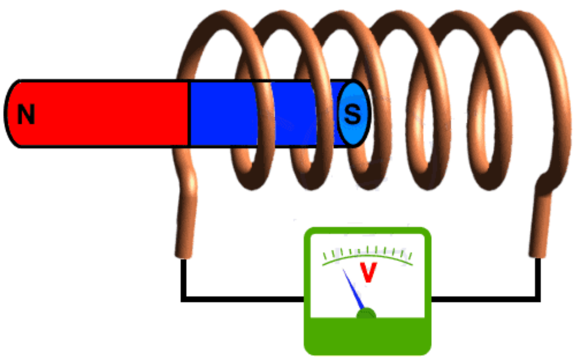
UNIT-19 ELECTROMAGNETIC

SHORT REASONING QUESTIONS

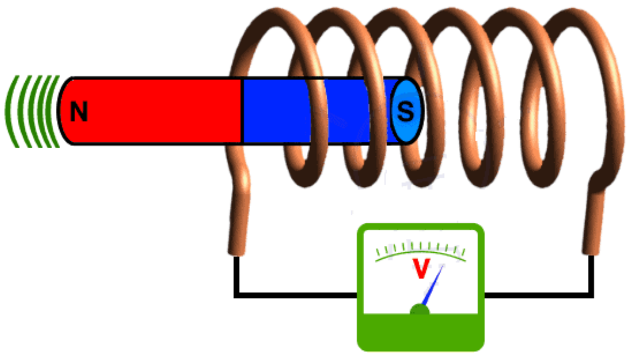
1. Explain Faraday's law of electromagnetic induction.

Faraday's Law of Electromagnetic Induction

Faraday's law of electromagnetic induction states the following:
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 an induced current.



As magnet moves to the right, magnetic field is changing with respect to the coil, and EMF is induced.



As magnet moves more rapidly to the right, magnetic field is changing more rapidly with respect to the coil and a greater EMF is induced.

Mentioned here are a few ways to change the magnetic field intensity in a closed loop:

- By rotating the coil relative to the magnet.
- By moving the coil into or out of the magnetic field.
- By changing the area of a coil placed in the magnetic field.
- By moving a magnet towards or away from the coil.

Faraday's law of electromagnetic induction also states that

The induced emf in a coil is equal to the rate of change of flux linkage. The flux linkage is the product of the number of turns in the coil and the flux associated with the coil. The formula of Faraday's law is given below.

$$emf = -N\frac{\Delta \Phi}{\Delta t}$$

2. State Lenz's law and discuss its significance in the context of electromagnetic induction.

LENZ LAW:

The rule for determining the directions of the induced current was proposed in 1834 by Heinrich Friedrich Emil Lenz (pronounced ***lents***)and is known as Lenz's law:

The induced emf will produce a current in a closed conduction loop that always acts to oppose the change that originally caused it

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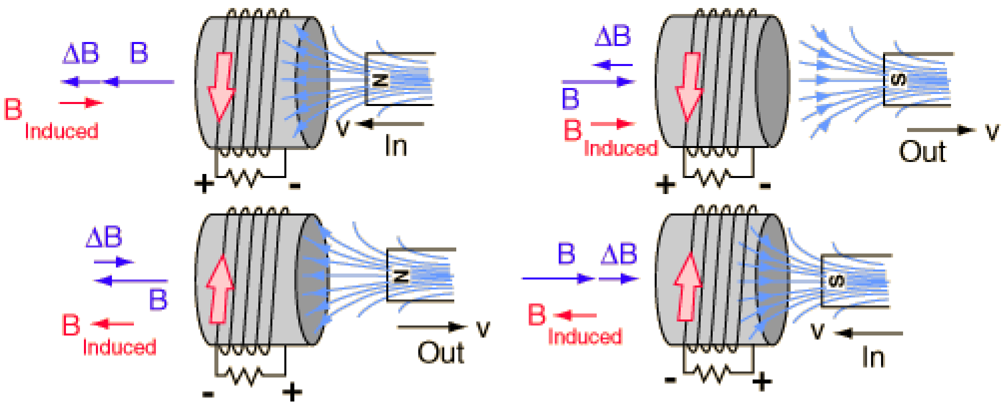
SIGNIFICANCE IN ELECTROMAGNETIC INDUCTION:

1 Determining the Direction of Induced Current:

Lenz's law is crucial for determining the direction of the induced current in a conductor when a magnetic field changes around it.

2 law of conservation of energy:

When a bar magnet's pole is pushed into a solenoid, a current is induced in it. This induced current sets up a magnetic field in the solenoid. In terms of Lenz's law, this "pushing" is the "change" that produces the induced current, and according to the law, the induced current opposes the "push". If we pull the magnet away from the coil, the induced current opposes the "pull". Thus, the agent that causes the magnet to move has to do work. From the conservation-of-energy principle, this work done becomes the electrical energy in the coil.

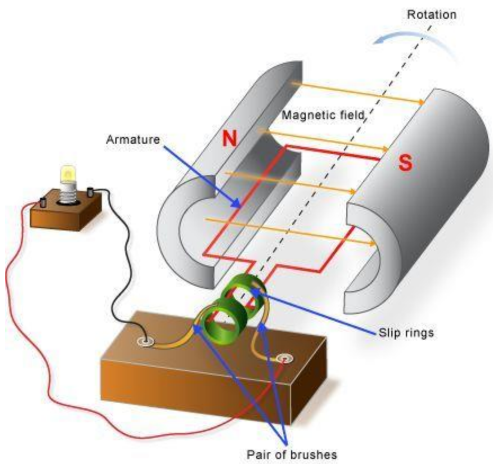


3. How does a step-up transformer differ from a step-down transformer?

Ans: Step-up transformers increase the voltage from the input to the output of the transformer. In this configuration, the primary winding features fewer turns than the secondary winding. This greater number of windings produces a higher voltage in the secondary side, increasing the output voltage. A step-down transformer decreases the voltage from input to output. With fewer turns on the secondary winding, the voltage from the primary winding decreases as it passes through the transformer. Step-down transformers create safe levels of alternating current (AC) for use in various products, such as televisions and voltage stabilizers, welding equipment, transmission lines, and adapters for electronics like cell phones.

