

Class: 12th

Subject: Physics

Chapter 15: ELECTROMAGNETIC INDUCTION

🔥 Important MCQs (From Key Points)

1. An emf is set up in a conductor when:

(a) It is heated

(b) It moves across a magnetic field

(c) It is stretched

(d) It is cooled

2. The emf induced by the motion of a conductor across a magnetic field is called:

(a) Back emf

(b) Motional emf

(c) Self emf

(d) Mutual emf

3. Magnitude of motional emf in a rod of length L moving with velocity v across a magnetic field B is proportional to:

(a) $L + v + B$

(b) $L \times v \times B \times \sin\theta$

(c) $L / v / B$

(d) $B - v + L$

4. Faraday's law states that induced emf in a coil is:

- (a) Equal to the change in current
- (b) Equal to the negative of rate of change of magnetic flux** ✓
- (c) Proportional to coil resistance
- (d) Independent of magnetic flux

5. Lenz's law states that the induced current always:

- (a) Supports the change causing it
- (b) Opposes the change causing it** ✓
- (c) Has constant direction
- (d) Increases with temperature

6. The phenomenon in which a changing current in one coil induces emf in another coil is called:

- (a) Self induction

(b) Mutual induction

(c) Motional emf

(d) Back emf

7. One henry is defined as the mutual inductance of coils in which:

(a) 1 A change per second in primary induces 1 V in secondary

(b) 1 V change induces 1 A in primary

(c) 1 Ω resistance produces 1 A current

(d) 1 T magnetic field produces 1 V emf

8. The phenomenon in which a changing current in a coil induces emf in itself is called:

(a) Mutual induction

(b) Self induction

(c) Motional emf

(d) Lenz's effect

9. A current generator is a device which:

(a) Converts electrical energy into mechanical energy

(b) Converts mechanical energy into electrical energy ✓

(c) Stores energy in a coil

(d) Reduces current

10. The emf produced in a generator is:

(a) Constant

(b) Sinusoidal ✓

(c) Zero

(d) Direct current

11. In a generator, the emf varies as:

(a) $V = NAB \sin(\omega t)$ ✓

(b) $V = L/R$

(c) $V = IR$

(d) $V = 0$

12. A motor is a device which:

(a) Converts electrical energy into mechanical energy

(b) Converts mechanical energy into electrical energy

(c) Stores magnetic energy

(d) Produces alternating current only

13. The induced emf in a motor:

(a) Aids the applied voltage

(b) Opposes the applied voltage

(c) Is zero

(d) Is constant

14. The induced emf in a motor is called:

- (a) Motional emf
- (b) Self emf
- (c) Back emf
- (d) Mutual emf

15. Back emf in a motor:

- (a) Increases with speed of motor
- (b) Decreases with speed
- (c) Is independent of speed
- (d) Is equal to applied voltage always

 **Important MCQs:**

1. Induced emf is produced when a conductor:

- (a) Is heated

(b) Moves across a magnetic field

(c) Is kept stationary

(d) Is connected to a battery

2. The current produced by induced emf is called:

(a) Primary current

(b) Induced current

(c) Alternating current

(d) Static current



3. Electromagnetic induction was discovered by:

(a) Coulomb

(b) Einstein

(c) Faraday and Henry

(d) Ohm

4. When the loop is stationary in a magnetic field, the galvanometer shows:

- (a) Positive current
- (b) Alternating current
- (c) Zero current
- (d) Negative current

5. Induced emf increases when the loop is moved:

- (a) Slowly
- (b) Not moved
- (c) Randomly
- (d) Faster

6. Induced current can be increased by using:

- (a) A weaker magnet

(b) A coil with many turns

(c) A stationary coil

(d) A cold magnet

7. The product $I \times R$ remains constant and is equal to:

(a) Power

(b) Resistance

(c) Induced emf

(d) Current



8. The induced emf depends on the:

(a) Weight of conductor

(b) Rate of change of magnetic flux

(c) Temperature of coil

(d) Length of wire only

9. When a bar magnet is moved toward a coil, a:

- (a) Heating effect occurs
- (b) Current is induced**
- (c) Voltage becomes zero
- (d) Force is produced

10. Moving a bar magnet away from the coil produces current:

- (a) In opposite direction**
- (b) In same direction
- (c) Only once
- (d) Not at all

11. Decreasing the area of a coil in a magnetic field produces:

- (a) No change

(b) Induced current

(c) Heat only

(d) Constant voltage

12. Electric generators work on the principle of:

(a) Chemical induction

(b) Heat conduction

(c) Electromagnetic induction

(d) Light reflection

13. When a coil rotates in a constant magnetic field, magnetic flux:

(a) Remains constant

(b) Changes continuously

(c) Becomes zero

(d) Reverses permanently

14. Coil S shows induced current when current in coil P:

(a) Remains steady

(b) Becomes constant

(c) Changes

(d) Is absent

15. Closing the switch in coil P suddenly produces in coil S:

(a) Continuous current

(b) No current

(c) Momentary current

(d) Direct current

16. When the current in coil P becomes steady, induced current in coil S becomes:

- (a) Maximum
- (b) Zero
- (c) Reversed
- (d) Alternating

17. Induction between coils occurs due to changing:

- (a) Pressure
- (b) Temperature
- (c) Magnetic flux
- (d) Mass



18. Changing magnetic flux can be produced by:

- (a) Changing area of the coil
- (b) Keeping coil fixed
- (c) Keeping magnet stationary

(d) Using plastic wire

19. An electromagnet can induce current in a nearby coil by changing its:

(a) Colour

(b) Current

(c) Shape

(d) Density

20. When a distorted coil returns to its original shape, the induced current:

(a) Stops permanently

(b) Flows in opposite direction

(c) Melts the coil

(d) Increases indefinitely

21. The emf induced due to motion of a conductor in a magnetic field is called:

- (a) Static emf
- (b) Thermal emf
- (c) Motional emf
- (d) Chemical emf

22. When the rod is stationary on metal rails in a magnetic field, the galvanometer shows:

- (a) Maximum current
- (b) Alternating current
- (c) Zero current
- (d) Decreasing current

23. When the rod moves to the right with constant velocity in a magnetic field, current is produced due to:

- (a) Heating effect
- (b) Motion across magnetic field

(c) Change in temperature

(d) Resistance of rod

24. The magnetic force on a charge moving in a magnetic field is given by:

(a) $F = qE$

(b) $F = qvB \sin\theta$

(c) $F = mv^2/r$

(d) $F = q/B$

25. In motional emf, the angle between velocity v and magnetic field B is:

(a) 0°

(b) 30°

(c) 60°

(d) 90°

26. The electric field developed inside the moving rod at equilibrium is:

(a) $E = qv$

(b) $E = v^2B$

(c) $E = vB$ ✓

(d) $E = B/v$

27. The formula of motional emf induced in a rod of length L moving with velocity v in field B is:

(a) $\varepsilon = LB/v$

(b) $\varepsilon = v/(BL)$

(c) $\varepsilon = vBL \sin\theta$ ✓

(d) $\varepsilon = B/vL$

28. In the given diagram, induced current flows along path abcda. Therefore, the induced current is:

(a) Clockwise

(b) Anticlockwise

(c) Upward only

(d) Downward only

29. As induced current flows, charges reach end a and magnetic force moves them again to end b. Therefore, current:

(a) Stops immediately

(b) Reverses direction

(c) Continues to flow

(d) Becomes zero permanently

30. A rod of length L moves with velocity v perpendicular to magnetic field B . The emf induced will be:

(a) Zero

(b) Maximum possible value

(c) Minimum value

(d) Independent of velocity

31. Motional emf in a rod moving perpendicular to magnetic field is given by:

(a) $\varepsilon = v/B$

(b) $\varepsilon = B/v$

(c) $\varepsilon = -vBL$ ✓

(d) $\varepsilon = -B/L$

32. Magnetic flux increases when the rod moves because:

(a) Magnetic field changes

(b) Length of rod increases

(c) Area of loop increases ($\Delta A = L \Delta x$) ✓

(d) Resistance decreases

33. Faraday's law states that induced emf in a coil is equal to:

-
- (a) Rate of change of current
- (b) Negative rate of change of flux through coil ($-\Delta\Phi/\Delta t$)
- (c) Rate of change of resistance
- (d) The flux itself

