Electromagnetic Induction

Lecture 4

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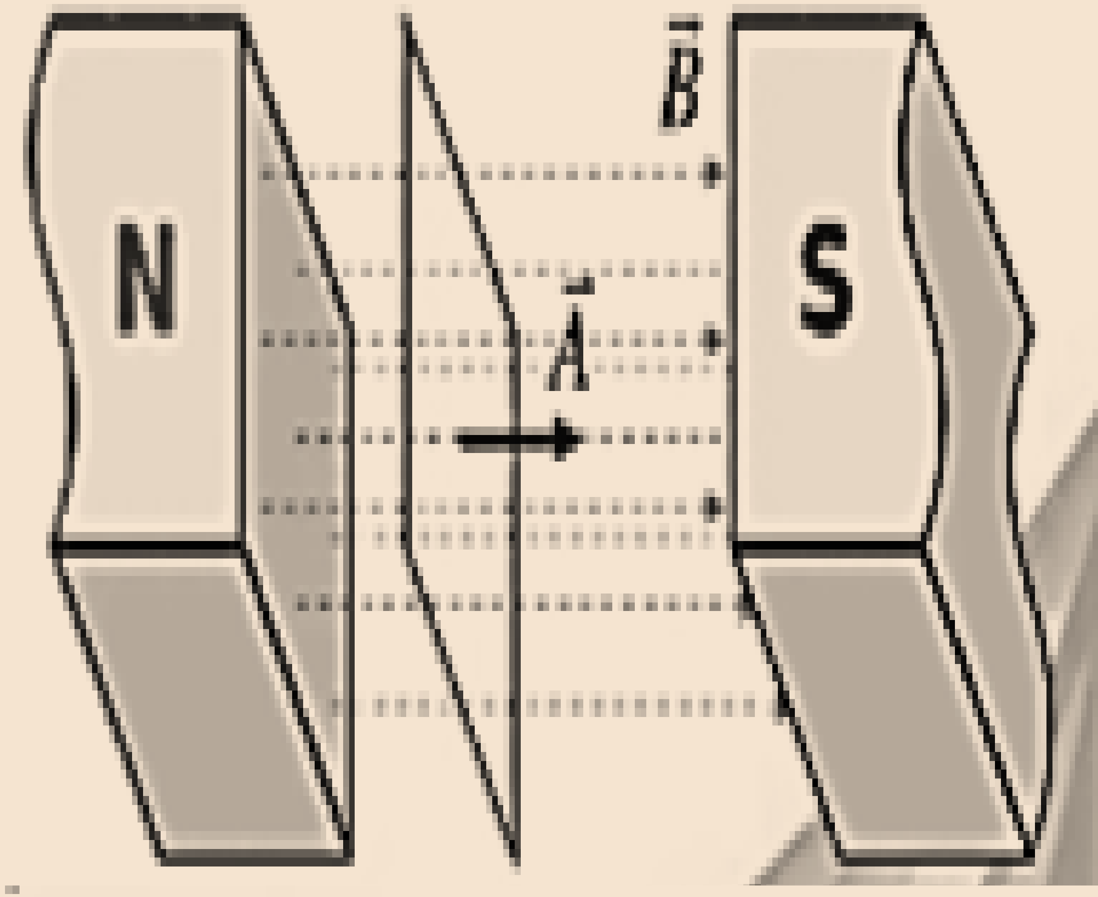
Introduction

- The word of electromagnetic induction is made up of two words electromagnet + induction.
- An electromagnet is a type of magnet in which the magnetic field is produced by electric current.
- the process in which generating current in a conductor by placing the conductor in a changing magnetic field is called induction.

Magnetic flux is defined as the number of lines passing through a given closed surface.

