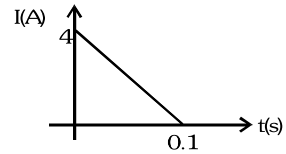
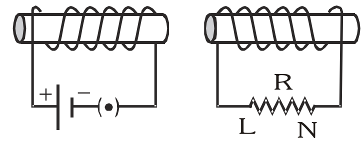
EXERCISE–01 CHECK YOUR GRASP

Select the correct alternative (only one correct answer)



1. When magnetic flux through a coil is changed, the variation of induced current in the coil with time is as shown in graph. If resistance of coil is 10 Ω, then the total change in flux of coil will be–

(A) 4 (B) 8
(C) 2 (D) 6



2. Two co–axial solenoids shown in figure. If key of primary suddenly opened then direction of instantaneous induced current in resistance 'R' which connected in secondary :–

(A) L to N (B) N to L
(C) alternating (D) zero

3. A coil having 500 square loops each of side 10 cm is placed normal to a magnetic field which increased at a rate of 1.0 T/sec. The induced e.m.f. (in volt) is :–

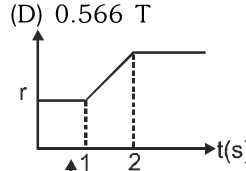
(A) 0.1 (B) 0.5 (C) 1.0 (D) 5.0

4. The magnetic field in a coil of 100 turns and 40 cm^2 an area is increased from 1 tesla to 6 tesla in 2 second. The magnetic field is perpendicular to the coil. The e.m.f. generated in it is :–

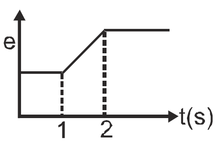
(A) 10^4 V (B) 1.2 V (C) 1.0 V (D) 10^{-2} V

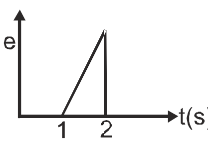
5. One coil of resistance 40Ω is connected to a galvanometer of 160Ω resistance. The coil has radius 6mm and turns 100. This coil is placed between the poles of a magnet such that magnetic field is perpendicular to coil. If coil is dragged out then the charge through the galvanometer is 32μC. The magnetic field is :–

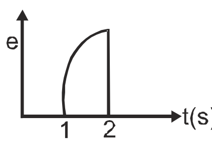
(A) 6.55 T (B) 5.66 T (C) 0.655 T (D) 0.566 T

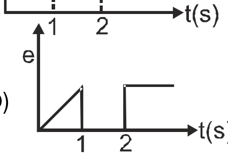


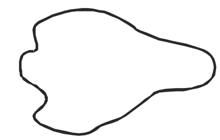
6. A flexible wire bent in the form of a circle is placed in a uniform magnetic field perpendicular to the plane of the coil. The radius of the coil changes with time as shown figure. The induced emf in the coil is :

(A) 

(B) 

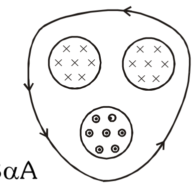
(C) 

(D) 



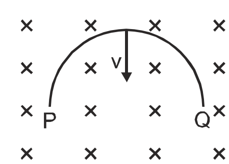
7. As a result of change in the magnetic flux linked to the closed loop shown in the figure, an e.m.f. . V volt is induced in the loop. The work done (joules) in taking a charge Q coulomb once along the loop is :–

(A) QV (B) zero (C) 2QV (D) QV/2



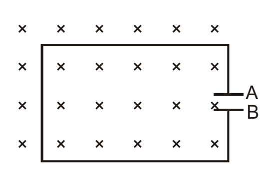
8. Figure shows three regions of magnetic field, each of area A, and in each region magnitude of magnetic field decreases at a constant rate α. If $\vec{E}$ is induced electric field then value of line integral $\oint \vec{E}.d\vec{r}$ along the given loop is equal to–

(A) αA (B) –αA (C) 3αA (D) –3αA



9. A semicircle loop PQ of radius 'R' is moved with velocity 'v' in transverse magnetic field as shown in figure. The value of induced emf. across the ends PQ of the loop is

(A) Bv (πr), end 'P' at high potential (B) 2 BRv, end P at high potential
(C) 2 BRv, end Q at high potential (D) $B\dfrac{\pi R^2}{2}v$, end P at high potential

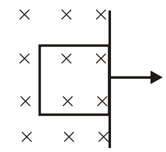


10. In the given figure if the magnetic field, which is perpendicular to the plane of the paper in the inward direction increases, then–

(A) Plate B of the capacitor will become positively charged
(B) Plate A of the capacitor will become positively charged.
(C) The capacitor will not be charged.
(D) Both plates will be charged alternately.