34. If a coil has N turns, the induced emf becomes:

- (a) Half
- (b) Double
- (c) Independent of N
- (d) N times ($\epsilon = -N \Delta\Phi/\Delta t$)



35. The negative sign in Faraday's law indicates that:

- (a) Emf is always positive
- (b) Magnetic field is decreasing
- (c) Induced emf opposes the change in flux (Lenz's law)

(d) Flux is constant

36. Lenz's law states that the induced current always:

(a) Supports the cause producing it

(b) Opposes the cause producing it

(c) Flows clockwise only

(d) Flows anti-clockwise only

37. The negative sign in Faraday's law ($\epsilon = -N\Delta\Phi/\Delta t$) shows:

(a) Emf increases flux

(b) Emf decreases resistance

(c) Direction of induced emf opposes change in flux

(d) Magnetic field is constant

38. When the north pole of a magnet is moved toward a coil, the coil develops:

-
- (a) A south pole toward the magnet
- (b) A north pole toward the magnet
- (c) A neutral side
- (d) Zero magnetic field

39. The induced current in a coil produces a magnetic field that:

- (a) Helps the external magnetic field
- (b) Opposes the external magnetic field change
- (c) Is always clockwise
- (d) Is always zero

40. Lenz's law is based on which scientific principle?

- (a) Newton's law
- (b) Coulomb's law

(c) Law of conservation of energy ✓

(d) Hooke's law

41. If a magnet is pulled away from a coil, the coil will produce a pole that:

(a) Attracts the magnet

(b) Opposes the pulling by becoming a south pole toward the magnet side ✓

(c) Remains neutral

(d) Creates zero emf

42. In a generator, the emf varies as:

(a) $V = NAB \sin(\omega t)$ ✓

(b) $V = L/R$

(c) $V = IR$

(d) $V = 0$

43. To keep the rod moving with constant velocity in a magnetic field, we must apply:

(a) No force

(b) A force opposite and equal to magnetic force F (dragging force)

(c) A vertical downward force

(d) A force to increase acceleration

44. If the induced current supported the motion of the rod, it would:

(a) Obey conservation of energy

(b) Create unlimited energy (impossible)

(c) Decrease the emf

(d) Stop the rod immediately

45. Lenz's law is directly applicable for determining:

(a) Magnitude of current only

(b) Direction of induced current in a closed loop

(c) Length of rod

(d) Drift velocity

46. The phenomenon in which a changing current in one coil induces emf in another coil is called:

(a) Self induction

(b) Mutual induction

(c) Magnetic shielding

(d) Faraday effect



47. In mutual induction, the emf induced in the secondary coil is due to:

(a) Constant current in primary

(b) Changing flux linked with secondary coil

(c) Resistance of secondary coil

(d) Heating effect

48. The induced emf in secondary coil is given by:

(a) $\epsilon = -LI/t$

(b) $\epsilon = -N\Phi$

(c) $\epsilon = -M (\Delta I/\Delta t)$ ✓

(d) $\epsilon = IR$

49. The unit of mutual inductance (M) is:

(a) Tesla

(b) Weber

(c) Henry (H) ✓

(d) Joule

50. Mutual inductance depends on:

(a) Number of turns

-
- (b) Area of coils
 - (c) Distance between coils
 - (d) All of these

51. One henry is defined as:

- (a) 1 volt induced for 1 ampere change per minute
- (b) 1 volt induced when $\Delta I = 1$ A/s in primary coil
- (c) 1 ampere produced per volt
- (d) 1 weber constant flux

52. Self induced emf is produced when:

- (a) Flux changes due to another nearby coil
- (b) Current in the coil itself changes
- (c) Magnetic field is constant
- (d) Resistance decreases

53. The self induction (L) of a coil is given by:

(a) $L = \Phi/I$

(b) $L = N\Phi/I$

(c) $L = (N\Phi)/I$ ✓

(d) $L = IR$

54. The self induced emf formula is:

(a) $\varepsilon = -M (\Delta I/\Delta t)$

(b) $\varepsilon = -N (\Delta\Phi/\Delta t)$

(c) $\varepsilon = -L (\Delta I/\Delta t)$ ✓

(d) $\varepsilon = V/R$

55. Self induced emf always:

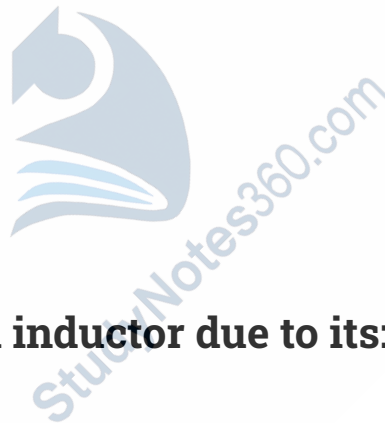
(a) Supports the change in current

(b) Opposes the change in current (back emf) ✓

-
- (c) Remains constant
- (d) Increases current rapidly

56. Energy stored in an inductor is given by:

- (a) $\frac{1}{2} C V^2$
- (b) $\frac{1}{2} L I^2$ ✓
- (c) $I V$
- (d) L / I



57. Energy is stored in an inductor due to its:

- (a) Electric field
- (b) Magnetic field ✓
- (c) Resistance
- (d) Capacitance

58. Work done by the battery in building current in an inductor becomes:

- (a) Heat
- (b) Electric charge
- (c) Magnetic potential energy in the inductor
- (d) Mechanical energy

59. When current in an inductor increases, the induced emf:

- (a) Aids the battery
- (b) Opposes the change (back emf)
- (c) Becomes zero
- (d) Acts randomly

60. The expression $U_m = \frac{1}{2} L I^2$ represents:

- (a) Power

(b) Total charge

(c) Magnetic energy stored in an inductor

(d) Mechanical energy

61. A generator converts:

(a) Electrical energy into mechanical energy

(b) Mechanical energy into electrical energy

(c) Heat into electrical energy

(d) Chemical energy into mechanical energy

62. The working principle of A.C. generator is:

(a) Coulomb's law

(b) Lenz's law

(c) Faraday's law of electromagnetic induction

(d) Joule's law

63. The purpose of slip rings in an A.C. generator is to:

- (a) Reverse current direction
- (b) Get alternating current from rotating coil**
- (c) Increase resistance
- (d) Stop the coil rotation

64. Induced emf in a rotating coil is maximum when:

- (a) Coil is parallel to magnetic field
- (b) Coil is perpendicular to magnetic field
- (c) $\sin(\omega t) = 1$ (maximum flux change)**
- (d) Angular speed is zero

65. The emf produced in a generator varies:

- (a) Linearly
- (b) Randomly

(c) Sinusoidally with time

(d) Exponentially

66. The maximum emf generated in an A.C. generator is:

(a) $E_0 = N * \omega * A * B$

(b) $E_0 = L * I^2$

(c) $E_0 = V / R$

(d) $E_0 = I * B * L$



67. In a D.C. generator, slip rings are replaced by:

(a) Brushes

(b) Split rings (commutator)

(c) Insulators

(d) Solenoids

68. The function of a commutator in a D.C. generator is to:

-
- (a) Convert D.C. to A.C.
 - (b) Keep output current in one direction only**
 - (c) Increase voltage
 - (d) Reduce magnetic field

69. The output of a simple D.C. generator is:

- (a) Pure D.C.
- (b) Zero
- (c) Pulsating D.C. (unidirectional)**
- (d) Alternating current

70. To reduce fluctuations in D.C. generator output:

- (a) Use one coil only
- (b) Use many coils on the armature**
- (c) Remove commutator

(d) Reduce magnetic field

71. Back motor effect in generators occurs because:

(a) Generator supplies current easily

(b) Magnetic field exerts counter torque on coil ✓

(c) Coil rotates without load

(d) Mechanical energy decreases

72. The larger the load connected to a generator:

(a) Less current is drawn

(b) More current is drawn ✓

(c) Current remains same

(d) Generator stops

73. A D.C. motor converts:

(a) Mechanical energy into electrical energy

(b) Electrical energy into mechanical energy

(c) Heat into mechanical energy

(d) Chemical energy into electrical energy

74. The torque in a D.C. motor depends upon:

(a) Current, magnetic field, coil area, number of turns

(b) Voltage only

(c) Resistance of coil only

(d) Mechanical load only



75. In a D.C. motor, commutator is used to:

(a) Reverse direction of current to maintain torque

(b) Increase voltage

(c) Reduce current

(d) Stop armature

76. Back emf in a motor is:

- (a) Same as applied voltage
- (b) Opposes the applied voltage
- (c) Always zero
- (d) Aids the applied voltage