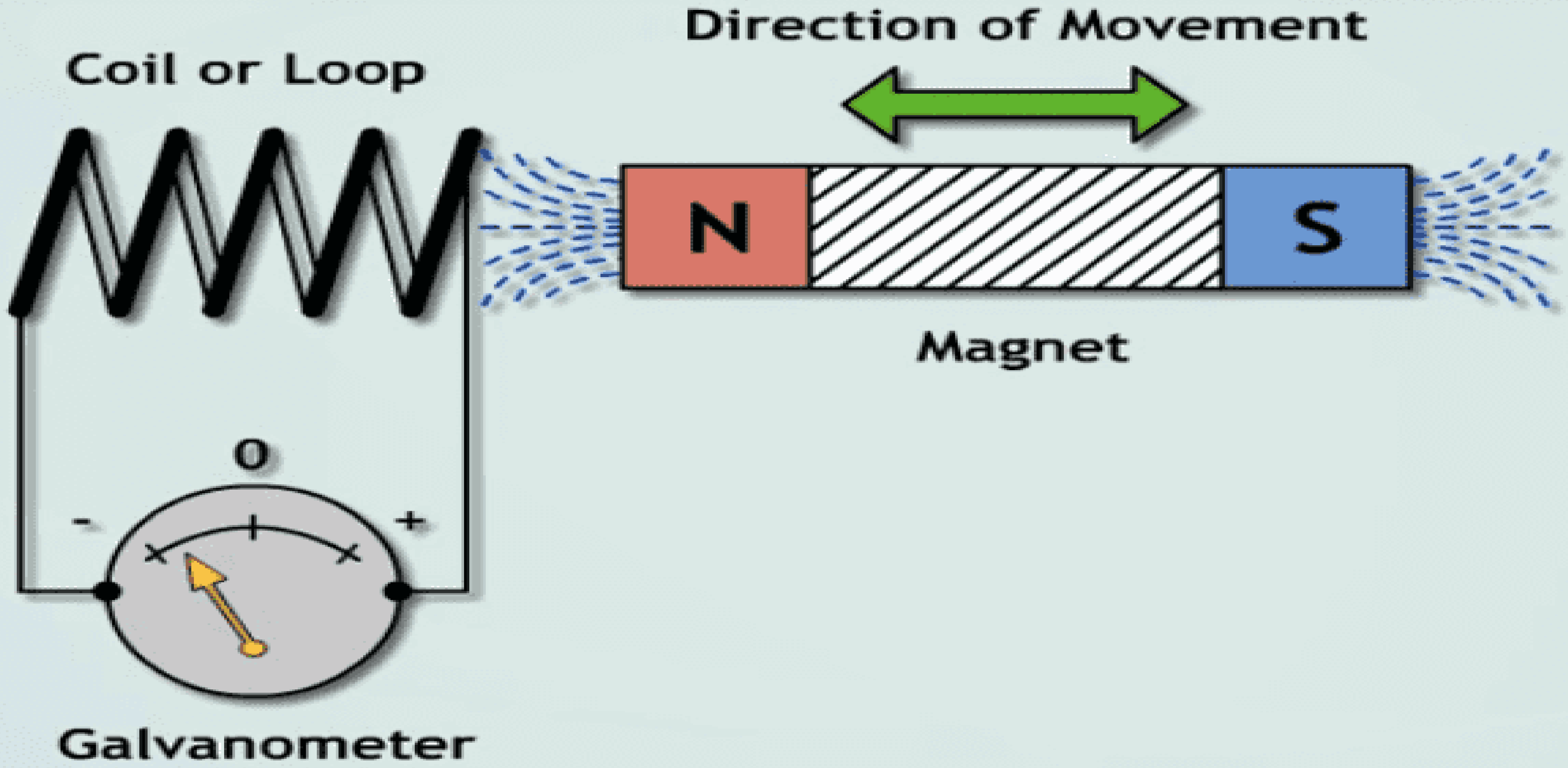


Where B is the magnetic field measured by weber & A is the area.

Magnetic flux symbol: Φ or Φ_B.