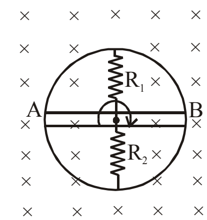
11. Two identical cycle wheels (geometrically) have different number of spokes connected from centre to rim. One is having 20 spokes and other having only 10(the rim and the spokes are resistanceless). One resistance of value R is connected between centre and rim. The current in R will be–
(A) double in first wheel than in the second wheel
(B) four times in first wheel than in the second wheel
(C) will be double in second wheel than that of the first wheel
(D) will be equal in both these wheels

12. A square loop of area $2.5 \quad 10^{-3} m^2$ and having 100 turns with a total resistance of 100 Ω is moved out of a uniform magnetic field of 0.40 T in 1 sec with a constant speed. Then work done, in pulling the loop is–



(A) zero (B) 1 mJ (C) 1 μJ (D) 0.1 mJ

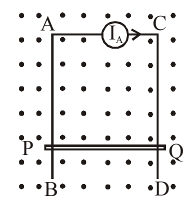
13. AB is resistanceless conducting rod which forms a diameter of a conducting ring of radius r rotating in a uniform magnetic field B as shown. The resistors R_1 and R_2 do not rotate. Then current through the resistor R_1 is–



(A) $\frac{B\omega r^2}{2R_1}$ (B) $\frac{B\omega r^2}{2R_2}$

(C) $\frac{B\omega r^2}{2R_1R_2}(R_1+R_2)$ (D) $\frac{B\omega r^2}{2(R_1+R_2)}$

14. AB and CD are fixed conducting smooth rails placed in a vertical plane and joined by a constant current source at its upper end. PQ is a conducting rod which is free to slide on the rails. A horizontal uniform magnetic field exists in space as shown. If the rod PQ in released from rest then,



(A) The rod PQ will move downward with constant acceleration
(B) The rod PQ will move upward with constant acceleration
(C) The rod will move downward with decreasing acceleration and finally acquire a constant velocity
(D) Either A or B

15. 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) NABRω (B) NAB (C) NABR (D) NABω

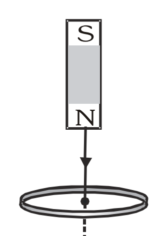
16. When the current changes from +2A to – 2A in 0.05 s, an emf of 8V is induced in a coil. The coefficient of self–induction of the coil is–
(A) 0.2 H (B) 0.4 H (C) 0.8 H (D) 0.1 H

17. Two identical circular coils A and B are placed parallel to each other with their centres on the same axis. The coil B carries a current I in the clock wise direction as seen from A. What would be the direction of the induced current in A seen from B when (i) The current in B is increased (ii) The coil B is moved towards A keeping the current in B constant
(A) clockwise, clockwise (B) clockwise, anti clockwise
(C) anti clockwise, clockwise (D) anti clockwise, anti clockwise

18. A rectangular loop of sides 'a' and 'b' is placed in xy plane. A very long wire is also placed in xy plane such that sides of length 'a' of the loop is parallel to the wire. The distance between the wire and the nearest edge of the loop is 'd'. The mutual inductance of this system is proportional to–
(A) a (B) b (C) 1/d (D) current in wire

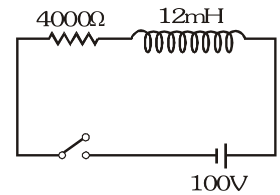
19. For a inductor coil L = 0.04 H then work done by source to establish a current of 5A in it is :–
(A) 0.5 J (B) 1.00 J (C) 100 J (D) 20 J