77. The net current in a motor circuit is given by:

- (a) $V + E / R$
- (b) $V - E / R$
- (c) $E - V / R$
- (d) $V * E / R$

78. When a D.C. motor starts, back emf is:

- (a) Maximum
- (b) Zero

(c) Equal to applied voltage

(d) Negative

79. In a step-up transformer:

(a) Secondary voltage is less than primary

(b) Secondary voltage is greater than primary ✓

(c) Primary and secondary voltages are equal

(d) Secondary current is greater than primary

80. In a step-down transformer:

(a) Secondary voltage is greater than primary

(b) Secondary voltage is less than primary ✓

(c) Secondary current is less than primary

(d) Power is zero

81. Ideal transformer works on the principle of:

-
- (a) Self induction
- (b) Mutual induction
- (c) Lenz's law only
- (d) Ohm's law

82. In an ideal transformer, input power and output power are:

- (a) Unequal
- (b) Nearly equal
- (c) Zero
- (d) Infinite



83. Power loss in a transformer occurs due to:

- (a) Friction
- (b) Eddy currents and hysteresis

(c) Resistance only

(d) Voltage drop

84. Laminated core in a transformer reduces:

(a) Resistance

(b) Eddy current losses

(c) Hysteresis

(d) Magnetic flux



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85. Hysteresis loss in transformer is due to:

(a) Resistance of wires

(b) Energy spent in magnetizing and demagnetizing the core

(c) Current flow

(d) Friction in core

86. Transformer efficiency is defined as:

(a) Input power / Output power $\times 100$

(b) Output power / Input power $\times 100$ ✓

(c) Input voltage / Output voltage $\times 100$

(d) Output current / Input current $\times 100$

87. In a transformer, to reduce current loss during transmission:

(a) Use thicker wires only

(b) Increase voltage and reduce current ✓

(c) Decrease voltage

(d) Decrease number of turns

88. For maximum flux coupling in transformer:

(a) Coils should be far apart

(b) Coils should be wound on same core

(c) Coils should be insulated only

(d) Coils should be in parallel

89. Transformer is used to:

(a) Convert D.C. to A.C.

(b) Change magnitude of A.C. voltage

(c) Convert electrical energy to mechanical energy

(d) Reduce power

90. Step-up transformer is used in:

(a) Household voltage supply

(b) Long-distance power transmission

(c) Low voltage devices

(d) Battery charging

🔥 Important Short Questions (From Key Points)

1. What is an induced emf?

Answer:

👉 An induced emf is an electromotive force set up in a conductor when it moves across a magnetic field or when the magnetic flux through it changes.

2. Define motional emf.

Answer:

👉 Motional emf is the emf induced in a conductor due to its motion across a magnetic field.

3. How is the magnitude of motional emf in a rod calculated?

Answer:

👉 The magnitude of motional emf in a rod of length L moving with velocity v across a magnetic field B making an angle θ with it is given by $\text{emf} = vBL \sin \theta$.

4. State Faraday's law of electromagnetic induction.

Answer:

👉 Faraday's law states that the emf induced in a conducting coil of N loops is equal to the negative of the rate at which the magnetic flux through the coil is changing with time.

5. What does Lenz's law state?

Answer:

👉 Lenz's law states that the direction of the induced current is always such that it opposes the change which causes it.

6. What is mutual induction?

Answer:

👉 Mutual induction is the phenomenon in which a changing current in one coil induces an emf in a nearby coil.

7. Define one henry in terms of mutual inductance.

Answer:

👉 One henry is the mutual inductance of a pair of coils in which a change of current of one ampere per second in the

primary coil produces an induced emf of one volt in the secondary coil.

8. What is self induction?

Answer:

👉 Self induction is the phenomenon in which a changing current in a coil induces an emf in the same coil.

9. What is the function of a current generator?

Answer:

👉 A current generator is a device that converts mechanical energy into electrical energy.

10. What is back emf in a motor and why does it occur?

Answer:

👉 Back emf is the induced emf in a motor that opposes the applied voltage. It occurs because the rotating coil in the motor generates an emf that opposes the current, in accordance with Lenz's law.

💧 **Important Short Questions:**

1. What is an induced emf?

Answer:

👉 An emf set up in a conductor when it moves across a magnetic field is called an induced emf.

2. Define induced current.

Answer:

👉 The current that flows in a closed circuit due to induced emf is called induced current.

3. How can induced current be increased in a conductor loop?

Answer:

👉 Induced current can be increased by using a stronger magnetic field, moving the loop faster, or using a coil with many turns.

4. What causes an induced emf in a stationary loop when a magnet is moved?

Answer:

👉 Relative motion between the magnet and the loop changes the magnetic flux through the loop, producing an induced emf.

5. How is induced current produced when a bar magnet is moved towards a coil?

Answer:

👉 Moving the bar magnet changes the magnetic flux through the coil, producing an induced emf and hence an induced current.

6. What happens when the area of a coil in a constant magnetic field is changed?

Answer:

👉 Changing the area of the coil changes the magnetic flux, producing an induced emf and current. The current stops when the area stops changing.

7. How does rotation of a coil in a constant magnetic field produce an induced current?

Answer:

👉 Rotating the coil changes the magnetic flux through it continuously, producing an induced emf and current.

8. What is observed in a secondary coil when the switch of a primary coil is suddenly closed or opened?

Answer:

👉 A sudden change in current in the primary coil changes the magnetic flux, inducing a momentary current in the secondary coil.

9. How can an electromagnet be used to produce an induced current in a nearby coil?

Answer:

👉 Changing the current in the electromagnet changes the magnetic flux through the nearby coil, inducing a current in it.

10. What determines the magnitude of induced emf in a conductor?

Answer:

👉 The magnitude of induced emf depends on the rate of change of magnetic flux, the number of turns in the coil, and the strength of the magnetic field.

11. What is motional emf?

Answer:

👉 Motional emf is the emf induced in a conductor due to its motion across a magnetic field.

12. How does a moving conductor produce current in a closed loop?

Answer:

👉 When the ends of a moving conductor are connected by a wire to form a closed loop, the induced motional emf causes a current to flow through the loop.

13. How is the magnetic force on a moving charge in a conductor calculated?

Answer:

👉 The magnetic force on a charge q moving with velocity v in a magnetic field B is $F = qvB \sin\theta$.

14. What is the equilibrium condition in a moving conductor under magnetic field?

Answer:

👉 Equilibrium is reached when the magnetic force on charges is balanced by the electrostatic force, i.e., $qE_0 = qvB$ or $E_0 = vB$.

15. How is the magnitude of motional emf in a rod of length L calculated?

Answer:

👉 The magnitude of motional emf is given by $\Delta V = vBL \sin\theta$, where v is the velocity of the rod, B is the magnetic field strength, and θ is the angle between v and B .

16. What is Faraday's law of electromagnetic induction?

Answer:

👉 Faraday's law states that the average emf induced in a conducting coil of N loops is equal to the negative of the rate at which the magnetic flux through the coil is changing with time.

17. How is the induced emf in a coil related to the number of loops?

Answer:

👉 The induced emf in a coil is directly proportional to the number of loops. If a coil has N loops, the induced emf is N times that of a single loop.

18. What does the negative sign in Faraday's law indicate?

Answer:

👉 The negative sign indicates that the direction of the induced emf opposes the change in magnetic flux through the coil.

19. What is Lenz's law?

Answer:

👉 Lenz's law states that the direction of the induced current is always such that it opposes the change which causes the current.

20. To which phenomenon does Lenz's law directly apply?

Answer:

👉 Lenz's law directly applies to induced currents in closed conducting loops or coils.

21. How can Lenz's law be applied if the loop is not closed?

Answer:

👉 If the loop is not closed, we can imagine it as closed, and then use the direction of induced current to determine the direction of induced emf.

22. How does Lenz's law demonstrate the law of conservation of energy?

Answer:

👉 Lenz's law ensures that the induced current opposes the change that produces it, preventing the generation of energy from nothing, thus obeying the law of conservation of energy.

23. In the experiment with a moving rod in a magnetic field, why must an external force be applied to keep the rod moving at constant velocity?

