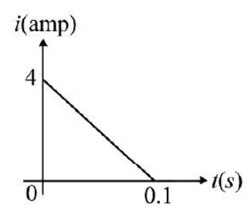
6 Electromagnetic Induction

Multiple Choice Questions (MCQs)

DIRECTIONS : *This section contains multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which only one is correct.*

1. In a coil of resistance 10 Ω, the induced current developed by changing magnetic flux through it, is shown in figure as a function of time. The magnitude of change in flux through the coil in weber is



(a) 8 (b) 2 (c) 6 (d) 4

2. Whenever the magnetic flux linked with a coil changes, an induced e.m.f.is produced in the circuit. The e.m.f. lasts

I. for a short time

II. for a long time

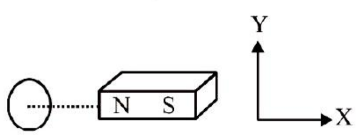
III. so long as the change in flux takes place

The true/false statement(s) is/are

(a) T, T, F (b) F, T, T

(c) T, F, T (d) F, F, T

3. Consider coil and magnet



Current is induced in coil when

I. coil and magnet both are at rest.

II. coil is at rest and magnet moves along x.

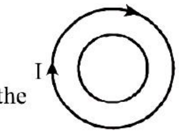
III. magnet is at rest and coil moves along x.

Then true/false statements are

(a) T, F, F (b) T, T, F

(c) F, F, T (d) F, T, T

4. Two different wire loops are concentric and lie in the same plane. The current in the outer loop (I) is clockwise and increases with time. The induced current i in the inner loop______.



(a) is clockwise

(b) is zero

(c) is counter clockwise

(d) has a direction that depends on the ratio of the loop radii.

5. According to Faraday's law of electromagnetic induction

I. The induced emf is not in the direction opposing the change in magnetic flux.

II. The relative motion between the coil and magnet produces change in magnetic flux.

III. Only the magnet should be moved towards coil.

The true/false statement(s) are

(a) T,T,F (b) F,T,F

(c) F,F,T (d) F,T,T

6. A cylindrical bar magnet is kept along the axis a circular coil. If the magnet is rotated about its axis, then ________ in the coil.

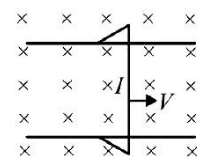
(a) a current will be induced

(b) no current will be induced

(c) only an e.m.f. will induced

(d) an e.m.f and a current both will be induced

7. The figure shows a wire sliding on two parallel conducting rails placed at a separation l. A magnetic field B exists in a direction perpendicular to the plane of the rails. The force required to keep the wire moving at a constant velocity v will be



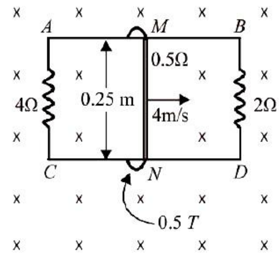
(a) evB

(b) $\dfrac{\mu_0 Bv}{4\pi l}$

(c) Blv

(d) zero

8. A sliding wire of length 0.25 m and having a resistance of 0.5 Ω moves along conducting guiding rails AB and CD with a uniform speed of 4 m/s. A magnetic field of 0.5 T exists normal to the plane of $ABCD$ directed into the page. The guides are short -circuited with resistances of 4 and 2 Ω as shown. The current through the sliding wire is :



(a) 0.27 A (b) 0.37 A
(c) 1.0 A (d) 0.72 A

9. A straight conductor of length 2m moves at a speed of 20 m/s. When the conductor makes an angle of 30° with the direction of magnetic field of induction of 0.1 wbm^2 then induced emf

(a) 4V (b) 3V (c) IV (d) 2V

10. A wire of length 1m is perpendicular to x-y plane. It is moved with velocity $\vec{v} = (3\hat{i} + 3\hat{j} + 2\hat{k})$ m/s through a region of uniform induction $\vec{B} = (\hat{i} + 2\hat{j})$ T. The potential difference between the ends of the wire is

(a) IV (b) 1.5V (c) 2.5V (d) 3V

11. A circular wire of radius r rotates about its own axis with angular speed ω in a magnetic field B perpendicular to its plane, then the induced e.m.f. is

(a) $\frac{1}{2}Br\omega^2$ (b) $Br\omega^2$ (c) $2Br\omega^2$ (d) zero

12. If the rate of change of current of 2A/s induces an emf of 10 mV in a solenoid, the self-inductance of the solenoid is

(a) 5×10^{-3} Henry (b) 8×10^{-3} Henry
(c) 25×10^{-6} Henry (d) 55×10^{-12} Henry

13. If N is the number of turns in a coil, the value of self inductance varies as

(a) N^0 (b) N (c) N^2 (d) N^{-2}

14. Two coils of self inductances 2 mH and 8 mH are placed so close together that the effective flux in one coil is completely linked with the other. The mutual inductance between these coils is

(a) 6mH (b) 4mH
(c) 16mH (d) 10mH

15. Two solenoids of same cross-sectional area have their lengths and number of turns in ratio of 1 : 2 both. The ratio of self-inductance of two solenoids is

(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) 1 : 4

16. A small square loop of wire of side ℓ is placed inside a large square loop of side L (L >> ℓ). The loop are coplanar and their centres coincide. The mutual inductance of the system is proportional is

(a) $\frac{\ell}{L}$ (b) $\frac{\ell^2}{L}$ (c) $\frac{L}{\ell}$ (d) $\frac{L^2}{\ell}$s

17. A square of side L metres lies in the xy-plane in a region, where the magnetic field is given by $B = B_0(2\hat{i} + 3\hat{j} + 4\hat{k})$ T, where B_0 is constant. The magnitude of flux passing through the square is

(a) $2B_0L^2$Wb (b) $3B_0L^2$Wb
(c) $4B_0L^2$Wb (d) $\sqrt{29}B_0L^2$Wb

18. A loop, made of straight edges has six corners at A (0, 0, 0), B (L, 0, 0), C(L, L, 0), D (0, L, 0), E(0, L, L) and F (0, 0, L). A magnetic field $B = B_0(\hat{i} + \hat{k})$ T is present in the region. The flux passing through the loop ABCDEFA (in that order) is

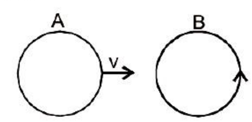
(a) B_0L^2 Wb (b) $2B_0L^2$Wb
(c) $\sqrt{2}B_0L^2$ Wb (d) $4B_0L^2$Wb

19. A cylindrical bar magnet is rotated about its axis. A wire is connected from the axis and is made to touch the cylindrical surface through a contact. Then,

(a) a direct current flows in the ammeter A
(b) no current flows through the ammeter A
(c) an alternating sinusoidal current flows through the ammeter A with a time period $T = \frac{2\pi}{\omega}$
(d) a time varying non-sinusoidal current flows through the ammeter A.