20. Consider a metal ring kept on a horizontal plane. A bar magnet is held above the ring with its length along the axis of the ring. If the magnet is dropped freely the acceleration of the falling magnet is (g is acceleration due to gravity)



(A) more than g (B) equal to g
(C) less than g (D) depend on mass of magnet

21. In the inductive circuit given in fig. the current rises after the switch is closed. At instant, when the current is 15 mA. Then potential difference across the inductor is :–



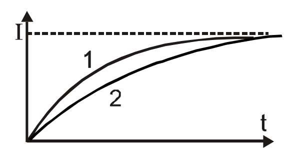
(A) 40 V (B) 80 V

(C) 160 V (D) 0

22 The time constant of an inductance coil is 2.0 10^{-3} s. When a 90 Ω resistance is joined in series, the time constant becomes 0.5 10^{-3} s. The inductance and resistance of the coil are :–

(A) 30 mH ; 30 Ω (B) 30 mH ; 60Ω (C) 60 mH ; 30Ω (D) 60mH ; 60Ω

23. When a certain circuit consisting of a constant emf E, an inductance L and a resistance R is closed, the current in, it increases with time according to curve 1. After one parameter (E, Lor R) is changed, the increase in current follows curve 2 when the circuit is closed second time. Which parameter was changed :–



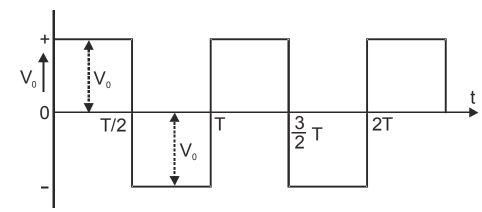
(A) L is increased (B) L is decreased

(C) R is increased (D) R is decreased

24. A coil of inductance 300 mH and resistance 2Ω is connected to a source of voltage 2V. The current reaches half of its steady state value in–

(A) 0.05 s (B) 0.1 s (C) 0.15 s (D) 0.3 s

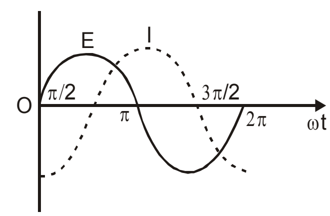
25. The average and rms value of voltage for square wave shown in fig. having peak value V_0 –



(A) $\frac{V_0}{\sqrt{2}}$, $\sqrt{2}V_0$ (B) $\sqrt{2}V_0$, $\frac{V_0}{\sqrt{2}}$

(C) V_0, V_0 (D) Zero, V_0

26. The variation of the instantaneous current (I) and the instantaneous emf (E) in a circuit is as shown in fig. Which of the following statements is correct –



(A) The voltage lags behind the current by π/2

(B) The voltage leads the current by π/2

(C) The voltage and the current are in phase

(D) The voltage leads the current by π

27. The current in a circuit varies with time as $I = 2\sqrt{t}$. Then the rms value of the current for the interval t = 2 to t = 4 sec is

(A) $\sqrt{3}A$ (B) $2\sqrt{3}A$ (C) $\sqrt{3}/2A$ (D) $(4-2\sqrt{2})$ A 7

28. In ac circuit when ac ammeter is connected it reads i current if a student uses dc ammeter in plane of ac ammeter the reading in the dc ammeter will be

(A) $\frac{i}{\sqrt{2}}$ (B) $\sqrt{2}i$ (C) 0.637 i (D) zero

29. An AC current is given by $I = I_0 + I_1 \sin \omega t$ then its rms value will be

(A) $\sqrt{I_0^2 + 0.5I_1^2}$ (B) $\sqrt{I_0^2 + 0.5I_0^2}$ (C) 0 (D) $\frac{I_0}{\sqrt{2}}$

30. Alternating current is flowing in inductance L and resistance R. The frequency of source is $\frac{\omega}{2\pi}$. Which of the following statement is correct :–

(A) for low frequency the limiting value of impedance is L.

(B) for high frequency the limiting value of impedance is Lω.

(C) for high frequency the limiting value of impedance is R.