Answer:

👉 The induced current produces a magnetic force opposing the rod's motion. An external force equal in magnitude but opposite in direction is required to keep the rod moving at constant velocity and supply energy for the induced current.

24. What is mutual induction?

Answer:

👉 Mutual induction is the phenomenon in which a changing current in one coil induces an emf in another nearby coil.

25. On what factors does the mutual inductance of two coils depend?

Answer:

👉 Mutual inductance depends on the number of turns of the coils, their area of cross-section, their closeness together, and the nature of the core material.

26. How is the emf induced in the secondary coil related to the rate of change of current in the primary coil?

Answer:

👉 The emf induced in the secondary coil is proportional to the time rate of change of current in the primary coil.

27. Define self induction.

Answer:

👉 Self induction is the phenomenon in which a changing current in a coil induces an emf in the same coil.

28. What is the self-inductance of a coil and what factors affect it?

Answer:

👉 Self-inductance (L) is the ratio of the induced emf to the rate of change of current in the coil. It depends on the number of turns of the coil, the area of cross-section, and the core material.

29. How is energy stored in an inductor?

Answer:

👉 Energy is stored in the magnetic field of an inductor when current flows through it.

30. Write the formula for energy stored in an inductor.

Answer:

👉 The energy stored in an inductor is $U_m = \frac{1}{2} * L * I^2$

31. How is the magnetic field inside a solenoid related to current?

Answer:

👉 The magnetic field inside a solenoid is $B = \mu_0 * n * I$, where n is the number of turns per unit length.

32. What is an alternating current (AC) generator?

Answer:

👉 An AC generator is a device that converts mechanical energy into alternating electrical energy by rotating a coil in a magnetic field.

33. What principle is the AC generator based on?

Answer:

👉 An AC generator works on the principle of Faraday's law of electromagnetic induction.

34. How is the induced emf in a rotating coil calculated?**Answer:**

👉 For a coil rotating in a magnetic field, the induced emf is $\epsilon = N \cdot \omega \cdot A \cdot B \cdot \sin(\omega \cdot t)$, where N is the number of turns, A is the area, B is the magnetic field, and ω is the angular velocity.

35. Why are slip rings used in an AC generator?**Answer:**

👉 Slip rings maintain continuous electrical contact between the rotating coil and the external circuit while allowing the coil to rotate freely.

36. What is a D.C. generator?**Answer:**

👉 A D.C. generator is similar to an AC generator but uses split rings (commutator) instead of slip rings to produce direct current.

37. What is the function of a commutator in a DC generator?

Answer:

👉 The commutator reverses the connection of the coil to the external circuit, keeping the output current in one direction.

38. How can fluctuations in the output of a DC generator be reduced?

Answer:

👉 Fluctuations are reduced by using multiple coils on the armature, each connected to separate commutators.

39. What is the maximum value of emf in a rotating coil?

Answer:

👉 The maximum emf occurs when $\sin(\omega * t) = 1$, and $\epsilon_{\max} = N * \omega * A * B$

40. Why is a DC generator preferred for running a DC motor instead of an AC generator?

Answer:

👉 A DC generator provides current in a single direction, which is necessary for the proper operation of DC motors.

💧 **Important long questions:**

🌟 **Q1. Explain the phenomenon of electromagnetic induction with the help of a straight conductor and a galvanometer.**

❖ **Answer:**

1. Introduction:

Electromagnetic induction is the phenomenon in which an emf (electromotive force) is generated in a conductor when it

experiences a change in magnetic flux. The resulting current (if the circuit is closed) is called the induced current.

2. Experimental Setup:

- Take a straight conductor (wire) and connect its ends to a sensitive galvanometer.
- This forms a closed circuit or loop without any external battery.
- Place the conductor in a magnetic field (e.g., between the poles of a permanent magnet).

3. Observation:

- **Initially**, when the conductor is at rest, the galvanometer shows no deflection, indicating no current flows.
- When the conductor is moved across the magnetic field, the galvanometer shows a deflection, indicating a current is induced.
- Reversing the direction of motion of the conductor reverses the direction of the induced current, which is reflected by the opposite deflection of the galvanometer.

4. Explanation:

- The motion of the conductor causes relative motion between the magnetic field and the conductor, which changes the magnetic flux linked with the loop.
- **According to Faraday's law**, a change in magnetic flux induces an emf in the conductor.
- **The induced emf** produces an induced current in the closed circuit.
- **The magnitude** of the current depends on the speed of the conductor, strength of the magnetic field, and resistance of the circuit.

Key Points:

- **Relative motion is essential:** either move the conductor or the magnet.
- Direction of induced current reverses when motion is reversed.
- The induced emf and current exist only while the flux is changing.

◆ Summary:

- Electromagnetic induction occurs due to relative motion between a conductor and a magnetic field.

-
- An emf is induced in the conductor, and if the circuit is closed, a current flows.
 - The direction of induced current is dependent on the direction of motion.
 - The phenomenon is the basis of generators and transformers.

✦ **Q2. Describe the methods of producing an induced current.**

❖ **Answer:**

Electromagnetic induction is the process of producing induced emf and current in a conductor due to a change in magnetic flux. There are several methods to produce an induced current:

1. Moving a conductor through a magnetic field:

- When a straight wire or conductor moves across a magnetic field, the magnetic flux linked with the conductor changes.
- According to Faraday's law, this change in flux induces an emf, and if the circuit is closed, a current flows.

- The direction of the induced current depends on the direction of motion of the conductor.

2. Changing the area of a coil:

- If a coil is placed in a constant magnetic field, changing its area alters the magnetic flux linked with it.
- Reducing the area of the coil produces an induced current in one direction, while increasing the area produces current in the opposite direction.
- This method demonstrates that any change in magnetic flux, not just motion of the conductor, induces current.

3. Rotating a coil in a magnetic field:

- Rotating a coil in a constant magnetic field continuously changes the flux through the coil.
- This is the basic principle of an electric generator, where mechanical rotation produces alternating current (AC).

4. Mutual induction:

- When two coils are placed close together, a changing current in one coil (primary) produces a changing magnetic flux in the surrounding space.

-
- This changing flux links with the second coil (secondary), inducing an emf in it.
 - This principle is used in transformers and other inductive devices.

5. Using an electromagnet:

- A stationary coil placed near an electromagnet can have a current induced if the current in the electromagnet changes.
- Changing the current changes the magnetic field, thereby altering the flux through the coil and producing an induced current.

◆ **Summary:**

- Induced current is produced whenever there is a change in magnetic flux through a conductor.
- It can be produced by motion of the conductor, changing coil area, rotation, mutual induction, or changing current in an electromagnet.
- The magnitude of the induced current depends on the rate of change of flux, strength of magnetic field, and number of turns in the coil.

★ Q3. What is motional emf? Explain its magnitude in a moving conductor.

❖ Answer:

Motional emf is the electromotive force induced in a conductor when it moves through a magnetic field. This is a type of induced emf caused by relative motion between the conductor and the magnetic field.

◆ Explanation with a moving conductor:

- Consider a straight conducting rod of length L moving with velocity v perpendicular to a uniform magnetic field B .
- The charges in the rod experience a magnetic force: $F = q \times v \times B$
- Positive charges are pushed to one end and negative charges to the opposite end, creating a potential difference across the rod.
- This potential difference is called motional emf.

◆ Magnitude of motional emf:

1. When the rod moves perpendicular to the magnetic field:

$$\varepsilon = B \times L \times v$$

2. When the rod moves at an angle θ to the magnetic field:

$$\varepsilon = B \times L \times v \times \sin\theta$$

Here:

- B = magnetic field strength (Tesla)
- L = length of the conductor (meters)
- v = velocity of the conductor (m/s)
- θ = angle between velocity vector and magnetic field

The induced emf drives a current if the conductor is part of a closed circuit.

◆ **Summary:**

- Motional emf is caused by motion of a conductor in a magnetic field.

- Its magnitude depends on the length, velocity, strength of the magnetic field, and angle of motion.
- It arises due to the magnetic force on moving charges, creating a potential difference across the conductor.

☀ **Q4. State and explain Faraday's law of electromagnetic induction.**

❖ **Answer:**

Faraday's Law of Electromagnetic Induction:

> "The emf induced in a coil of N turns is equal to the negative of the rate of change of magnetic flux through the coil."