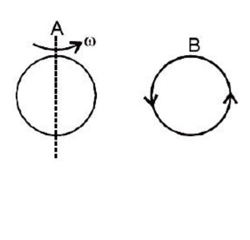
20. There are two coils A and B as shown in figure a current starts flowing in B as shown, when A is moved towards B and stops when A stops moving. The current in A is counter clockwise. B is kept stationary when A moves. We can infer that

(a) there is a constant current in the clockwise direction in A
(b) there is a varying current in A
(c) there is no current in A
(d) there is a constant current in the counter clockwise direction in A



21. Same as problem 4 except the coil A is made to rotate about a vertical axis (figure). No current flows in B if A is at rest. The current in coil A, when the current in B (at t = 0) is counter-clockwise and the coil A is as shown at this instant, t = 0, is

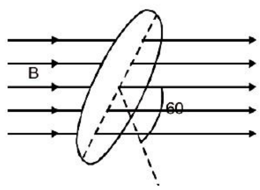
(a) constant current clockwise
(b) varying current clockwise
(c) varying current counter clockwise
(d) constant current counter clockwise



22. The self inductance L of a solenoid of length l and area of cross-section A, with a fixed number of turns N increases as

(a) l and A increase
(b) l decreases and A increases
(c) l increases and A decreases
(d) both l and A decrease

23. Fig shown below represents an area A = 0.5 m^2 situated in a uniform magnetic field B = 2.0 weber/m^2 and making an angle of 60° with respect to magnetic field.



The value of the magnetic flux through the area would be equal to

(a) 2.0 weber (b) $\sqrt{3}$ weber
(c) $\sqrt{3}/2$ weber (d) 0.5 weber

24. A conductor of length 0.4 m is moving with a speed of 7 m/s perpendicular to a magnetic field of intensity 0.9 Wb/m^2. The induced e.m.f. across the conductor is

(a) 1.26 V (b) 2.52 V
(c) 5.04 V (d) 25.2 V

25. A coil is wound on a frame of rectangular cross-section. If all the linear dimensions of the frame are increased by a factor 2 and the number of turns per unit length of the coil remains the same, self-inductance of the coil increases by a factor of

(a) 4 (b) 8
(c) 12 (d) 16

26. In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is

(a) N.A.B.R.ω (b) N.A.B.
(c) N.A.B.R. (d) N.A.B.ω

27. The total charge induced in a conducting loop when it is moved in a magnetic field depends on

(a) the rate of change of magnetic flux
(b) initial magnetic flux only
(c) the total change in magnetic flux
(d) final magnetic flux only

28. According to Faraday's law of electromagnetic induction

(a) the direction of induced force is such that it opposes the cause producing it
(b) the magnitude of induced e.m.f. produced in a coil is directly proportional to the rate of change of magnetic flux
(c) the direction of induced e.m.f. is such that it opposes the cause producing it
(d) None of these

29. Lenz's law gives

(a) the magnitude of the induced e.m.f.
(b) the direction of the induced current
(c) both the magnitude and direction of the induced current
(d) the magnitude of the induced current

30. Induced emf in the coil depends upon

(a) conductivity of coil
(b) amount of flux
(c) rate of change of linked flux
(d) resistance of coil

31. An inductor may store energy in

(a) its electric field
(b) its coils
(c) its magnetic field
(d) both in electric and magnetic fields

32. A varying magnetic flux linking a coil is given by $\phi = xt^2$. If at a time t = 3s, the emf induced is 9V, then value of x is

(a) 0.66 Wb/s^2 (b) 1.5 Wb/s^2
(c) – 0.66 Wb/s^2 (d) –1.5 Wb/s^2

33. The magnetic flux (in weber) linked with a coil of resistance 10 Ω is varying with respect to time t as $\phi = 4t^2 + 2t + 1$. Then the current in the coil at time t = 1 second is

(a) 0.5 A (b) 2 A (c) 1.5 A (d) 1 A

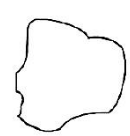
34. A rectangular coil of 100 turns and size 0.1 m × 0.05 m is placed perpendicular to a magnetic field of 0.1 T. The induced e.m.f. when the field drops to 0.05 T in 0.05s is

(a) 0.5 V (b) 1.0 V (c) 1.5 V (d) 2.0 V

35. A magnetic field of 2×10^{-2} T acts at right angles to a coil of area 100 cm^2, with 50 turns. The average e.m.f. induced in the coil is 0.1 V, when it is removed from the field in t sec. The value of t is

(a) 10 s (b) 0.1 s (c) 0.01 s (d) 1 s

36. As a result of change in the magnetic flux linked to the closed loop shown in the fig, an e.m.f. V volt is induced in the loop. The work done (joule) in taking a charge Q coulomb once along the loop is

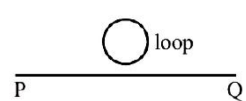


(a) QV (b) 2QV (c) QV/2 (d) Zero

37. A current i = 2 sin (πt/3) amp is flowing in an inductor of 2 henry. The amount of work done in increasing the current from 1.0 amp to 2.0 amp is

(a) 1 J (b) 2 J (c) 3 J (d) 4 J

38. An electron moves along the line PQ which lies in the same plane as a circular loop of conducting wire as shown in figure. What will be the direction of the induced current in the loop?



(a) Anticlockwise
(b) Clockwise
(c) Alternating
(d) No current will be induced

39. A coil of circular cross-section having 1000 turns and 4 cm^2 face area is placed with its axis parallel to a magnetic field which decreases by 10^{-2} Wb m^{-2} in 0.01 s. The e.m.f. induced in the coil is:
(a) 400mV (b) 200mV (c) 4mV (d) 0.4mV

40. A rectangular coil of 20 turns and area of cross-section 25 sq. cm has a resistance of 100Ω. If a magnetic field which is perpendicular to the plane of coil changes at a rate of 1000 tesla per second, the current in the coil is
(a) 1 A (b) 50 A (c) 0.5 A (d) 5 A

41. A coil of effective area 4 m^2 is placed at right angles to the magnetic induction B. The e.m.f. of 0.32 V is induced in the coil. When the field is reduced to 20% of its initial value in 0.5 sec. Find B.
(a) 0.14 Wb/m^2 (b) 0.05 Wb/m^2
(c) 0.4 Wb/m^2 (d) 0.14 Wb/m^2