(D) for low frequency the limiting value of impedance is Lω.

31. The self inductance of a choke coil is 10 mH. when it is connected with a 10 V D.C. source, then the loss of power is 20 watt. When it is connected with 10 volt A.C. source loss of power is 10 watt. The frequency of A.C. source will be :–

(A) 50 Hz (B) 60 Hz (C) 80 Hz (D) 100 Hz

32. In an A.C. circuit capacitance of 5μF has a reactance as 1000 Ω. The frequency of A.C. will be :–

(A) $\frac{1000}{\pi}$ cycle/s (B) $\frac{100}{\pi}$ cycle/s (C) 200 cycle/s (D) 5000 cycle/s

33. A capacitor of capacitance 100 μF and a resistance of 100Ω is connected in series with AC supply of 220V, 50Hz. The current leads the voltage by :–

(A) $\tan^{-1}\left(\frac{1}{2\pi}\right)$ (B) $\tan^{-1}\left(\frac{1}{\pi}\right)$ (C) $\tan^{-1}\left(\frac{2}{\pi}\right)$ (D) $\tan^{-1}\left(\frac{4}{\pi}\right)$

34. In an AC Circuit decrease in impedance with increase in frequency is indicates that circuit has/have :–

(A) only resistance. (B) resistance and inductance.

(C) resistance and capacitance (D) resistance, capacitance and inductance.

35. 200 Ω resistance and 1H inductance are connected in series with an A.C. circuit. The frequency of the source is $\frac{200}{2\pi}$ Hz. Then phase difference in between V and I will be :–

(A) 30 (B) 60 (C) 45 (D) 90

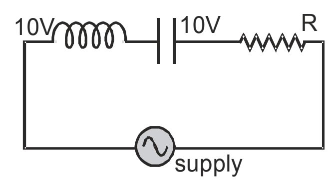
36. The phase difference between current and voltage in an AC circuit is $\frac{\pi}{4}$ radian, If the frequency of AC is 50 Hz, then the phase difference is equivalent to the time difference :–

(A) 0.78 s (B) 15.7 ms (C) 2.5 s (D) 2.5 ms

37. A student connects a long air cored – coil of magnanin wire to a 100 V D.C. supply and records a current of 25 amp. When the same coil is connected across 100 V. 50 Hz A.C. the current reduces to 20 A , the reactance of the coil is :–

(A) 4 Ω (B) 3 Ω (C) 5 Ω (D) None

38. If value of R is changed, then :–



(A) voltage across L remains same

(B) voltage across C remains same

(C) voltage across LC combination remains same

(D) voltage across LC combination changes

39. In a circuit L, C and R are connected in series with an alternating voltage source of frequency f. The current leads the voltage by 45 . The value of C is :–

(A) $\frac{1}{2\pi f(2\pi f L - R)}$ (B) $\frac{1}{2\pi f(2\pi f L + R)}$ (C) $\frac{1}{\pi f(2\pi f L - R)}$ (D) $\frac{1}{\pi f(2\pi f L + R)}$

40. In an LCR series ac circuit, the voltage across each of the components. L, C and R is 50 V. The voltage across the LC combination will be–

(A) 50 V (B) $50\sqrt{2}$ V (C) 100 V (D) 0

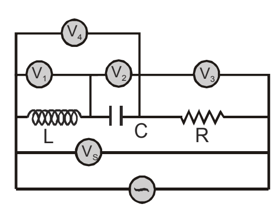
41. In an LCR circuit, capacitance is changed from C to 2C. For the resonant frequency to remain unchanged, the inductance should be changed from L to–

(A) 4 L (B) 2L (C) L/2 (D) L/4

42. In a series resonant LCR circuit, the voltage across R is 100 volts and R = 1 kΩ with C = 2μF. The resonant frequency ω is 200 rad/s. At resonance the voltage across L is–