Mathematical Form:

$$\varepsilon = -N \times (\Delta\Phi / \Delta t)$$

Where:

- ε = induced emf (volts)
- N = number of turns in the coil
- $\Delta\Phi$ = change in magnetic flux (weber)

-
- Δt = time interval in which the change occurs (seconds)

Explanation:

1. When the magnetic flux through a coil changes, an emf is induced in it.

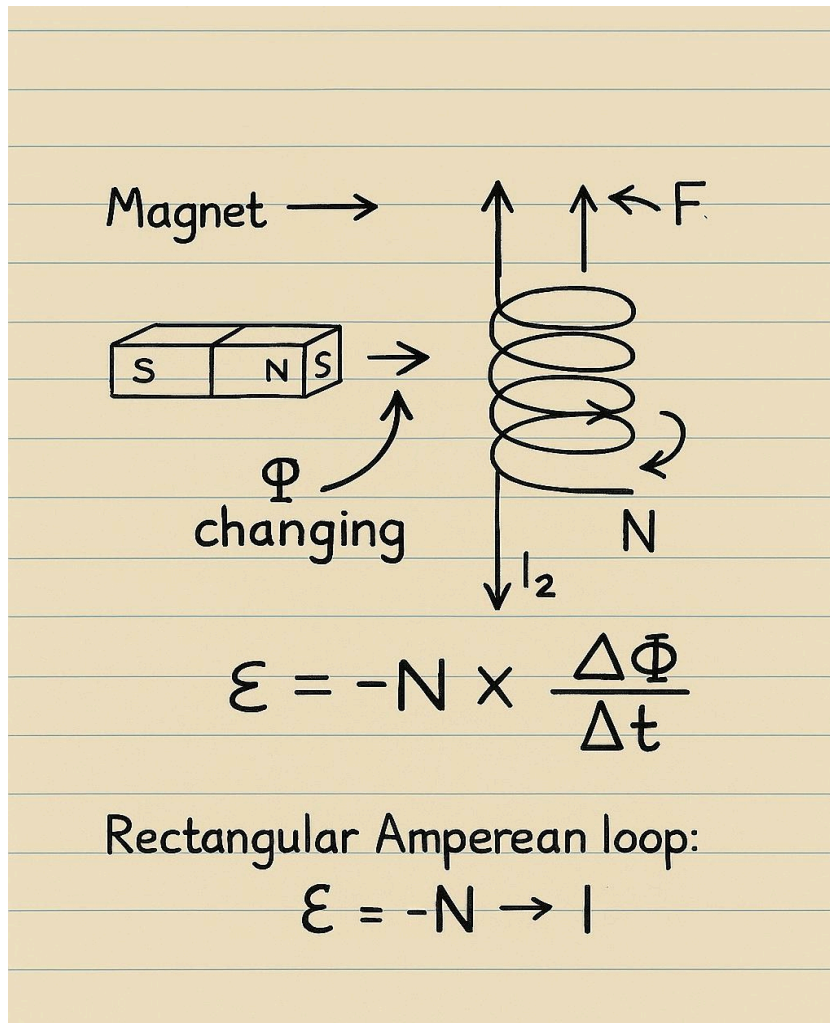
2. The negative sign indicates Lenz's Law: the induced emf always acts to oppose the change in magnetic flux that produces it.

3. Faraday's law is general; it applies to all types of induced emf, including motional emf, self-induction, and mutual induction.

4. The faster the magnetic flux changes, the greater the induced emf.

5. If the coil has multiple turns, the induced emf is proportional to the number of turns.

◆ Digram:



◆ **Summary:**

- Faraday's law links the change in magnetic flux to the induced emf.
- The law ensures the induced emf always opposes the cause of its induction.
- It forms the basic principle of generators, transformers, and inductors.

★ Q5. Explain Lenz's law and its importance in determining the direction of induced current.

❖ Answer:

Lenz's Law:

> "The direction of induced current is always such that it opposes the change which produces it."

Explanation:

1. Lenz's law helps determine the direction of induced current in a coil.
2. If a magnet is pushed towards a coil, the induced current generates a magnetic field that opposes the motion (repels the magnet).
3. If a magnet is pulled away from the coil, the induced current attracts the magnet, opposing its removal.

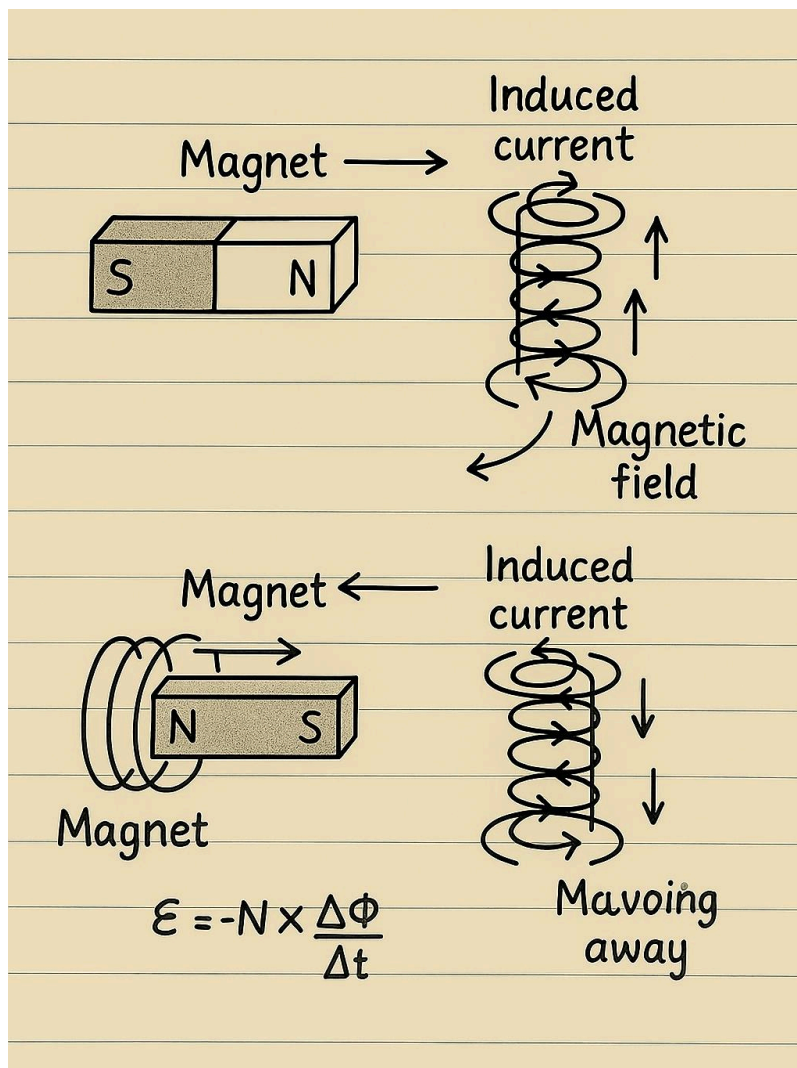
4. This behavior ensures that energy is conserved in electromagnetic induction, preventing perpetual motion.

5. The law is a practical application of the negative sign in Faraday's law ($\epsilon = -N \times \Delta\Phi/\Delta t$).

Importance:

- Determines the direction of induced current.
- Ensures conservation of energy in electromagnetic systems.
- Critical in understanding motors, generators, and transformers.

◆ **Digram:**



◆ **Summary:**

- Lenz's law states that induced current always opposes the change in magnetic flux.
- It explains the direction of induced current in any electromagnetic system.
- Ensures energy conservation in electrical devices.

☀ Q6. Explain mutual induction with the help of an experimental setup.

❖ Answer:

◆ **Experimental Setup:**

1. Place two coils near each other:

- **Primary coil (P):** Connected to a battery, rheostat, and a switch.
- **Secondary coil (S):** Connected to a galvanometer only.

2. Procedure:

- When the current in the primary coil is changed (by closing the switch or adjusting the rheostat), the magnetic flux around it changes.
- This changing magnetic flux links with the secondary coil.

As a result, an emf is induced in the secondary coil, which is detected by the galvanometer.

The induced current exists only when the primary current is changing, not when it is steady.