42. Two identical circular loops of metal wire are lying on a table without touching each other. Loop–A carries a curent which increases with time. In response, the loop–B
(a) Remains stationary
(b) is attracted by the loop-A
(c) is repelled by the loop-A
(d) rotates about its CM, with CM fixed

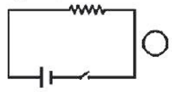
43. The magnetic flux through a circuit of resistance R changes by an amount $\Delta\phi$ in a time Δt. Then the total quantity of electric charge Q that passes any point in the circuit during the time Δt is represented by
(a) $R\cdot\frac{\Delta\varphi}{\Delta t}$ (b) $\frac{1}{R}\cdot\frac{\Delta\varphi}{\Delta t}$ (c) $\frac{\Delta\varphi}{R}$ (d) $\frac{\Delta\varphi}{\Delta t}$

44. A metal ring is held horizontally and bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet
(a) is equal to g
(b) is less than g
(c) is more than g
(d) depends on the diameter of ring and length of magnet

45. Two identical coaxial coils P and Q carrying equal amount of current in the same direction are brought nearer. The current in
(a) P increases while in Q decreases
(b) Q increases while in P decreases
(c) both P and Q increases
(d) both P and Q decreases

46. A solenoid has 2000 turns wound over a length of 0.3 m. Its cross-sectional area is 1.2×10^{-3} m^2. Around its central section a coil of 300 turns is wound. If an initial current of 2 A flowing in the solenoid is reversed in 0.25 s, the emf induced in the coil will be
(a) 2.4×10^{-4} V (b) 2.4×10^{-2} V
(c) 4.8×10^{-4} V (d) 4.8×10^{-2} V

47. Consider the situation shown in figure. If the switch is closed and after some time it is opened again, the closed loop will show



(a) a clockwise current
(b) an anticlockwise current
(c) an anticlockwise current and then clockwise
(d) a clockwise current and then an anticlock wise current.

48. A circular disc of radius 0.2 meter is placed in a uniform magnetic field of induction $\frac{1}{\pi}\left(Wb/m^2\right)$ in such a way that its axis makes an angle of 60° with $\vec{B}$. The magnetic flux linked with the disc is:
(a) 0.02 Wb (b) 0.06 Wb
(c) 0.08 Wb (d) 0.01 Wb

49. A 100 turns coil of area of cross section 200 cm^2 having 2 Ω resistance is held perpendicular to a magnetic field of 0.1 T. If it is removed from the magnetic field in one second, the induced charge produced in it is
(a) 0.2 C (b) 2 C (c) 0.1 C (d) 1 C

50. If N is the number of turns in a coil, the value of self inductance varies as
(a) N^0 (b) N (c) N^2 (d) N^{-2}

51. If the number of turns per unit length of a coil of solenoid is doubled, the self-inductance of the solenoid will
(a) remain unchanged (b) be halved
(c) be doubled (d) become four times

52. The self inductance of a long solenoid cannot be increased by
(a) increasing its area of cross section
(b) increasing its length
(c) changing the medium with greater permeability
(d) increasing the current through it

53. A 100 millihenry coil carries a current of 1 A. Energy stored in its magnetic field is
(a) 0.5 J (b) 1 A (c) 0.05 J (d) 0.1 J

54. The self induced emf is 0.4 henry in the coil when current in it changes at the rate of 500 A/s, is
(a) 8×10^{-4} V (b) 8×10^{-3} V
(c) 200 V (d) 500 V

55. Find the self inductance of a coil in which an e.m.f. of 10 V is induced when the current in the circuit changes uniformly from 1 A to 0.5 A in 0.2 sec.
(a) 4 H (b) 2 H (c) 3 H (d) 5 H

56. In an inductor of self-inductance $L = 2$ mH, current changes with time according to relation $i = t^2e^{-t}$. At what time emf is zero?
(a) 4s (b) 3s (c) 2s (d) 1s

57. The current in self inductance L = 40 mH is to be increased uniformly from 1 amp to 11 amp in 4 milliseconds. The e.m.f. induced in the inductor during the process is
(a) 100 volt (b) 0.4 volt
(c) 4.0 volt (d) 440 volt

58. In an induction coil the current increases from 0 to 6 amp in 0.3 sec by which induced emf of 30 volt is produced in it then the value of coefficient of self inductance of coil will be
(a) 3 henry (b) 2 henry
(c) 1 henry (d) 1.5 henry

59. When the current in a coil changes from 8 amp to 2 amp in 3×10^{-2} seconds, the emf induced in the coil is 2 volt. The self inductance of the coil is
(a) 10mH (b) 20mH (c) 5mH (d) 1mH

60. When the current changes from +2 A to -2A in 0.05 second, an e.m.f. of 8 V is induced in a coil. The coefficient of self -induction of the coil is
(a) 0.2 H (b) 0.4 H (c) 0.8 H (d) 0.1 H

61. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon
(a) the rates at which currents are changing in the two coils
(b) relative position and orientation of the two coils
(c) the materials of the wires of the coils
(d) the currents in the two coils

62. Induction furnace is based on the heating effect of
(a) electric field (b) eddy current
(c) magnetic field (d) gravitational field

63. If rotational velocity of a dynamo armature is doubled, then induced e.m.f. will become
(a) half (b) two times
(c) four times (d) unchanged

64. The back e.m.f. in a d.c. motor is maximum, when
(a) the motor has picked up max speed
(b) the motor has just started moving
(c) the speed of motor is still on the increase
(d) the motor has just been switched off

65. Eddy currents are produced when
(a) a metal is kept in varying magnetic field
(b) a metal is kept in steady magnetic field
(c) a circular coil is placed in a magnetic field
(d) through a circular coil, current is passed

66. If a coil made of conducting wires is roated between poles pieces of the permanent magnet. The motion will generate a current and this device is called
(a) electric motor (b) electric generator
(c) electromagnet (d) All of the above.

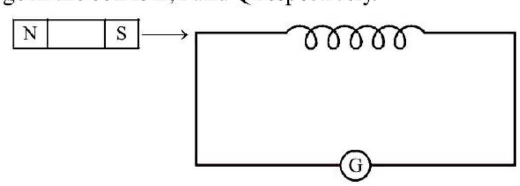
67. The armature of a dc motor has 20W resistance. It draws a current of 1.5 A when run by a 220 V dc supply. The value of the back emf induced in it is
(a) 150 V (b) 170 V (c) 180 V (d) 190 V

Case/Passage Based Questions

DIRECTIONS : *Study the given Case/Passage and answer the following questions.*

Case/Passage-I

A magnet is moved with a fast speed towards a coil at rest. Due to this induced electromotive force, induced current and induced charge in the coil is E, I and Q respectively.