(A) 2.5 10^{-2} V (B) 40 V (C) 250 V (D) 4 10^{-3} V

43. In the adjoining A.C. circuit the voltmeter whose reading will be zero at resonance is :–



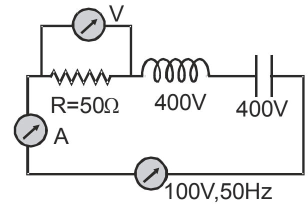
(A) V_1

(B) V_2

(C) V_3

(D) V_4

44. In given LCR circuit, the voltage across the terminals of a resistance and current will be :–

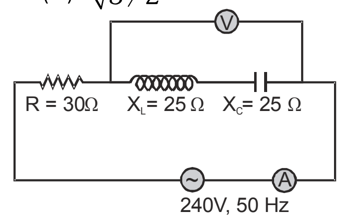


(A) 400V, 2A
(B) 800V, 2A
(C) 100V, 2A
(D) 100V, 4A

45. An ac source of angular frequency ω is fed across a resistor R and a capacitor C in series. The current registered is I. If now the frequency of source is changed to ω/3 (but maintaining the same voltage), the current in the circuit is found to be halved. Then the ratio of reactance to resistance at the original frequency ω is :

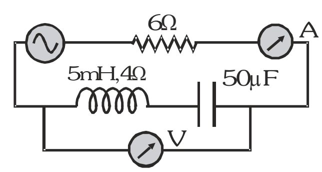
(A) $\sqrt{3/5}$ (B) $\sqrt{5/3}$ (C) $\sqrt{2/3}$ (D) $\sqrt{3/2}$

46. In the circuit shown in the figure, neglecting source resistance, the voltmeter and ammeter readings will respectively be–



(A) 0 V, 8 A
(B) 150 V, 8 A
(C) 150 V, 3 A
(D) 0 V, 3 A

47. In the circuit shown in the figure, the A.C. source gives a voltage V = 20 cos (2000 t) volt neglecting source resistance, the voltmeter and ammeter readings will be :–



(A) 0V, 1.4A
(B) 5.6V, 1.4A
(C) 0V, 0.47 A
(D) 1.68 V, 0.47 A

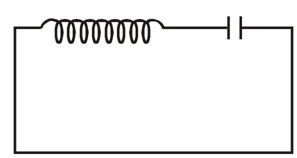
48. In an AC circuit the voltage applied is $E = E_0 \sin\omega t$. The resulting current in the circuit is $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$. The power consumption in the circuit is given by :–

(A) $P = \frac{E_0 I_0}{\sqrt{2}}$ (B) P=zero (C) $P = \frac{E_0 I_0}{2}$ (D) $P = \sqrt{2}\, E_0 I_0$

49. A coil has an inductance of 0.7 henry and is joined in series with a resistance of 220 Ω. When the alternating emf of 220 V at 50 Hz is applied to it then the phase through which current lags behind the applied emf and the wattless component of maximum current in the circuit will be respectively :–

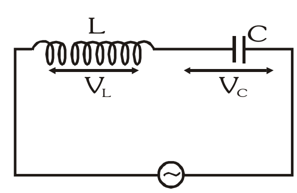
(A) 30 , 1 A (B) 45 , 0.5 A (C) 60 , 1.5 A (D) None of these

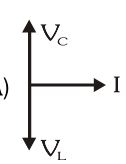
50. In an LC circuit, the capacitor has maximum charge q_0. The value of $\left.\frac{di}{dt}\right|_{max}$ is

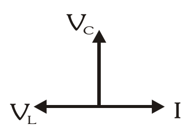


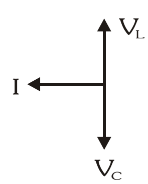
(A) $\frac{q_0}{LC}$ (B) $\frac{q_0}{\sqrt{LC}}$ (C) $\frac{q_0}{LC} - 1$ (D) None of these

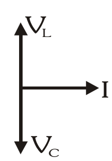
51. The current I, potential difference V_L across the inductor and potential difference V_C across the capacitor in circuit as shown in the figure are best represented vectorially as :–



(A) 

(B) 

(C) 

(D) 

52. In an oscillating LC circuit the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic fields is–

(A) Q/2 (B) $Q/\sqrt{3}$ (C) $Q/\sqrt{2}$ (D) Q

53. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon–

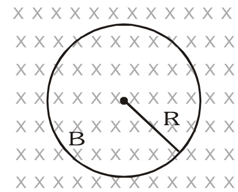
(A) the rates at which currents are changing in the two coils