Mutual Inductance (M):

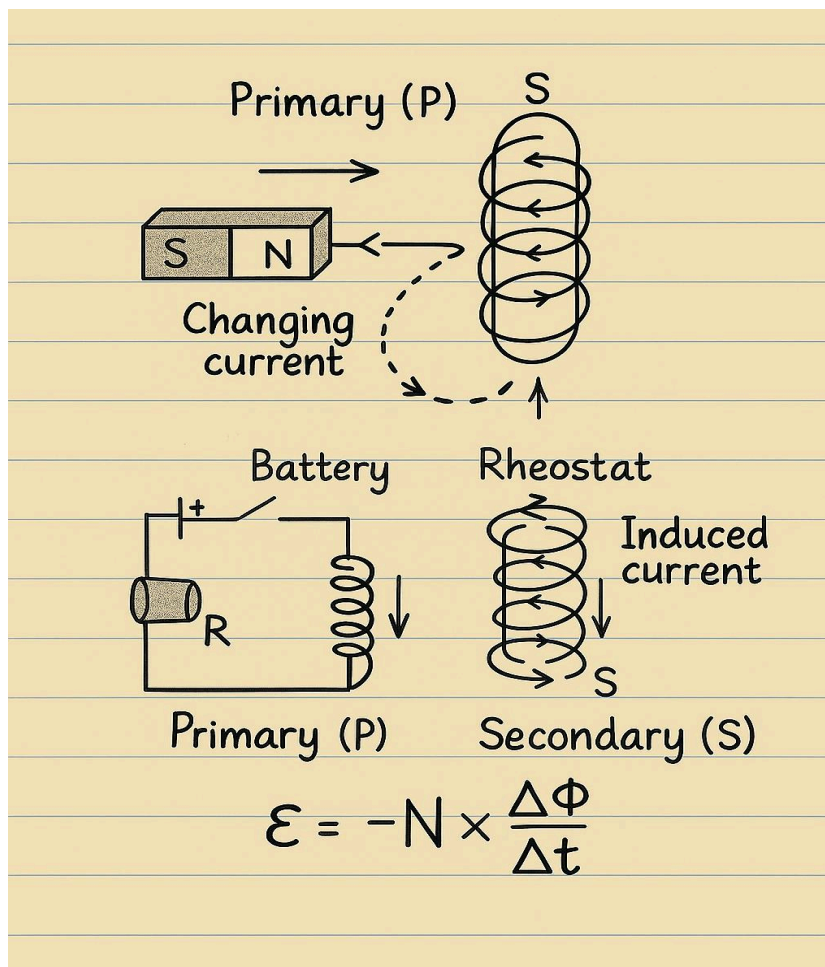
- Mutual inductance is the property of a pair of coils by which a change in current in one coil induces an emf in the other coil.

Factors affecting M:

1. Number of turns in both coils.
2. Cross-sectional area of the coils.
3. Distance between the coils.
4. Nature of the core material.

SI Unit: Henry (H) – One henry is the mutual inductance of a pair of coils in which a change of current of one ampere per second in the primary induces an emf of one volt in the secondary.

◆ Digram:



◆ Summary:

- Mutual induction is the process where a changing current in one coil induces emf in a nearby coil.
- It is the principle behind transformers, inductive sensors, and many electrical devices.
- The induced emf depends on the rate of change of current in the primary and the mutual inductance M .

☀ Q7. Explain self-induction and the concept of back emf.

❖ Answer:

Self-Induction:

- Self-induction is the phenomenon in which a changing current in a coil induces an emf in the same coil.
- When the current in a coil changes (increases or decreases), the magnetic flux linked with the coil also changes.

According to Faraday's law, this change in flux induces an emf in the coil itself.

Mathematical Expression:

Induced emf in a coil:

- $\varepsilon = -L \times (\Delta I / \Delta t)$
- L = Self-inductance of the coil (in Henry, H)
- $\Delta I / \Delta t$ = Rate of change of current

Negative sign indicates the induced emf opposes the change in current (Lenz's law).

Back EMF:

The emf induced in the coil due to self-induction is often called back emf.

- If the current increases, back emf opposes the rise.
- If the current decreases, back emf tries to maintain it, aiding the battery.

This property prevents sudden changes in current, making inductors useful in circuits.

Applications:

- Coils with self-inductance are called inductors.
- Widely used in electronic devices, transformers, AC circuits, and motor circuits.

◆ Summary:

-
- Self-induction occurs when a coil induces emf in itself due to a changing current.
 - Back emf always opposes the change in current, ensuring energy conservation.
 - Inductors utilize self-induction to regulate current in electrical circuits.

✨ **Q8. Explain the energy stored in an inductor.**

❖ **Answer:**

Concept:

- When a current I flows through an inductor of inductance L , a magnetic field is created around the coil.
- Work is required to increase the current because the inductor produces a back emf opposing the change in current.
- This work is stored as magnetic potential energy in the inductor.

Mathematical Expression:

Energy stored in an inductor:

$$U = \frac{1}{2} \times L \times I^2$$

- **U** = Energy stored (in joules, J)
- **L** = Inductance of the coil (in Henry, H)
- **I** = Current flowing through the inductor (in Amperes, A)

Explanation:

1. As the current rises, the inductor opposes the change (back emf).
2. The external source does work to overcome this opposition.
3. The work done in establishing the current is stored in the magnetic field of the inductor.
4. If the current decreases, the inductor releases this stored energy back into the circuit.

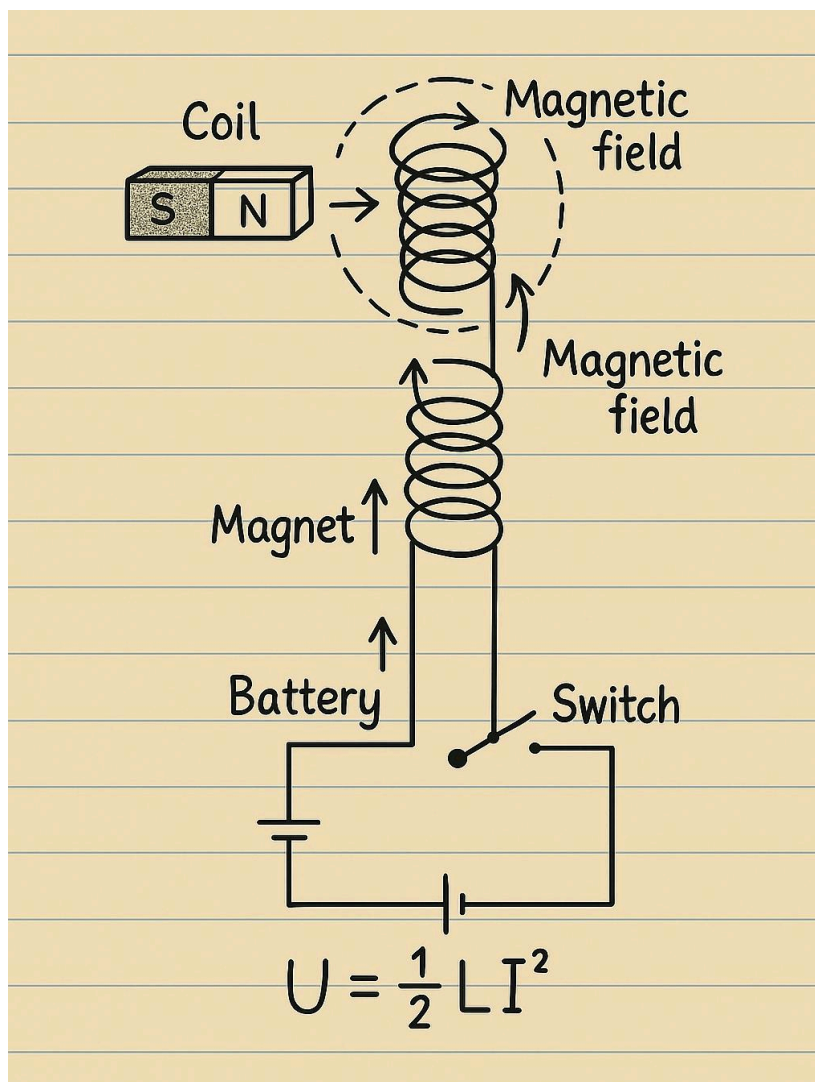
Comparison with Capacitor:

- A capacitor stores energy in its electric field.
- An inductor stores energy in its magnetic field.

Applications:

Inductors are used in transformers, electric circuits, filters, and energy storage systems.

◆ Digram:



◆ Summary:

- Energy in an inductor arises due to the magnetic field created by the current.

Formula: $U = \frac{1}{2} \times L \times I^2$.