68. If the speed of the magnet is doubled, then
(a) E decreases
(b) E increases
(c) E remains same
(d) Either decreases or remains same

69. If the speed of the magnet is doubled, then
(a) I increases (b) I decreases
(c) I remains same (d) None of these

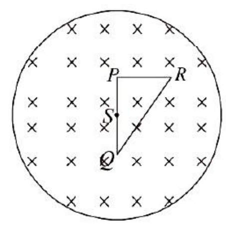
70. If the speed of the magnet is doubled, then
(a) Q increases (b) Q decreases
(c) Q remains same
(d) Either increases or decreases

71. If the speed of the magnet is halved, then
(a) E decreases (b) I decreases
(c) Q decreases (d) both (a) and (b)

72. If the speed of the magnet is halved, then
(a) E increases (b) I increases
(c) Q remains same (d) None of these

Case/Passage-II

Consider a region of cylindrical magnetic field, changing with time at the rate x. A triangular conducting loop PQR is placed in the field such that mid point of side PQ coincides with axis of the magnetic field region. $PQ = 2l$, PR = $2l$.



73. The emf induced in the side PQ of the loop is
(a) 0 (b) xl^2 (c) $\frac{xl^2}{2}$ (d) $2xl^2$

74. The emf induced in the side QR of the loop is
(a) 0 (b) xl^2 (c) $\frac{xl^2}{4}$ (d) $4xl^2$

75. The emf induced in the side PR of the loop is
(a) xl^2 (b) $\frac{xl^2}{2}$ (c) $\frac{3}{2}xl^2$ (d) zero

76. Induced emf in the coil depends upon
(a) conductivity of coil
(b) amount of flux
(c) rate of change of linked flux
(d) resistance of coil

77. Whenever the magnetic flux linked with a coil changes, an induced e.m.f.is produced in the circuit. The e.m.f. lasts
(a) for a short time
(b) for a long time
(c) for ever
(d) so long as the change in flux takes place

Case/Passage-III

Self inductance of a long solenoid: Self-inductance of a long, air-cored solenoid of lenght l, having n turns per unit length of cross-sectional area A is given by $L = \mu_0 n^2 \ell A$

When a magnetic material of relative permeability μ_r is inserted into the solenoid as a core, then the self-inductance becomes

$$L = \mu_0 \mu_r n^2 \ell A$$

78. When current in a coil changes from 5 A to 2 A in 0.1 s, average voltage of 50 V is produced. The self-inductance of the coil is :
(a) 6 H (b) 0.67 H (c) 3 H (d) 1.67 H

79. The self inductance associated with a coil is independent of
(a) current (b) time
(c) induced voltage (d) resistance of coil

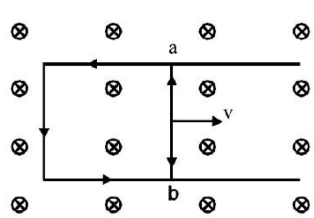
80. When the current in a coil changes from 2 amp. to 4 amp. in 0.05 sec., an e.m.f. of 8 volt is induced in the coil. The coefficient of self inductance of the coil is
(a) 0.1 henry (b) 0.2 henry
(c) 0.4 henry (d) 0.8 henry

81. The coefficient of self inductance of a solenoid is 0.18 mH. If a core of soft iron of relative permeability 900 is inserted, then the coefficient of self inductance will become nearly.
(a) 5.4 mH (b) 162 mH
(c) 0.006 mH (d) 0.0002 mH

82. The inductance of a closed-packed coil of 400 turns is 8 mH. A current of 5 mA is passed through it. The magnetic flux through each turn of the coil is
(a) $\frac{1}{4\pi}\mu_0 \text{Wb}$ (b) $\frac{1}{2\pi}\mu_0 \text{Wb}$
(c) $\frac{1}{3\pi}\mu_0 \text{Wb}$ (d) $0.4\,\mu_0 \text{Wb}$

Case/Passage-IV

Suppose the moving rod ab slides along a stationary U-shaped conductor, forming a complete circuit. Under the action of this field a counterclockwise current is established around this complete circuit.



The moving rod becomes a source of electromotive force. Within it, charge moves from lower to higher potential and in the remainder of the circuit, charge moves from higher to lower potential. We call this a motional electromagnetic force denoted by e, we can write,

Electromotive force. $e = Bv\ell$

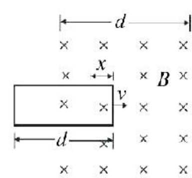
If R is the resistance of the circuit, then current in the circuit

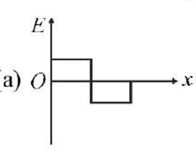
$$i = \frac{e}{R} = \frac{Bv\ell}{R}$$

83. A 10-meter wire is kept in east-west direction. It is falling down with a speed of 5.0 meter/second, perpendicular to the horizontal component of earth's magnetic field of 0.30 $\times 10^{-4}$ weber/meter^2. The momentary potential difference induced between the ends of the wire will be
(a) 0.0015 V (b) 0.015 V
(c) 0.15 V (d) 1.5 V

84. A conductor AB of length l moves in x – y plane with velocity $\vec{v} = v_0(\hat{i} - \hat{j})$. A magnetic field $\vec{B} = B_0(\hat{i} + \hat{j})$ exists in the region. The iduced emf is
(a) zero (b) $B_0 l v_0$
(c) $B_0 l v_0$ (d) $\sqrt{2} B_0 l v_0$

85. A rectangular loop is being pulled at a constant speed v, through a region of certain thickness d, in which a uniform magnetic field B is set up.
The graph between position x of the right hand edge of the loop and the induced emf E will be



(a)


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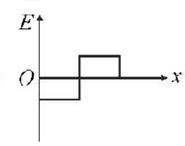
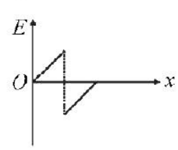
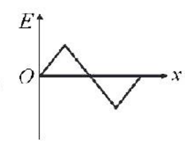
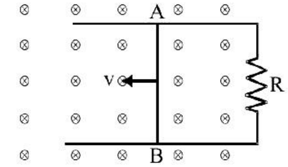


(c)


(d)


86. A six pole generator with fixed field excitation develops an e.m.f. of 100 V when operating at 1500 r.p.m. At what speed must it rotate to develop 120V?
(a) 1200 r.p.m (b) 1800 r.p.m
(c) 1500 r.p.m (d) 400 r.p.m

87. Consider the situation shown. The wire AB is sliding on fixed rails with a constant velocity. If the wire AB is replaced by semi-circular wire, the magnitude of induced e.m.f. will



(a) increase
(b) decrease
(c) remain the same
(d) increase or decrease depending on whether the semi-circle buldges towards the resistance or away from it.