(B) relative position and orientation of the two coils

(C) the materials of the wires of the coils

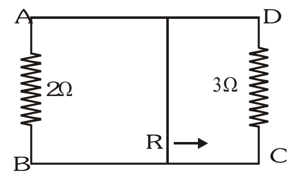
(D) the currents in the two coils

54. A conductor loop of radius R is present in a uniform magnetic field B perpendicular the plane of the ring. If radius R varies as a function of time 't', as $R = R_0 + t$. The e.m.f. induced in the loop is



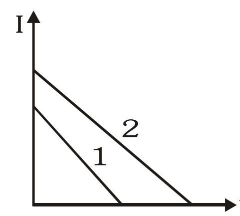
(A) $2\pi(R_0 + t)$ B clockwise
(B) $\pi(R_0 + t)$B clockwise
(C) $2\pi(R_0 + t)$ B anticlockwise
(D) zero

55. A rectangular loop with a sliding connector of length 10 cm is situated in uniform magnetic field perpendicular to plane of loop. The magnetic induction is 0.1 tesla and resistance of connector (R) is 1 ohm. The sides AB and CD have resistances 2 ohm and 3 ohm respectively. Find the current in the connector during its motion with constant velocity one metre / sec.



(A) $\frac{1}{110}$A
(B) $\frac{1}{220}$A
(C) $\frac{1}{55}$A
(D) $\frac{1}{440}$A

56. Two identical inductance carry currents that vary with time according to linear laws (as shown in figure). In which of two inductance is the self induction emf greater?



(A) 1

(B) 2

(C) same

(D) data are insufficient to decide

57. L,C and R represent physical quantities inductance, capacitance and resistance. The combination which has the dimensions of frequency is

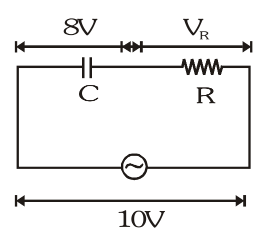
(A) $\frac{1}{RC}$ and $\frac{R}{L}$
(B) $\frac{1}{\sqrt{RC}}$ and $\sqrt{\frac{R}{L}}$
(C) $\sqrt{LC}$
(D) $\frac{C}{L}$

58. An inductor coil stores U energy when i current is passed through it and dissipates energy at the rate of P. The time constant of the circuit, when this coil is connected across a battery of zero internal resistance is

(A) $\frac{4U}{P}$
(B) $\frac{U}{P}$
(C) $\frac{2U}{P}$
(D) $\frac{2P}{U}$

59. In a series CR circuit shown in figure, the applied voltage is 10V and the voltage

voltage across capacitor is found to be 8V. then the voltage across R, and the phase difference between current and the applied voltage will respectively be



(A) 6V, $\tan^{-1}\left(\frac{4}{3}\right)$
(B) 3V, $\tan^{-1}\left(\frac{3}{4}\right)$
(C) 6V, $\tan^{-1}\left(\frac{5}{3}\right)$
(D) None

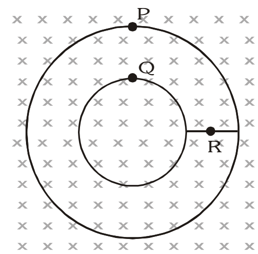
60. The effective value of current $i = 2 \sin 100\pi t + 2 \sin (100\pi t + 30)$ is

(A) $\sqrt{2}$A
(B) $2\sqrt{2+\sqrt{3}}$
(C) 4
(D) None

61. In series LR circuit X_L=3R and R is resistance. Now a capacitor with X_C = R is added in series. Ratio of new to old power factor is

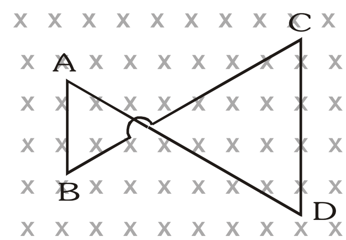
(A) 1 (B) 2 (C) $\frac{1}{\sqrt{2}}$ (D) $\sqrt{2}$

62. Figure shows plane figure made of a conductor located in a magnetic field along the inward normal to the plane of the figure. The magnetic field starts diminishing. Then select incorrect statement.