Energy can be stored and released, making inductors essential in AC and DC circuits.

★ **Q9. Explain the working principle of an AC generator.**

❖ **Answer:**

Working Principle:

Based on Faraday's Law of Electromagnetic Induction:

> When a coil rotates in a magnetic field, the magnetic flux through it changes, inducing an emf.

- A rectangular coil of area A is rotated about its axis in a uniform magnetic field B .
- The ends of the coil are connected to slip rings which rotate with the coil.

-
- Carbon brushes maintain contact with the slip rings and connect the coil to an external circuit.
 - As the coil rotates, the magnetic flux changes continuously, producing a sinusoidal (alternating) emf.
 - Induced emf in two vertical sides of the coil adds up to give total emf in the circuit.

For a coil with N turns, the emf is:

- $\varepsilon = N \times \omega \times A \times B \times \sin(\omega t)$
- N = number of turns
- ω = angular velocity of rotation (rad/s)
- A = area of each turn of the coil
- B = magnetic field strength
- t = time

Explanation:

1. As the coil rotates, the angle between the magnetic field and the normal to the coil changes.
2. This changes the magnetic flux through the coil continuously.

3. According to Faraday's Law, this changing flux induces an emf.

4. The slip rings ensure that the output current is alternating, as the coil sides periodically reverse direction relative to the magnetic field.

Applications:

- Used in power stations to produce electricity.
- Supplies alternating current (AC) to homes and industries.

◆ Summary:

- AC generator converts mechanical energy into electrical energy.
- Rotation of coil in the magnetic field changes flux → induces emf → AC output.
- Output emf is sinusoidal and depends on N , A , B , and rotation speed.

★ Q10. Explain the working of a DC generator and the role of a commutator.

❖ Answer:**Working Principle:**

- A DC generator is similar in construction to an AC generator: a coil rotates in a magnetic field to produce an emf.
- The main difference is that slip rings are replaced by a split-ring commutator.
- Split-ring commutator reverses the coil's connection to the external circuit every half rotation.
- This ensures that the output current always flows in the same direction, producing direct current (DC).

Explanation:

1. As the coil rotates in the magnetic field, the magnetic flux changes, inducing emf.
2. Without a commutator, the current would reverse every half turn (AC).

3. The split-ring commutator flips the connections of the coil to the external circuit at the appropriate instant, keeping the current unidirectional.

4. Using multiple coils and commutators, the generator reduces fluctuations in output, making it nearly constant DC.

Applications:

Powers DC motors, battery charging, and electronic devices requiring DC supply.

◆ Summary:

- A DC generator converts mechanical energy into electrical energy.
- The commutator ensures unidirectional current by reversing connections every half turn.
- Multiple coils help smooth the output for practical DC use.

Exercise Questions:

☀ Q15.1 Does the induced emf in a circuit depend on the resistance of the circuit? Does the induced current depend on the resistance of the circuit?

❖ **Answer:**

- **The induced emf** in a circuit does not depend on the resistance of the circuit.
- It **depends only** on the **rate** of change of magnetic flux linked with the circuit.
- If the **magnetic flux** changes at the same rate, the induced emf remains constant even if the resistance is changed.
- **However**, the induced current does depend on the resistance of the circuit.
- **According to Ohm's law**, the induced current is equal to induced emf divided by resistance.
- An **increase in resistance** decreases the **induced current**, while a decrease in resistance increases the induced current.

◆ **Summary:**

- Induced emf → independent of resistance

- Induced current → depends on resistance

✦ Q15.2 A square loop of wire is moving through a uniform magnetic field. The normal to the loop is oriented parallel to the magnetic field. Is an emf induced in the loop? Give a reason.

❖ **Answer:**

No, no emf is induced in the loop.

This is because there is no change in magnetic flux through the loop. When the normal to the loop is parallel to the magnetic field, the magnetic field remains perpendicular to the plane of the loop and stays constant during motion. Since magnetic flux does not change, no emf is produced.

According to Faraday's law, induced emf is produced only when magnetic flux changes with time.

◆ **Summary:**

- Magnetic flux remains constant
- No change in flux means no induced emf
- Motion of the loop alone does not induce emf

☀️ Q15.3 A light metallic ring is released from above into a vertical bar magnet. Viewed from above, does the current flow clockwise or anticlockwise in the ring?

❖ **Answer:**

👉 The induced current flows anticlockwise (when viewed from above).

Reason:

As the ring falls towards the magnet, the magnetic flux through the ring increases. According to Lenz's law, the induced current flows in such a direction that it opposes the increase in magnetic flux.

To oppose this change, the ring produces a magnetic field that repels the magnet, which requires the current to be anticlockwise when seen from above.

◆ **Summary:**

- Ring moves towards magnet → flux increases

- Induced current opposes the increase in flux
- Direction of current (from above): anticlockwise

☀️ Q15.4 What is the direction of the current through resistor R in Fig. Q.15.4 when switch S is:

(a) When switch S is closed

👉 Current flows through resistor R in such a direction that it opposes the increase of magnetic flux.

Explanation:

When the switch is closed, current in the circuit starts increasing. Due to this increase, magnetic flux linked with the loop increases. According to Lenz's law, the induced current flows in a direction that opposes this increase.

(b) When switch S is opened

👉 Current flows through resistor R in the opposite direction to that in part (a).

Explanation:

When the switch is opened, current in the circuit decreases and magnetic flux decreases. The induced current now flows in such a direction that it opposes the decrease in flux, hence its direction reverses.

◆ **Summary:**

- **Switch closed:** Induced current opposes increasing flux
- **Switch opened:** Induced current opposes decreasing flux
- Direction of current through resistor reverses in the two cases

🌟 **Q15.5 Does the induced emf always act to decrease the magnetic flux through a circuit?**

❖ **Answer:**

👉 No, the induced emf does not always act to decrease the magnetic flux.

Explanation:

-
- According to Lenz's law, the induced emf always acts to oppose the change in magnetic flux, not the flux itself.
 - If the magnetic flux increases, the induced emf acts to reduce the increase.
 - If the magnetic flux decreases, the induced emf acts to increase the flux.

Thus, the induced emf may either oppose an increase or oppose a decrease in magnetic flux, depending on the situation.

◆ **Summary:**

- Induced emf opposes change in flux, not flux itself
- It can act to reduce increasing flux or support decreasing flux
- This ensures conservation of energy

★ **Q15.6: When the switch in the circuit is closed, a current is established in the coil and the metal ring jumps upward. Why? What happens if the battery polarity is reversed?**

❖ **Answer:**

Explanation:

1. When the switch is closed, current starts flowing through the coil.
2. The changing current produces a changing magnetic flux through the metal ring.
3. By Faraday's law, an emf is induced in the ring.
4. According to Lenz's law, the induced current in the ring flows in a direction to oppose the change in flux.
5. The interaction between the coil's magnetic field and the induced magnetic field of the ring produces a repulsive force, making the ring jump upward.

If the battery polarity is reversed:

- The direction of the current in the coil reverses.
- The induced current in the ring also reverses direction.
- The ring will still jump upward, but the polarity of magnetic fields is reversed.

◆ Summary:

- The ring jumps due to repulsion between coil and induced ring fields.
- Reversing battery polarity reverses magnetic fields but the upward motion of the ring remains.

★ Q15.7: A coil of wire lies in the xy -plane with a magnetic field along the y -axis. Around which axis should the coil be rotated to generate emf and current?

❖ Answer:**Explanation:**

1. Magnetic flux through the coil depends on the component of the magnetic field perpendicular to the plane of the coil.
2. The coil is in the xy -plane and the magnetic field is along the y -axis.

3. To change the magnetic flux through the coil, it must rotate so that the angle between the coil's normal and the magnetic field changes.

4. Rotating the coil about the x-axis or z-axis will change the flux through the coil.

- **Rotation about y-axis:** Flux does not change → No induced emf.

5. According to Faraday's law, a changing flux induces an emf and consequently a current.

◆ **Summary:**

- Rotate the coil about the x-axis or z-axis to generate emf and current.
- Rotation about the y-axis will not generate emf.