Assertion & Reason

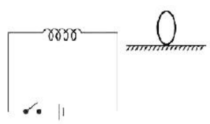
DIRECTIONS : *Each of these questions contains an assertion followed by reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.*

(a) If both **Assertion** and **Reason** are **correct** and the Reason is the **correct explanation** of the Assertion.
(b) If both **Assertion** and **Reason** are correct but Reason is **not the correct explanation** of the Assertion.
(c) If the **Assertion** is **correct** but **Reason** is **incorrect**.
(d) If the **Assertion** is **incorrect** but the **Reason** is **correct**.

88. **Assertion :** Only a change in magnetic flux will maintain an induced current in the coil.

Reason : The presence of constant magnetic field through a coil maintain an induced current in the coil of the circuit.

89. **Assertion :** Figure shows a horizontal solenoid connected to a battery and a switch. A copper ring is placed on a smooth surface, the axis of the ring being horizontal.



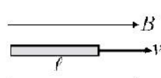
As the switch is closed, the ring will move away from the solenoid.

Reason : Induced current in the ring, $i = -\frac{d\phi}{dt}$.

90. **Assertion :** The induced charge that flows in the circuit does not depends on the time rate change of flux.

Reason : $i = \frac{dq}{dt} = -\frac{1}{R}\left(\frac{d\phi}{dt}\right) \Rightarrow dq = -\frac{d\phi}{R}$

91. **Assertion :** Figure shows a metallic conductor moving in magnetic field. The induced emf across its ends is zero.



Reason : The induced emf across the ends of a conductor is given by $e = Bv\ell\sin\theta$.

92. **Assertion :** When number of turns in a coil is doubled, coefficient of self-inductance of the coil becomes 2 times.

Reason : This is because $L \propto 1/N$.

93. **Assertion :** An induced emf appears in any coil in which the current is constant.

Reason : Self induction phenomenon does not obey Faraday's law of induction.

Match the Following

DIRECTIONS : *Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in column-I have to be matched with statements (1, 2, 3, 4) in column-II.*

94. Match the column-I and column-II

	Column I		Column II
(A)	AC generator	(1)	Eddy current
(B)	Dead beat galvanometer	(2)	Slip rings
		(3)	Split ring
(C)	Solenoid	(4)	Insulated copper wire wound in the form of a cylindrical coil

(a) (A) → (2) ; (B) → (2) ; (C) → (1)
(b) (A) → (4) ; (B) → (1) ; (C) → (3)
(c) (A) → (2) ; (B) → (1) ; (C) → (4)
(d) (A) → (2) ; (B) → (3) ; (C) → (4)

Fill in the Blanks

DIRECTIONS : *Complete the following statements with an appropriate word / term to be filled in the blank space(s).*

95. A conductor of length 0.4 m is moving with a speed of 7 m/s perpendicular to a magnetic field of intensity 0.9 Wb/m^2. The induced e.m.f. across the conductor is ______ V.

96. A varying current in a coil changes from 10A to zero in 0.5 sec. If the average e.m.f induced in the coil is 220V, the self-inductance of the coil is ______ H.

97. The mutual inductance of a pair of coils is 0.75 H. If current in the primary coil changes from 0.5 A to zero in 0.01 s, find average induced e.m.f. in secondary coil ______ V.

98. A coil of N = 100 tuns carries a current I = 5A and creates a magnetic flux $\phi = 10^{-5}$ Tm^2 per turn. The value of its inductance L will be ______ mH.

99. A generator has an e.m.f. of 440 Volt and internal resistance of 4000 hm. Its terminals are connected to a load of 4000 ohm. The voltage across the load is ____________ volt.

100. The number of turns of a solenoid are doubled without changing its length and area of cross-section. The self-inductance of the solenoid will become ________ times.

[CBSE 2020]

True / False

DIRECTIONS : *Read the following statements and write your answer as true or false.*

101. Emf will always induce whenever there is change in magnetic flux associated with a circuit.

102. Current will never induces whenever there is change in magnetic flux.

103. An emf can be induced by moving a conductor in a magnetic field.

104. An emf can be induced by changing the magnetic field.

ANSWER KEY & SOLUTIONS

1. **(b)** The charge through the coil = area of current-time $(i-t)$ graph

$q=\frac{1}{2}\times 0.1\times 4=0.2\,\text{C}$

$q=\frac{\Delta\phi}{R}$ [$\because$ Change in flux $(\Delta\phi)=q\times R$]

$q=0.2=\frac{\Delta\phi}{10}$

$\Delta\phi=2$ weber

2. **(d)** The induced e.m.f. is given by rate of change of magnetic flux linked with the circuit.

$e=-\frac{d\phi}{dt}$

For N turns $e=-N\frac{d\phi}{dt}$

Negative sign indicates that induced emf (e) opposes the change of flux.

3. **(d)** Relative motion between the magnet and the coil that is responsible for induction in the coil.

4. **(c)** As I increases, ϕ increases

$\therefore$ I_i is such that it opposes the increases in ϕ.

Hence, ϕ decreases (By Right Hand Rule). The induced current will be counter clockwise.

5. **(b)** The relative motion between the coil and the magnet produces change in the magnetic flux in the coil and the induced emf is always in such a direction that it opposes the change in the flux.

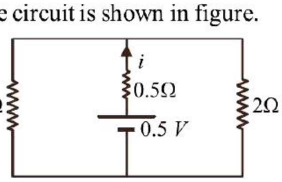
6. **(b)** Because there is no change in flux linked with coil.

7. **(d)** No change in flux, hence no force required.

8. **(a)** The induced emf across the sliding wire

$e=Bv\ell=0.5\times 4\times 0.25=0.5\,\text{V}$

The effective circuit is shown in figure.



The equivalent resistance of the circuit

$r=\frac{4\times 2}{4+2}+0.5=1.83\,\Omega$

Now, $i=\frac{V}{R}=\frac{0.5}{1.83}=0.27\text{A}$

9. **(d)** $|e|=BlV\sin\theta$

10. **(d)** $e=[Bv\ell]$

$$|e|=\begin{vmatrix}3 & 3 & 2\\ 1 & 2 & 0\\ 0 & 0 & 1\end{vmatrix}$$

(as length of conductor is $0\hat{i}+0\hat{j}+1\hat{k}$)

$\therefore$ $|e|=3\text{V}$

11. **(d)** The e.m.f. is induced when there is change of flux. As in this case there is no change of flux, hence no e.m.f. will be induced in the wire.

