, repel the approaching north pole of the magnet; On withdrawing the magnet, the induced current reverses, and the coil tries to attract the now withdrawing north pole of the magnet

movement **against repulsion**




movement **against attraction**

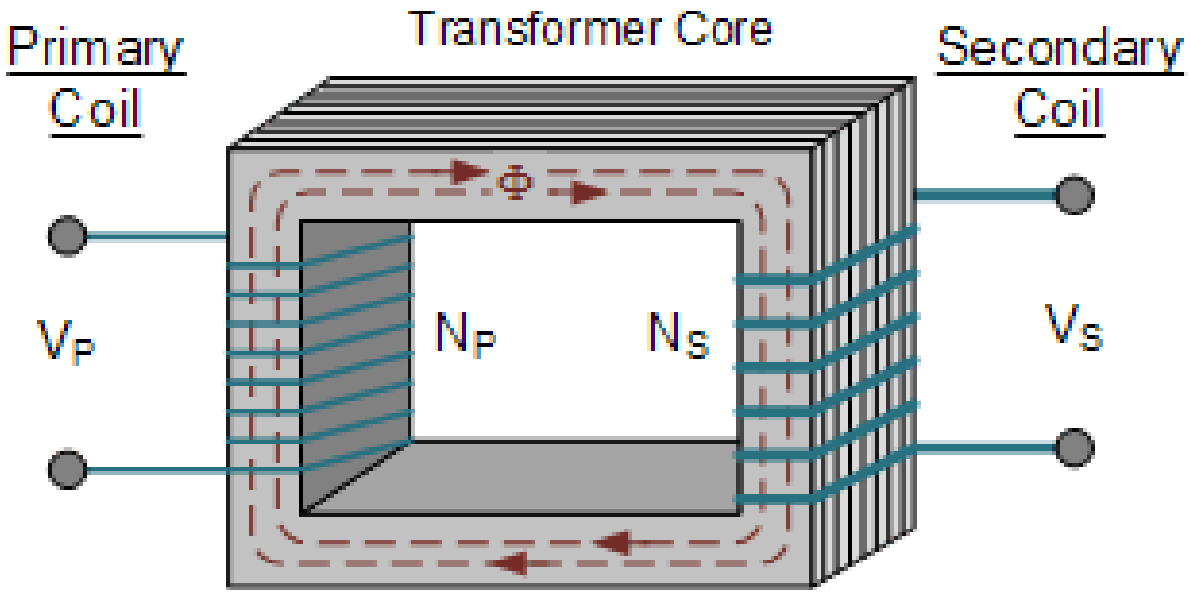


# Applications :Transformers

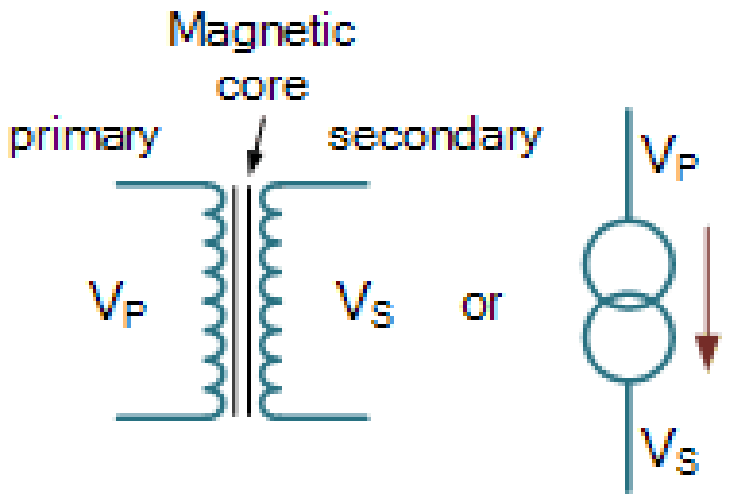
- Transformers : electrical components used to increase or decrease the voltage flowing in a circuit

It consists of two coils, that are electrically isolated, but magnetically linked; It works on the principle of mutual inductance

When an AC signal is applied to one of the coils, it produces a varying magnetic field around it; this field is linked to the other coil using a ferro magnetic material; the varying magnetic field around the second coil induces an EMF in it – if the circuit to the second coil is closed, current will flow through it




Transformer Construction




Transformer Symbols

# Applications :Transformers ..

- The difference in voltage between the primary and secondary windings is achieved by changing the number of turns in the primary and secondary; this leads to a fixed ratio between number of turns in secondary vs the primary – this is known as turns ratio – dictates the operation of the transformer: step up, step down, or isolation
- Turns ratio is given by the formula Windings on the primary / Windings on secondary

Example : Primary winding : 1500 turns, Secondary winding : 500 turns = 1500/500 = 3/1 = 3:1 ; what this means is that for every 3V increment on the primary, there will be a corresponding 1 V increment on the secondary – step down transformer

# Losses in a Transformer

- When magnetic flux flows through the core of a transformer , there are two losses that occur  - Hysteresis losses and Eddy current losses
- Transformer Hysteresis Losses are caused because of the friction of the molecules against the flow of the magnetic lines of force required to magnetize the core, which are constantly changing in value and direction due to the sinusoidal nature of AC – This friction causes heat which can reduce the life of insulating materials – cooling is important
- Transformer Eddy Current Losses are caused by the flow of circulating currents induced in the core by the flow of the magnetic flux around the core; These circulating currents are generated because to the magnetic flux the core is acting like a single loop of wire – they oppose the flow of the induced current and causes heating and power loss – can be reduced by reducing surface area of core

# Types of transformers

- Step up : used to boost voltage; primary has less turns than secondary
- Step down : used to lower voltage; primary has more turns than secondary
- Isolation : used to isolate two parts of a circuit with same voltage levels; primary and secondary windings are equal
- Variable : The primary and secondary have an adjustable number of turns which can be selected without reconnecting the transformer

# Application : Generators

- Generators are electrical devices that convert mechanical energy into electrical energy

It consists of fixed permanent magnets around which a coil is rotated rapidly using mechanical means; as the magnetic flux around the coil varies, a proportional EMF is induced in the coil

Based on the arrangement that delivers the induced current in the coil, the output could either be AC or pulsating DC

# Thank you

Questions and comment in the chat box!