★ **Q15.8: How would you position a flat loop of wire in a changing magnetic field so that there is no emf induced in the loop?**

❖ **Answer:**

Explanation:

1. According to Faraday's law of electromagnetic induction, the emf induced in a loop is proportional to the rate of change of magnetic flux through it.
2. Magnetic flux depends on the component of the magnetic field perpendicular to the plane of the loop.
3. To ensure no emf is induced, the magnetic flux through the loop must remain constant or zero.
4. This can be achieved by placing the plane of the loop parallel to the magnetic field lines, so that the magnetic field passes along the plane rather than through it.
5. In this position, even if the magnetic field changes in magnitude, the perpendicular component of flux is zero, resulting in no induced emf or current.

◆ **Summary:**

- Position the loop parallel to the magnetic field.
- No change in magnetic flux through the loop → No induced emf.

This principle is used in experiments to control or prevent induced currents.

★ Q15.9: In a certain region the Earth's magnetic field points vertically down. When a plane flies due north, which wingtip is positively charged?

❖ **Answer:**

Explanation:

When a conductor (here, the plane's wings act as conductors) moves through a magnetic field, a motional emf is produced. This causes separation of charges along the conductor. This is the same principle as in Faraday's electromagnetic induction.

1. Given:

- Magnetic field (B) → vertically downward

-
- Velocity of plane (v) \rightarrow due north
 - Wings of the plane \rightarrow act as horizontal conductors

2. Use the Right-Hand Rule for positive charges:

- Point thumb in the direction of the velocity (north)
- Point fingers in the direction of magnetic field (downward)
- The palm direction gives the force on positive charges

3. Result:

- Positive charges move toward the right wingtip
- Negative charges accumulate on the left wingtip

◆ Summary:

The right wingtip of the plane is positively charged, the left wingtip is negatively charged.

This occurs because the motional emf acts on the free charges in the plane's wings due to its motion through the Earth's magnetic field.

☀ Q15.10: Show that ε (emf) and $\Delta\Phi/\Delta t$ have the same units

❖ **Answer:**

Given: Faraday's Law:

$$\varepsilon = -N \times (\Delta\Phi / \Delta t)$$

We need to show that the units of emf (ε) are the same as the units of $\Delta\Phi / \Delta t$.

Step 1: Unit of emf (ε)

Emf is measured in volts (V).

- 1 volt = 1 joule per coulomb (J/C)
- 1 joule = 1 kg·m²/s²
- 1 coulomb = 1 A·s

So,

$$\text{Volt (V)} = (\text{kg}\cdot\text{m}^2/\text{s}^2) / (\text{A}\cdot\text{s}) = \text{kg}\cdot\text{m}^2 / (\text{A}\cdot\text{s}^3)$$

Step 2: Unit of $\Delta\Phi / \Delta t$

Magnetic flux $\Phi = B \times A$

- B (magnetic field) in tesla (T)
- A (area) in m^2
- 1 tesla (T) = $1 \text{ kg} / (\text{A} \cdot \text{s}^2)$

So, flux Φ :

$$\Phi = B \times A = (\text{kg} / (\text{A} \cdot \text{s}^2)) \times \text{m}^2 = \text{kg} \cdot \text{m}^2 / (\text{A} \cdot \text{s}^2)$$

$$\Delta\Phi / \Delta t = (\text{change in flux}) / \text{time} = (\text{kg} \cdot \text{m}^2 / (\text{A} \cdot \text{s}^2)) / \text{s} = \text{kg} \cdot \text{m}^2 / (\text{A} \cdot \text{s}^3)$$

Step 3: Compare units

- Unit of $\varepsilon = \text{kg} \cdot \text{m}^2 / (\text{A} \cdot \text{s}^3)$
- Unit of $\Delta\Phi / \Delta t = \text{kg} \cdot \text{m}^2 / (\text{A} \cdot \text{s}^3)$

◆ Summary:

- Faraday's law is dimensionally consistent.

-
- Both emf and $\Delta\Phi/\Delta t$ have the same units: $\text{kg}\cdot\text{m}^2 / (\text{A}\cdot\text{s}^3)$

☀ Q15.11: Does an electric motor act as a generator when in use?

❖ **Answer:**

Yes, an electric motor also acts as a generator when it is running.

Explanation:

1. When a motor rotates, its coil cuts through magnetic lines of flux.
2. According to Faraday's law, this motion induces an emf in the coil itself.
3. **This induced emf is called a back emf because:**
 - It opposes the applied voltage of the motor (Lenz's Law).
 - It reduces the net voltage across the motor, controlling the current.

4. Consequence:

- The motor draws less current when running at normal speed.
- Back emf protects the motor from drawing excessive current, which could overheat or damage it.
- When the motor is starting (speed low), back emf is small → current is high, providing initial torque.

◆ Summary:

- Every running electric motor also acts as a generator, producing back emf.
- Back emf opposes applied voltage, regulates current, and protects the motor.

★ Q15.12: Can a D.C. motor be turned into a D.C. generator?

❖ Answer:

Yes, a D.C. motor can be turned into a D.C. generator with minor modifications.

Explanation:

1. Both D.C motors and generators have similar construction:

- Armature (rotating coil)
- Magnetic field (stator)
- Commutator and brushes

2. To convert a D.C motor into a generator:

- Supply mechanical energy to rotate the motor shaft (instead of electrical energy).
- Ensure brushes and commutator connections allow current to flow out of the machine.
- In most cases, no major internal changes are needed.

3. Working principle:

- When the shaft is rotated, the armature cuts magnetic lines of flux.
- According to Faraday's law, an emf is induced.
- The commutator ensures the output is unidirectional, giving D.C output.

◆ **Summary:**

- A D.C motor can function as a D.C generator.
- Mechanical rotation replaces electrical input.
- Output voltage is produced according to Faraday's law.

★ **Q15.13: Is it possible to change both the area of the loop and the magnetic field passing through the loop and still not have an induced emf in the loop?**

❖ **Answer:**

Yes, it is possible if the rate of change of magnetic flux through the loop is zero.

Explanation:

1. The induced emf in a loop is given by Faraday's law:

$$\varepsilon = - \Delta\Phi / \Delta t$$

$\Phi = B \times A \times \cos\theta$, where B is magnetic field, A is area, θ is the angle between B and the normal to the loop.

2. If both B and A are changing simultaneously, but the product $B \times A \times \cos\theta$ remains constant, then:

$$\Delta\Phi / \Delta t = 0$$

⇒ No induced emf appears in the loop.

3. This happens because emf depends on the rate of change of flux, not on B or A individually.

◆ **Summary:**

- Changing B or A individually usually induces emf.
- Simultaneous changes can cancel each other if flux remains constant.
- No induced current flows if $\Delta\Phi / \Delta t = 0$.

☀ **Q15.14: Can an electric motor be used to drive an electric generator with the output from the generator being used to operate the motor?**

❖ **Answer:**

No, a motor cannot continuously drive a generator to power itself.

Explanation:

1. When a motor runs, it converts electrical energy into mechanical energy.

2. If the motor drives a generator, the generator converts mechanical energy back into electrical energy.

3. Energy losses occur due to:

- Resistance in wires
- Friction in bearings
- Magnetic losses in cores

4. As a result, the electrical energy produced by the generator is always less than the energy consumed by the motor.

5. Therefore, the system cannot sustain itself indefinitely – it cannot become a perpetual motion machine.

◆ Summary:

A motor and generator can be connected, but the generator cannot fully power the motor that drives it.

- Energy losses prevent perpetual operation.
- This is consistent with the law of conservation of energy.

★ Q15.15: A suspended magnet is oscillating freely in a horizontal plane. The oscillations are strongly damped when a metal plate is placed under the magnet. Explain why this occurs?

❖ Answer:

The damping occurs due to induced currents (eddy currents) in the metal plate that oppose the motion of the magnet.

Explanation:

1. As the magnet oscillates, the magnetic flux through the nearby metal plate changes continuously.

2. According to Faraday's Law, a changing magnetic flux induces currents in the conducting metal plate.
3. These induced currents are called eddy currents.
4. **By Lenz's Law**, the eddy currents produce a magnetic field that opposes the motion of the magnet.
5. This opposing force extracts kinetic energy from the oscillating magnet and converts it into heat in the metal plate.
6. **As a result**, the amplitude of oscillations decreases rapidly – the oscillations are strongly damped.

◆ **Summary:**

- Damping is caused by eddy currents induced in the metal plate.
- The opposing magnetic field from the eddy currents reduces the magnet's kinetic energy.
- Energy is dissipated as heat, leading to rapid decrease in oscillation amplitude.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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