12. **(a)** $L=\frac{\varepsilon}{dI/dt}=\frac{10\times 10^{-3}}{2}=5\times 10^{-3}$ Henry

13. **(b)** $L=\frac{N\phi}{i}$

14. **(b)** Mutual Inductance of two coils

$M=\sqrt{L_1L_2}=\sqrt{2\text{mH}\times 8\text{mH}}=4\text{mH}$

15. **(b)** Given $\frac{\ell_1}{\ell_2}=\frac{1}{2}$ and $\frac{N_1}{N_2}=\frac{1}{2}$ From

$L=\frac{\mu_0N^2A}{\ell}\alpha\frac{N^2}{\ell}$

we get, $\frac{L_1}{L_2}=\left(\frac{N_1}{N_2}\right)^2\bigg/\left(\frac{\ell_1}{\ell_2}\right)=\frac{(1/2)^2}{1/2}=\frac{1}{2}$

16. **(b)**

17. **(c)** As we know that, the magnetic flux linked with uniform surface of area A in uniform magnetic field is

$\phi=$ B.A

The direction of A is perpendicular to the plane of square and square line in x-y plane in a region.

$A=L^2k$

As given that, $B=B_0\left(2\hat{i}+3\hat{j}+4\hat{k}\right)$

So, $\phi=B.A=B_0\left(2\hat{i}+3\hat{j}+4\hat{k}\right).L^2\hat{k}=4B_0L^2\,\text{Wb}$

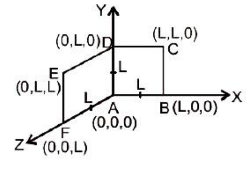
18. **(b)** The loop can be considered in two planes, Plane of ABCDA lies x-y plane whose area vector

$A_1=|A|\,\hat{k}$, $A_1=L^2\hat{k}$

whereas plane of ADEFA lies in y-z plane whose area vector

$A_2=|A|\,\hat{i}$, $A_2=L^2\hat{i}$.

Then the magnetic flux linked with uniform surface of area A in uniform magnetic field is

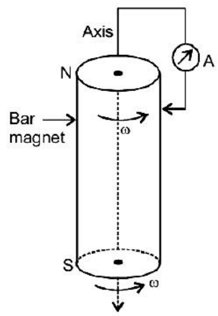


$\phi = B.A$

$A = A_1 + A_2 = (L^2\hat{k} + L^2\hat{i})$ and $B = B_0(\hat{i} + \hat{k})$

Now, $\phi = B.A = B_0(\hat{i} + \hat{k}) \cdot (L^2\hat{k} + L^2\hat{i}) = 2\,B_0L^2$ Wb

19. **(b)** Induced current flow only when circuit is complete and there is a variation about circuit this problem is associated with the phenomenon of electromagnetic induction.



If there is a symmetry in magnetic field of cylindrical bar magnet is rotated about its axis, no change in flux linked with the circuit takes place, consequently no emf induces and hence, no current flows in the ammeter (A).

20. **(d)** When the coil A stops moving the current in B b ecome ze ro, it possible only if the current in A is constant. If the current in A would be variable, there must be an induced emf (current) in B even if the A stops moving. So there is a constant current in same direction or counter clockwise direction in A as in B by lenz's law.

21. **(a)** By Lenz's law, at (t = 0) the current in B is counter-clockwise and the coil A is considered above to it. The counterclockwise flow of the current in B is equivalent to north pole of magnet and magnetic field lines are emanating upward to coil A.

When coil A start rotating at t = 0, the current in A is constant along clockwise direction by Lenz's rule. As flux changes across coil A by rotating it near the N-pole formed by flowing current in B, in anticlockwise.

22. **(b)** The self-inductance of a long solenoid of cross-sectional area A and length l, having n turns per unit length, filled the inside of the solenoid with a material of relative permeability is given by

$L = \mu_r\mu_0 n^2 Al$

$\therefore\quad n = N/l$

$$L = \mu_r\mu_0\left[\frac{N^2.A}{l.l}\right]l$$

$$L = \mu_r\mu_0\,[N^2A/l] \qquad \left(L \propto A,\ L \propto \frac{1}{l}\right)$$

As μ_r and N are constant here so, to increase L for a coil, area A must be increased and l must be decreased.

23. **(d)** $\varphi = BA\cos\theta = 2.0 \times 0.5 \times \cos 60^\circ$

$= \dfrac{2.0 \times 0.5}{2} = 0.5$ weber.

24. **(b)** Length of conductor (l) = 0.4 m; Speed (v) = 7 m/s and magnetic field (B) = 0.9 Wb/ m^2. Induced e.m.f. $(\varepsilon) = Blv\cos\theta = 0.9 \times 0.4 \times 7 \times \cos 0^\circ = 2.52$ V.

25. **(b)**

26. **(d)** $e = -\dfrac{d\phi}{dt} = -\dfrac{d(N\vec{B}.\vec{A})}{dt}$

$= -N\dfrac{d}{dt}(BA\cos\omega t) = NBA\omega\sin\omega t \Rightarrow e_{max} = NBA\omega$

27. **(c)** $q = \int idt = \dfrac{1}{R}\int edt = \dfrac{1}{R}\int\left(\dfrac{-d\phi}{dt}\right)dt = \dfrac{1}{R}\int d\phi$

(taking only magnitude of e)

Hence, total charge induced in the conducting loop depends upon the total change in magnetic flux.

28. **(b)** Induced of e.m.f., $e = -\dfrac{d\phi}{dt}$

29. **(b)** **30.** **(c)** **31.** **(c)**

32. **(d)** $e = -\dfrac{d\phi}{dt} = -2x\ t = 9$

$\therefore\ -2x \times 3 = 9 \quad \therefore\ x = -1.5$ Wb/s^2 [At t = 3]

33. **(d)** Given : $\phi = 4t^2 + 2t + 1$ wb

$\therefore\quad \dfrac{d\phi}{dt} = \dfrac{d}{dt}(4t^2 + 2t + 1) = 8t + 2 = |\varepsilon|$

$I = \dfrac{|\varepsilon|}{R} = \dfrac{8t+2}{10\Omega} = \dfrac{8t+2}{10}A = 1A$ At t = 1 s

34. **(a)** $e = \dfrac{d\phi}{dt} = \dfrac{d}{dt}(NBA) = NA\dfrac{dB}{dt} = 0.5\,V$

35. **(b)** $e = \dfrac{-(\phi_2 - \phi_1)}{t} = \dfrac{-(0 - NBA)}{t} = \dfrac{NBA}{t}$

$t = \dfrac{NBA}{e} = \dfrac{50 \times 2 \times 10^{-2} \times 10^{-2}}{0.1} = 0.1$ s

36. **(a)** $\xi = \dfrac{W}{Q} \Rightarrow V = \dfrac{W}{Q} \Rightarrow W = QV$

37. **(c)** **38.** **(a)**

39. **(a)** **Given:** No. of turns $N = 1000$

Face area, $A = 4\ cm^2 = 4 \times 10^{-4}\ m^2$

Change in magnetic field,

$\Delta B = 10^{-2}\ wbm^{-2}$

Time taken, $t = 0.01s = 10^{-2}$ sec

Emf induced in the coil e = ?