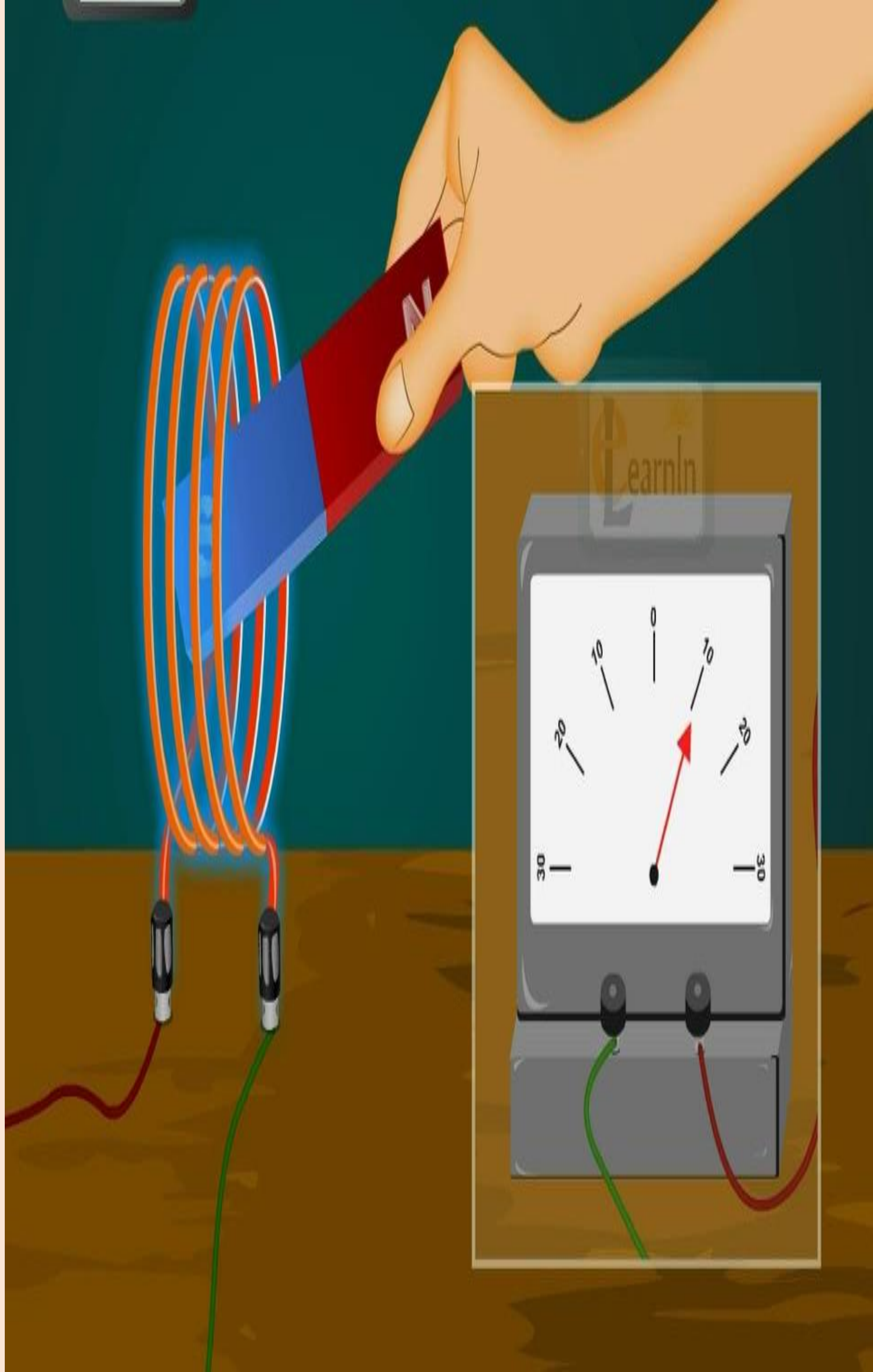
$$\Phi_B = B.A = BA\cos\theta$$

Faraday's Experiment

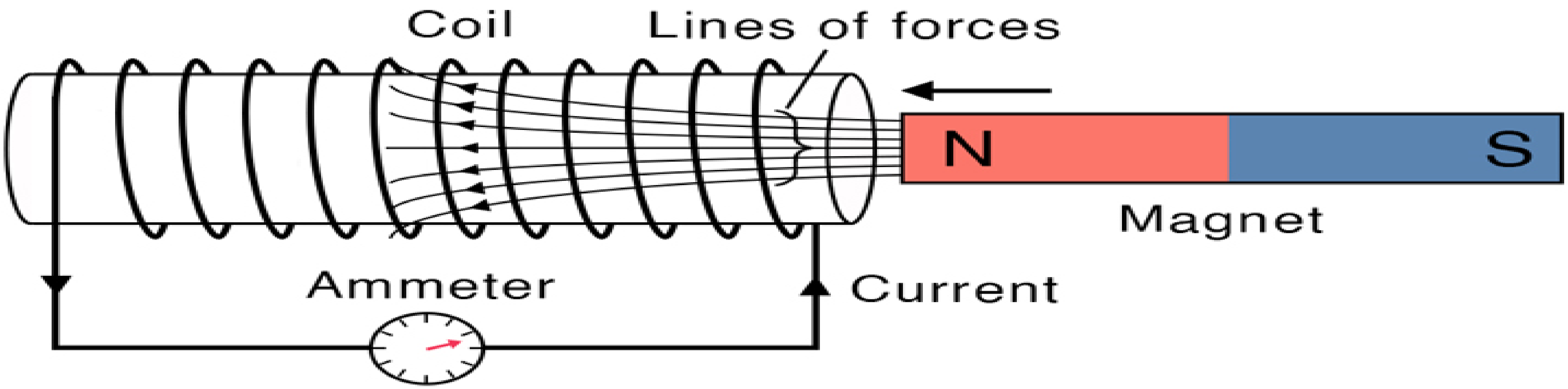


Faraday’s Experiment

From his experiment, Faraday concluded that whenever there is relative motion between a conductor and magnetic field, the change in flux induces a voltage a cross a coil.