4. Describe the principle of operation of an AC generator.

Ans: AC generators work on the principle of Faraday's law of electromagnetic induction. When the armature rotates between the magnet's poles upon an axis perpendicular to the magnetic field, the flux linkage of the armature changes continuously. Due to this, an emf is induced in the armature



5. Define self-induction and explain how it occurs in a coil.

Ans *A phenomenon in which a changing current in a coil induces an emf in itself is called self-induction.*

Self-Induction Occurs in a Coil

1 **Changing Current**: When the current through a coil changes (increases or decreases), the magnetic flux linked with the coil also changes.

2. **Magnetic Flux**: The changing current produces a changing magnetic field around the coil, which in turn generates a changing magnetic flux through the coil itself.

3 **Faraday's Law of Induction**: According to Faraday's Law, a changing magnetic flux through a coil induces an EMF in the coil. This EMF is called the self-induced EMF.

4 **Lenz's Law**: The direction of the self-induced EMF is such that it opposes the change in the current that caused it. If the current is increasing, the induced EMF will oppose the increase, and if the current is decreasing, the induced EMF will oppose the decrease.

6. Define mutual induction and provide an example of a system exhibiting mutual induction.

Ans: Mutual induction is a phenomenon in which a changing current in one coil induces an electromotive force (EMF) in a nearby coil. This occurs due to the magnetic field produced by the changing current in the first coil linking with the second coil. The property that quantifies this effect is called mutual inductance (M), measured in Henries (H).

Example of a System Exhibiting Mutual Induction

Transformer: A transformer is a classic example of a system that exhibits mutual induction. It consists of two coils (primary and secondary) wound around a common magnetic core.

Primary Coil: When an alternating current (AC) flows through the primary coil, it generates a changing magnetic field in the core.

Secondary Coil: The changing magnetic field induces an EMF in the secondary coil, causing a current to flow in it if the circuit is closed.

Energy Transfer: The transformer transfers electrical energy from the primary coil to the secondary coil without direct electrical connection, relying solely on mutual induction.

7. How does the arrangement of coils influence the degree of mutual induction between them?

Ans: The degree of **mutual induction** between two coils is significantly influenced by their arrangement and physical configuration. The mutual inductance ($\mathrm{M}M$) depends on several factors, which determine how effectively the magnetic field produced by one coil links with the other. Here are the key factors:

1. **DISTANCE BETWEEN THE COILS**

Closer Proximity: When the coils are placed closer to each other, more magnetic flux from the primary coil links with the secondary coil, increasing mutual inductance.

Farther apart: If the coils are far apart, the magnetic flux linking the secondary coil decreases, reducing mutual inductance.

2 **Number of Turns in the Coils**

More Turns: Increasing the number of turns in both coils enhances the magnetic flux linkage, leading to higher mutual inductance.

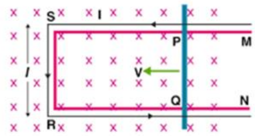
Fewer Turns: Fewer turns reduce the flux linkage and, consequently, the mutual inductance.

3 Presence of a Magnetic Core

Ferromagnetic Core: Placing a ferromagnetic material (like iron) inside or between the coils significantly increases the magnetic flux linkage, enhancing mutual inductance.

8. DEFINE MOTIONAL ELECTROMOTIVE FORCE (EMF)

Ans: When a conductor is moved in a magnetic field, a potential difference appears across its ends. This potential difference is known as a motional emf.



Motional emf is calculated using the formula emf = BLv, where B is the magnetic field strength, L is the length of the conductor, and v is its velocity.

9. Differentiate between motional emf and electromagnetic induction in terms of their fundamental principles.

ANS: Induced EMF and motional EMF are both concepts related to electromagnetic induction, but they arise from different scenarios:

INDUCED EMF

Definition: Induced EMF (Electromotive Force) refers to the voltage generated in a conductor due to a change in magnetic flux through the conductor over time.

Cause: It is primarily caused by a changing magnetic field.

Example: A common example is a coil of wire placed in a changing magnetic field, .

MOTIONAL EMF

Definition: Motional EMF is the voltage generated in a conductor when it moves through a magnetic field.

Cause: It occurs due to the motion of the conductor across magnetic field lines.

Example: An example of motional EMF is a straight wire moving perpendicularly through a uniform magnetic field.

10. Differentiate between AC (alternating current) and DC (direct current) in the context of long-distance power transmission.

Key Differences in Long-Distance Power Transmission

ASPECT	AC TRANSMISSION	DC TRANSMISSION
Voltage Transformation	Easy-to-use transformers.	Requires power electronic converters.
Power Losses	Higher due to resistive heating and skin effect.	Lower due to no skin effect or reactive losses.
Infrastructure	Well-established and widely used.	Requires specialized HVDC technology.
Cost	Lower initial cost.	Higher initial cost.
Synchronization	Requires frequency and phase synchronization.	No synchronization is needed.
Applications	Used in most power grids.	Used for very long-distance or undersea transmission.