Applying formula,

Induced emf, $e = \dfrac{-d\phi}{dt} = N\left(\dfrac{\Delta B}{\Delta t}\right)A\cos\theta = 400$ mV

40. **(c)** $i = \dfrac{e}{R} = \dfrac{\frac{nAdB}{dt}}{R} = \dfrac{20 \times (25 \times 10^{-4}) \times 1000}{100} = 0.5A$

41. **(b)** Given : A = 4 m^2, e = 0.32 V, dt = 0.5sec.

B_1 is the initial magnetic induction and when it is reduced to 20% $B_2 = 0.2\,B_1$

$e = \dfrac{d\phi}{dt} = \dfrac{A(B_1 - B_2)}{\Delta t}$ or $0.32 = \dfrac{4(B_1 - 0.2B_1)}{0.5}$

Magnetic induction $B_1 = \dfrac{0.16}{3.2} = 0.05$ Wb/m^2

42. **(c)** If the current increases with time in loop A, then magnetic flux in B will increase. According to Lenz's law, loop -B is repelled by loop -A because current in loop B will be antiparallel to that in A.

43. **(c)** $\frac{\Delta\phi}{\Delta t} = \varepsilon = iR \Rightarrow \Delta\phi = (i\Delta t)R = QR \quad \Rightarrow Q = \frac{\Delta\phi}{R}$

44. **(b)** Induced e.m.f. in the ring opposes the motion of the magnet.

45. **(d)** When the coils P and Q are brought nearer, the magnetic flux linked with each coil will increase and the induced current will induces in the direction opposite to original current according to Lenz, law and hence current in both P and Q decreases.

46. **(b)** $n = \frac{N}{\ell} = \frac{2000}{0.3} = \frac{20000}{3}$; $\xi = \frac{d}{dt}(NBA) = NA\frac{dB}{dt}$

Since $B = \mu_0 nI \Rightarrow \xi = (\mu NAn)\frac{dt}{dt} \Rightarrow \xi = 0.024\,V$

47. **(d)** According to Lenz's law, when switch is closed, the flux in the loop increases out of plane of paper, so induced current will be clockwise.

48. **(a)** Here, $B = \frac{1}{\pi}$ (Wb/m^2)

$\theta = 60°$

Area normal to the plane of the disc

$= \pi r^2 \cos 60° = \frac{\pi r^2}{2}$

Flux = B × normal area

$= \frac{0.2 \times 0.2}{2} = 0.02\,Wb$

49. **(c)** $A = 200\,cm^2 = 200 \times 10^{-4}\,m^2$; $N = 100$; $R = 2\Omega$

Initial magnetic flux linked with the coil is

$\phi_i = BA\cos\theta = 0.1 \times 200 \times 10^{-4} \times \cos 0° = 2 \times 10^{-3}$ Wb

Final magnetic flux linked with the coil is $\phi_f = 0$

$$\varepsilon = -\frac{N\Delta\phi}{\Delta t} = \frac{-N(\phi_f - \phi_i)}{\Delta t} = \frac{-100(0 - 2\times10^{-3})}{1} = 0.2V$$

Induced current $I = \frac{\varepsilon}{R} = \frac{0.2V}{2\Omega} = 0.1A$

Induced charge $q = It = 0.1 \times 1 = 0.1$ C

50. **(c)** Self inductance, $L = \mu_r\mu_0 N^2 Al$

51. **(d)** Self inductance of a solenoid $= \frac{\mu n^2 A}{\ell}$

So, self induction $\propto n^2$

So, inductance becomes 4 times when n is doubled.

52. **(d)** The self inductance of a long solenoid is given by

$L = \mu_r\mu_0 n^2 Al$

Self inductance of a long solenoid is independent of the current flowing through it.

53. **(c)** $E = \frac{1}{2}Li^2 = \frac{1}{2}\times(100\times10^{-3})\times1^2 = 0.05$ J

54. **(c)** According to faraday law of electro magnetic induction,

$$e = \left|L\frac{dI}{dt}\right| = 0.4\times\frac{500}{1} = 200 \text{ volts.}$$

55. **(a)** Given : e = 10 V and $\frac{dI}{dt} = \frac{1-0.5}{0.2} = \frac{0.5}{0.2} = 2.5$ A / s

Self inductance of coil $L = \frac{e}{dI/dt} = \frac{10}{2.5} = 4$ H

56. **(c)** $L = 2mH$, $i = t^2e^{-t}$

$$E = L\frac{di}{dt} = L[\ t^2e^{-t} + 2te^{-t}]$$

when $E = 0$,

$-e^{-t}t^2 + 2te^{-t} = 0$ or, $2t\,e^{-t} = e^{-t}t^2 \Rightarrow t = 2$ sec.

57. **(a)** $e = L\frac{di}{dt}$

Given that $L = 40 \times 10^{-3}$ H,

$di = 11\,A - 1\,A = 10\,A$

and $dt = 4 \times 10^{-3}$ s

$\therefore\ e = 40 \times 10^{-3} \times \left(\frac{10}{4\times10^{-3}}\right) = 100V$

58. **(d)** $\Delta I = 6A$, $\Delta t = 0.3s$, $E = 30\,V$

$E = L\frac{dI}{dt} \quad \therefore L = \frac{30\times0.3}{6} = 1.5\,H.$

59. **(a)** According to Faraday's law of electro-magnetic inductions,

$$e = \left|L\frac{dI}{dt}\right| \Rightarrow 2 = L\,\frac{(8-2)}{3\times10^{-2}} \Rightarrow L = 10\,mH$$

60. **(d)** $e = -\frac{\Delta\phi}{\Delta t} = \frac{-\Delta(LI)}{\Delta t} = -L\frac{\Delta I}{\Delta t} \quad \therefore |e| = L\frac{\Delta I}{\Delta t}$

$\Rightarrow 8 = L\times\frac{4}{0.05} \quad \Rightarrow L = \frac{8\times0.05}{4} = 0.1H$

61. **(b)** Mutual inductance depends on the relative position and orientation of the two coils.