Faraday's Law Equation



$$\varepsilon = -N\frac{d\phi}{dt}$$

ε : Electromotive force (EMF)

N : Number of turns of the coil

$\frac{d\phi}{dt}$: Instaneous change of magnetic flux with time

Solved problems

Magnetic field through a coil having 200 turns and cross sectional area 0.04 m^2 changes from 0.1 wb m^{-2} to 0.04 wb m^{-2} in 0.02 s Find the induced emf.

Data : N = 200, A = 0.04 m^2, B_1 = 0.1 wb m^{-2},
B_2 = 0.04 wb m^{-2}, t = 0.02 s, e = ?

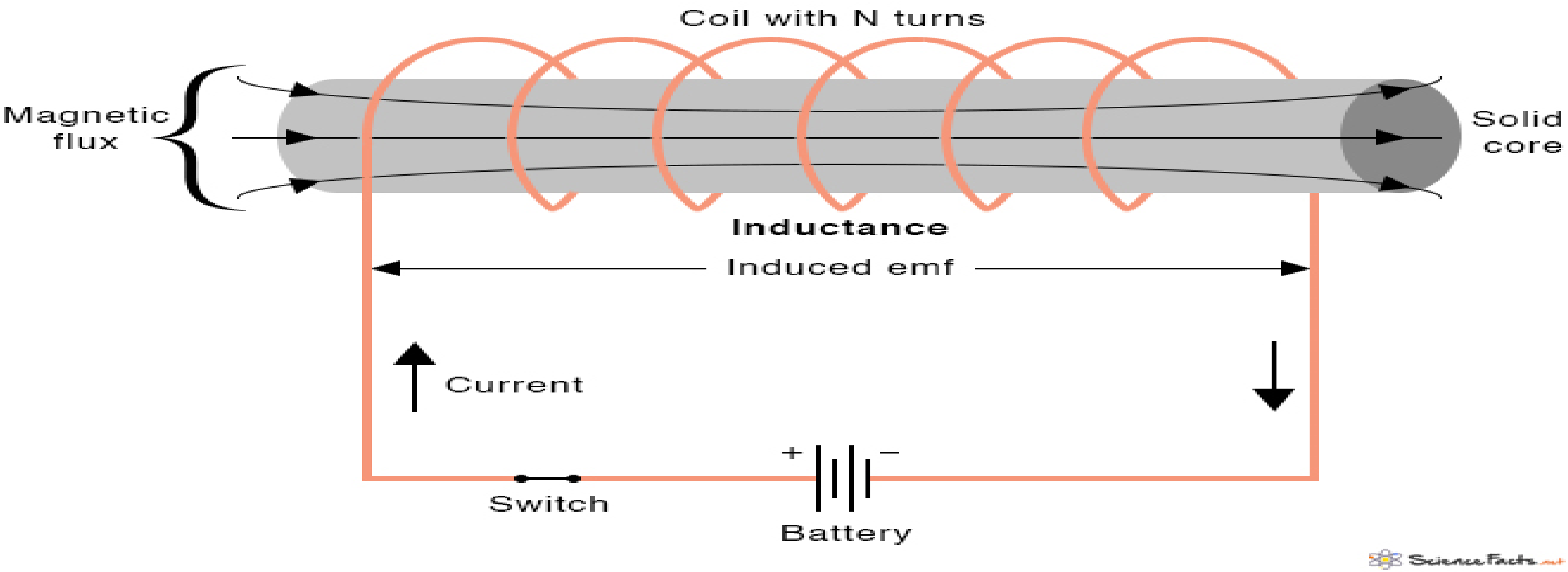
Solution : $e = -\dfrac{d\phi}{dt} = -\dfrac{d}{dt}(\phi)$