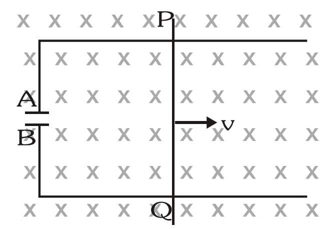
(A) the induced current at point P is clockwise
(B) the induced current at point Q is anticlockwise
(C) the induced current at point Q is clockwise
(D) the induced current at point R is zero

63. A conducting wire frame is placed in a magnetic field which is directed into the paper. The magnetic field is increasing at a constant rate. The directions of induced currents in wires AB and CD are



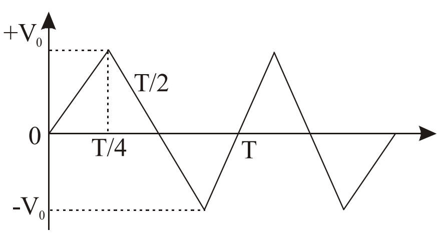
(A) B to A and D to C (B) A to B and C to D
(C) A to B and D to C (D) B to A and C to D

64. A conducting rod PQ of length L = 1.0 m is moving with a uniform speed v = 20 m/s in a uniform magnetic field B = 4.0 T directed into the paper. A capacitor of capacity C = 10 μF is connected as shown in figure. Then



(A) q_A = + 800 μC and q_B = - 800 μC
(B) q_A = - 800 μC and q_B = + 800 μC
(C) q_A = 0 = q_B
(D) charge stored in the capacitor increases exponentially with time

65. The voltage time (V–t) graph for triangle wave having peak value. V_0 is as shown in figure : The rms value of V in time interval from t = 0 to T/4 is



(A) $\frac{V_0}{\sqrt{3}}$ (B) $\frac{V_0}{2}$ (C) $\frac{V_0}{\sqrt{2}}$ (D) None of these

CHECK YOUR GRASP **ANSWER KEY** EXERCISE –1

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	C	A	D	C	D	B	A	B	C	A	D	D	A	D	D	D	A	A	B	C
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	A	C	A	B	D	B	B	D	A	B	C	B	B	C	C	D	B	C	B	D
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	C	C	D	C	A	A	B	B	B	A	D	C	B	C	B	A	A	C	A	D
Que.	61	62	63	64	65															
Ans.	D	B	A	A	A															

EXERCISE–02 BRAIN TEASURES

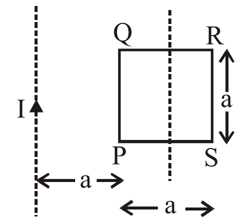
Select the correct alternatives (one or more than one correct answers)

1. A conducting loop is placed in a uniform magnetic field with its plane perpendicular to the field. An emf is induced in the loop if :–

(A) It is translated within magnetic field (B) It is rotated about its axis

(C) It is rotated about a diameter (D) It is deformed

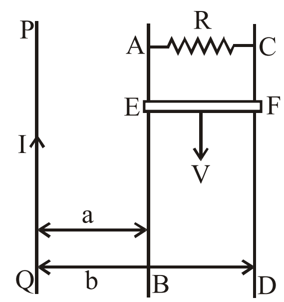
2. In the figure shown a square loop PQRS of side 'a' and resistance 'r' is placed in near an infinitely long wire carrying a constant current I. The sides PQ and RS are parallel to the wire. The wire and the loop are in the same plane. The loop is rotated by 180 about an axis parallel to the long wire and passing through the mid point of the side QR and PS. The total amount of charge which passes through any point of the loop during rotation is–



(A) $\frac{\mu_0 Ia}{2\pi r}\ell n2$ (B) $\frac{\mu_0 Ia}{\pi r}\ell n2$ (C) $\frac{\mu_0 Ia^2}{2\pi r}$