62. **(b)** Induction furnace is based on the heating effect of eddy current. The furnace is used to prepare alloys by melting the constituent metals. It produces very high temperature.

63. **(b)** $e \propto \omega$

64. **(a)** The back e.m.f. in a motor is induced e.m.f., which is maximum, when speed of rotation of the coil is maximum.

65. **(a)** 66. **(b)** 67. **(d)**

68. **(b)** E increases if the speed of the magnet increases.

69. **(a)** I increases if the speed of the magnet.

70. **(c)** Q remains same if the speed of the magnet is doubled.

71. **(d)** If the speed of the magnet is halved, then E and I decreases.

72. **(c)** Q does not depend upon the speed of the magnet.

73. **(a)** $e = \frac{d}{2}\ell\left(\frac{dB}{dt}\right)$

For PQ, $d = 0$, $e_{PQ} = 0$

For QR, $d = \ell$, $ePR = \frac{\ell}{2}\times 2\ell\ x = x\,\ell^2$

In close loop, $e_{QP} + e_{PR} + e_{RQ} = 0$

or $0 + e_{PR} + e_{RQ} = 0$

$\therefore \quad e_{RQ} = -e_{PR}$

$= e_{RP}$

$= xl^2$

74. **(b)** **75.** **(a)**

76. **(c)** Induced emf in the coil depends upon rate of change of linked flux.

77. **(d)** The emf lasts so long as the change in flux takes place.

78. **(d)** According to Faraday's law of electromagnetic induction,

Induced emf, $e = \frac{Ldi}{dt}$

$50 = L\left(\frac{5-2}{0.1\text{sec}}\right)$

$\Rightarrow \quad L = \frac{50 \times 0.1}{3} = \frac{5}{3} = 1.67 \text{ H}$

79. **(d)**

80. **(b)** $\varepsilon = M\frac{di}{dt}$ or $8 = M\left[\frac{(4-2)}{0.05}\right]$

$\therefore \quad M = \frac{8 \times 0.05}{2} = 0.2$ henry

81. **(b)** $L = \mu_0 nI$

$\therefore \quad \frac{L_2}{L_1} = \frac{\mu}{\mu_0}$ ----($\because$ n and l are same)

$\therefore \quad L_2 = \mu_r L_1 = 900 \times 0.18 = 162$ mH

82. **(a)** $N\phi = LI$

$\therefore \quad \phi = \frac{LI}{N} = \frac{8 \times 10^{-3} \times 5 \times 10^{-3}}{400}$

$= 10^{-7} = \frac{\mu_0}{4\pi}$ Wb

83. **(a)** If a wire, l meter in length, moves perpendicular to a magnetic field of B weber/meter^2 with a velocity of v meter/second, then the e.m.f. induced in the wire is given by $V = Bv\ell$ volt.

Here, $B = 0.30 \times 10^{-4}$ weber/meter^2,

$v = 5.0$ meter/second and $\ell = 10$ meter.

$\therefore B = 0.30 \times 10^{-4} \times 5.0 \times 10 = 0.0015$ volt.

84. **(a)** $\vec{\ell}, \vec{v}$, and $\vec{B}$ are coplanar.

85. **(b)** Till front side of the loop moves into the field the emf induced $e = Bvl$ across it. When rear side comes in the field, the emf is induced across it.

86. **(b)** The e.m.f. induced is directly proportional to rate at which flux is intercepted which in turn varies directly as the speed of rotation of the generator.

87. **(c)** E.m.f. will remain same because change in area per unit time will be same in both cases.

88. **(c)**

89. **(c)** When switch is closed , the magnetic flux through the ring will increase and so ring will move away form the solenoid so as to compensate this flux. This is according to Lenz's law.

90. **(a)** $\frac{dq}{dt} = -\frac{1}{R}\frac{d\phi}{dt} \Rightarrow dq = -\frac{d\phi}{R} \Rightarrow q = \frac{(\phi_1 - \phi_2)}{R}$

which is indipendent of time.

91. **(a)** In the given case, there is no component of velocity in perpendicular to the magnetic field and so $e = Bv\ell \sin 0°$.

92. **(c)** Number of flux linkages with the coil is proportional to the current i, N f µ i

or $N\phi = Li$ [N is the number of turns in coils]

[N ϕ is total flux linkage]

Hence, $L = \frac{N\phi}{i}$ = co-efficient of self-inductance.

93. **(d)**

94. **(c)** (A)$\rightarrow$(2); (B)$\rightarrow$(1); (C)$\rightarrow$(4)

Slip ring is a part of an AC generator.

In a dead beat galvanometer, eddy current helps in electromagnetic damping.

A solenoid is formed of long coil of circular loops of insulated copper wire

95. (2.52) Length of conductor (l) = 0.4 m; Speed (v) = 7 m/s and magnetic field (B) = 0.9 Wb/ m^2. Induced e.m.f. (V) = $Blv \sin\theta = 0.9 \times 0.4 \times 7 \times \sin 90° = 2.52$ V.

96. (11) Initial current (I_1) = 10 A; Final current (I_2) = 0; Time (t) = 0.5 sec and induced e.m.f. (ε) = 220 V.

Induced e.m.f. (ε)

$= -L\frac{dI}{dt} = -L\frac{(I_2 - I_1)}{t} = -L\frac{(0-10)}{0.5} = 20L$

or, $L = \frac{220}{20} = 11$H

97. (37.5) Given : M = 0.75 H and $\frac{dI}{dt} = \frac{0.5-0}{0.01} = 50$ A/s

$\therefore$ Average induced e.m.f. in secondary coil

$e = M\frac{dI}{dt} = 0.75 \times 50 = 37.5$ V

98. (0.20) $N\phi = Li \Rightarrow L = \frac{N\phi}{i} = \frac{100 \times 10^{-5}}{5} = 0.20$mH

99. (400) Total resistance of the circuit = 4000 + 400 = 4400 W

Current flowing $i = \frac{V}{R} = \frac{440}{4400} = 0.1$ amp.

Voltage across load = R i = 4000 × 0.1 = 400 volt.

100. (Four) Self-inductance of a long solenoid

$L = \frac{M_0 N^2 A}{\ell}$ or $L \propto N^2$ and N = 2 hence L becomes four times.

101. (True) Emf will always induces whenever, there is change in magnetic flux.

102. (False)

103. (True)

104. (True)