$$e = -\frac{d}{dt}(NBA) = -NA \, . \, \frac{dB}{dt} = -NA. \, \frac{(B_2 - B_1)}{dt}$$

$$e = -200 \times 4 \times 10^{-2} \, \frac{(0.04 - 0.1)}{0.02}$$

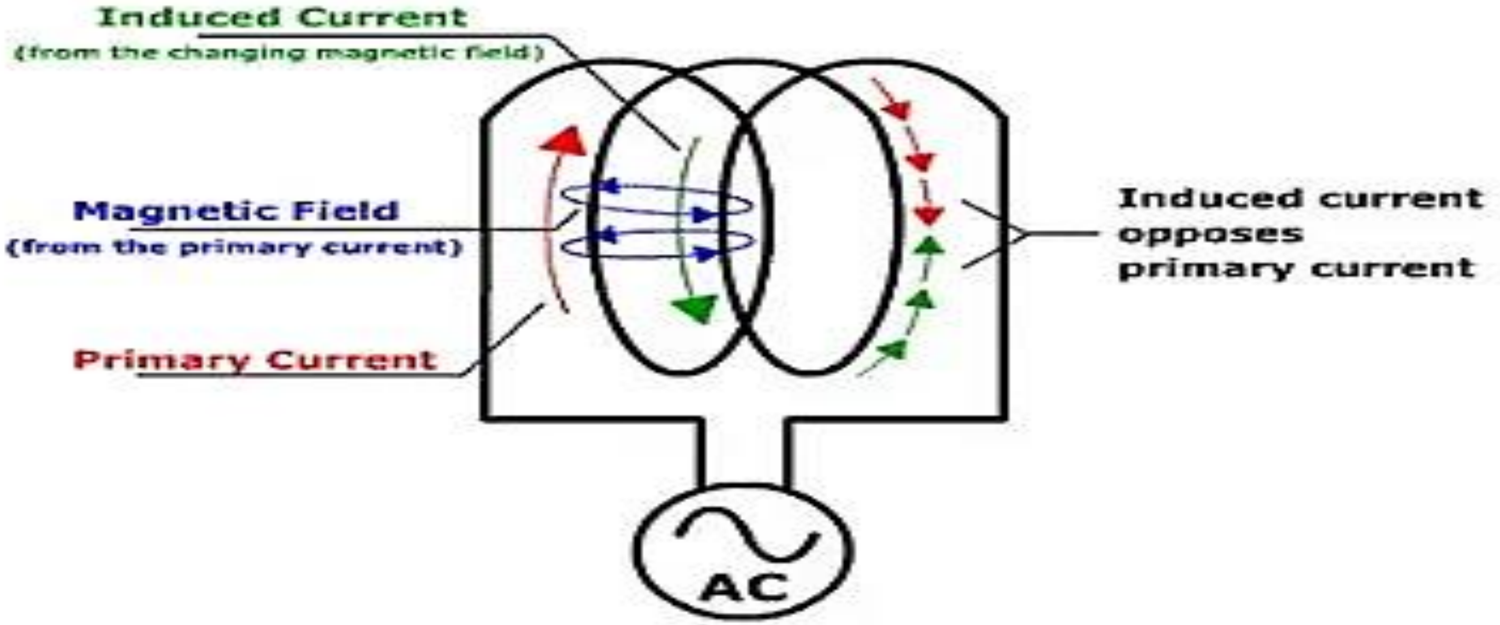
$$e = 24 \text{ V}$$

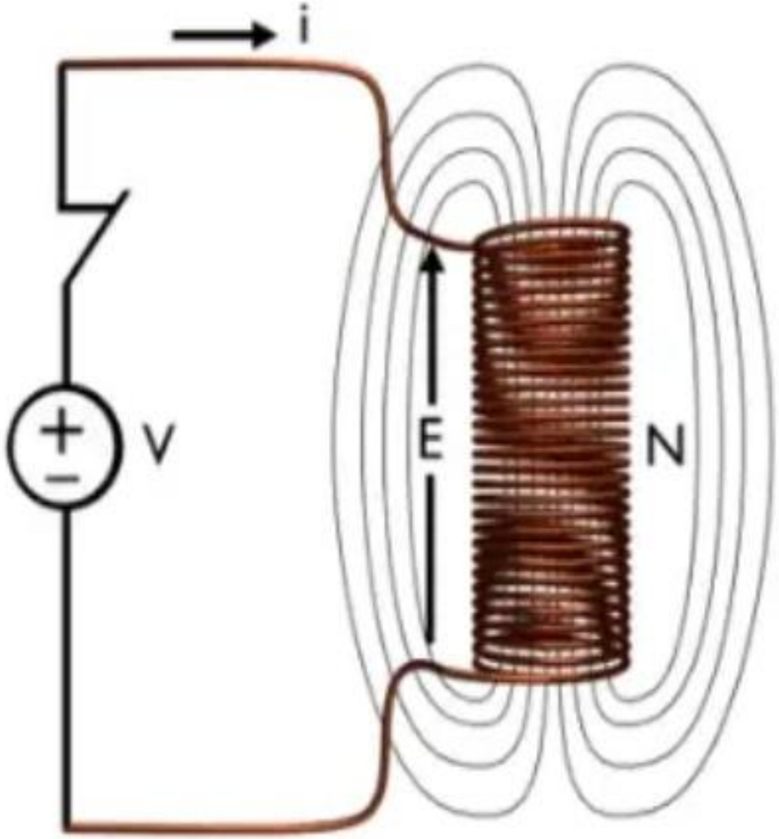
Inductance



Inductance: is a property of a conducting wire wound in the shape of a coil that opposes any change in the current flowing through it.

What is Self Inductance?

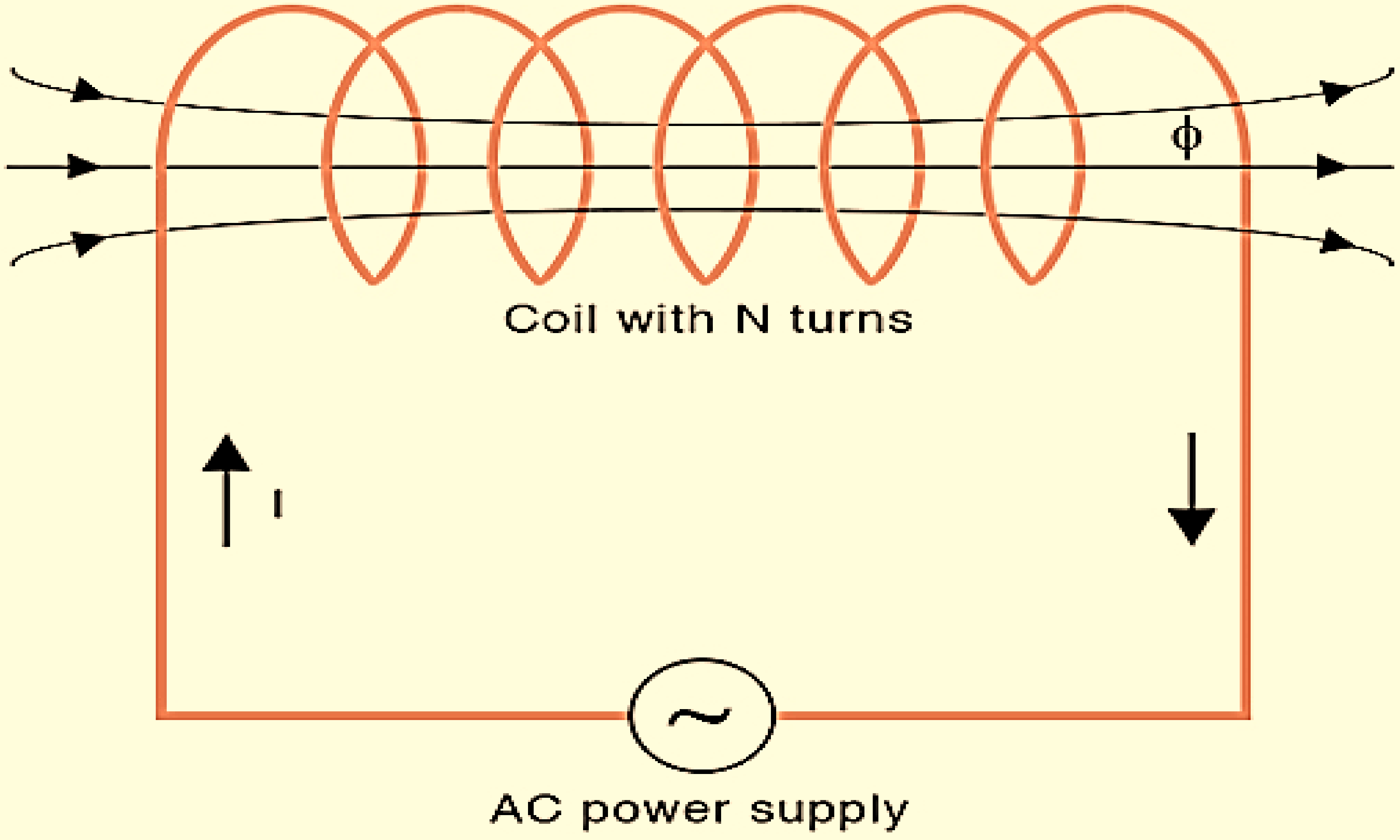




Self- Induction:

If the emf is induced in the same coil as the flowing current, it is know as self-inductance.

Self-Inductance Equation



$$L = \frac{N\phi}{I}$$

L : Self-inductance

N : Number of turns

ϕ : Magnetic flux

I : Current

Example

A loop of wire carries a current of 180 mA. The magnetic flux produced by the current is 0.77wb. What is self-inductance of the loop?

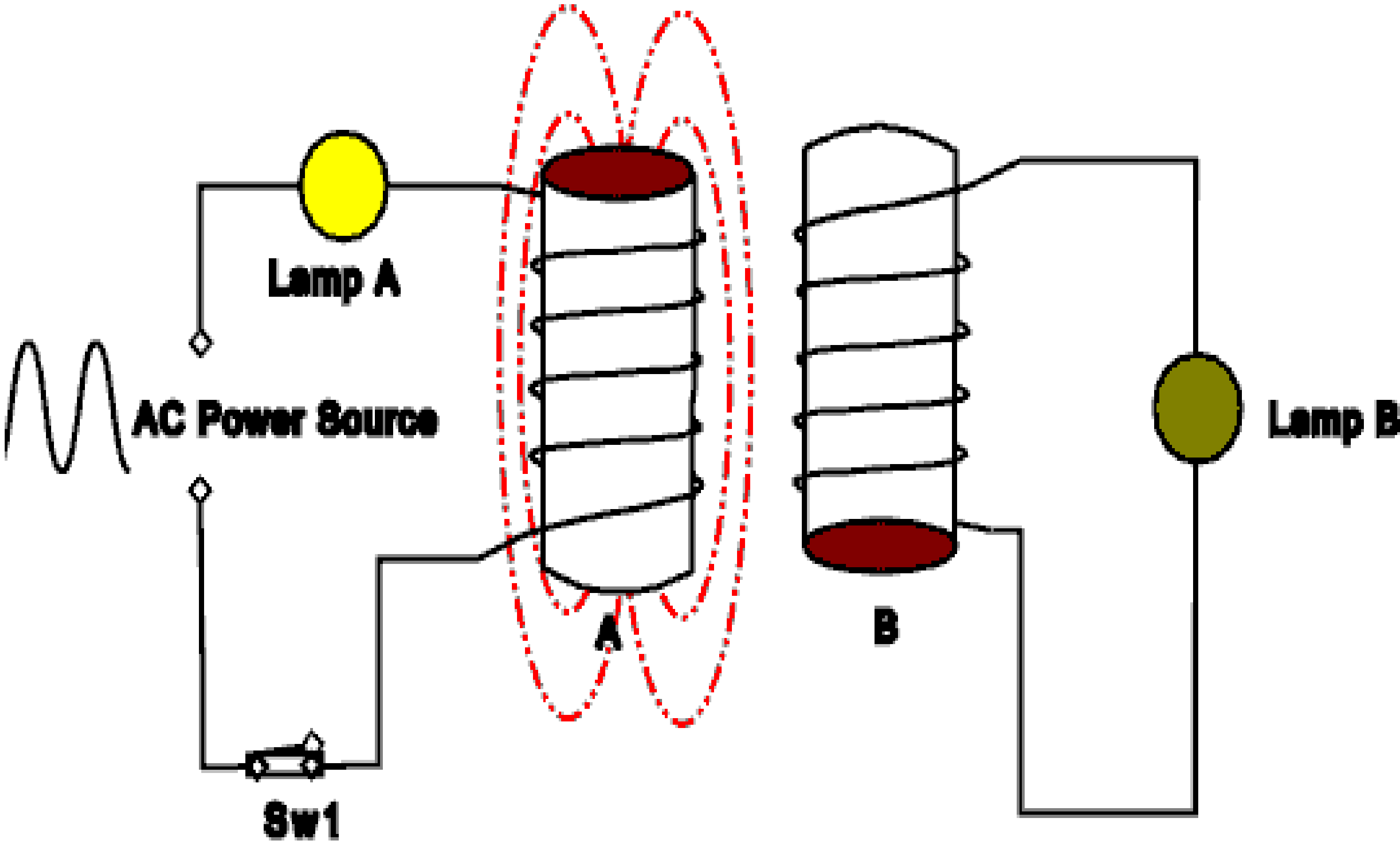
Solution:

$$L = \frac{\Phi_m}{I}$$

$$L = \frac{0.77\,Wb}{0.180\,A} = \boxed{4.3\,H}$$

Mutual Inductance

If the emf is produced in anther coil placed next to the first, it is known as mutual inductance.



The electromotive force generated by the second coil is:

$$\varepsilon_2 = -M \frac{di_1}{dt}$$

Where M is the mutual inductance of the two coils.

Two coils have mutual inductance of 3.25×10^{-4} H. The current in the first coil increases at a uniform rate of 830 A/s .

A) What is the magnitude of induced emf in the 2^{nd} coil? Is it constant?

B) suppose that the current is instead in the 2^{nd} coil, what is the magnitude of the induced emf in the 1^{st} coil?

$$\varepsilon_2 = -M\frac{di_1}{dt}$$

$$= -(3.25\times10^{-4} H)(830\frac{A}{s}) = -0.27V$$

$$\varepsilon_1 = -M\frac{di_2}{dt} = -0.27V$$


Thank
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