(D) cannot be found because time of rotation not give

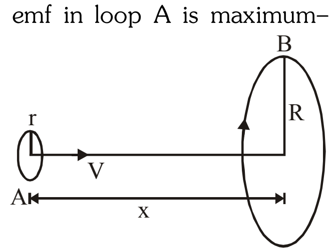
3. PQ is an infinite current carrying conductor. AB and CD are smooth conducting rods on which a conductor EF moves with constant velocity V as shown. The force needed to maintain constant speed of EF is–



(A) $\frac{1}{VR}\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]^2$ (B) $\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]^2\frac{1}{VR}$

(C) $\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]^2\frac{V}{R}$ (D) $\frac{V}{R}\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]^2$

4. Loop A of radius (r << R) moves towards loop B with a constant velocity V in such a way that their planes are always parallel. What is the distance between the two loops (x) when the induced emf in loop A is maximum–



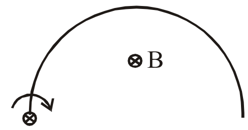
(A) R (B) $\frac{R}{\sqrt{2}}$

(C) $\frac{R}{2}$ (D) $R\left(1-\frac{1}{\sqrt{2}}\right)$

5. A superconducting loop of radius R has self inductance L. A uniform and constant magnetic field B is applied perpendicular to the plane of the loop. Initially current in this loop is zero. The loop is rotated by 180º. The current in the loop after rotation is equal to–

(A) zero (B) $\frac{B\pi R^2}{L}$ (C) $\frac{2B\pi R^2}{L}$ (D) $\frac{B\pi R^2}{2L}$

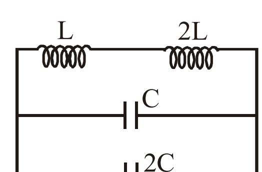
6. A semicircular wire of radius R is rotated with constant angular velocity ω about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength B. The induced e.m.f. between the ends is–



(A) B $\omega R^2/2$ (B) 2B ωR^2

(C) is variable (D) none of these

7. The frequency of oscillation of current in the inductor is–



(A) $\frac{1}{3\sqrt{LC}}$ (B) $\frac{1}{6\pi\sqrt{LC}}$

(C) $\frac{1}{\sqrt{LC}}$ (D) $\frac{1}{2\pi\sqrt{LC}}$

8. An LCR series circuit with 100 Ω resistance is connected to an AC source of 200 V and angular frequency 300 radians per second. When only the capacitance is removed, the current lags behind the voltage by 60 . When only the inductance is removed, the current leads the voltage by 60 . Then the current and power dissipated in LCR circuit are respectively

(A) 1A, 200 watt. (B) 1A, 400 watt. (C) 2a, 200 watt. (D) 2A, 400 watt.

9. A bulb is rated of 100 V, 100W, it can be treated as a resistor. Find out the inductance of an inductor (called choke coil) that should be connected in series with the bulb to operate the bulb at its rated power with the help of an ac source of 200V and 50 Hz

(A) $\frac{\pi}{\sqrt{3}}$ H (B) 100H (C) $\frac{\sqrt{2}}{\pi}$ H (D) $\frac{\sqrt{3}}{\pi}$ H

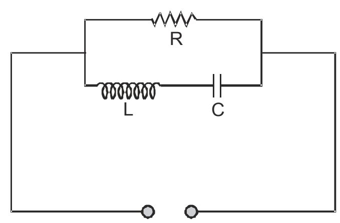
10. Two different coils have self–inductances L_1 = 8 mH and L_2 = 2mH. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate. At a certain instant of time, the power given to the two coils is the same. At that time, the current, the induced voltage and the energy stored in the first coil are i_1, V_1 and W_1 respectively. Corresponding values for the second coil at the same instant are i_2, V_2 and W_2 respectively. Then :

(A) $\frac{i_1}{i_2}=\frac{1}{4}$ (B) $\frac{i_1}{i_2}=4$ (C) $\frac{W_1}{W_2}=\frac{1}{4}$ (D) $\frac{V_1}{V_2}=4$

11. The capacitance of a telephone wire of length 300 km is 0.01 μF per km. If wire caries an ac of 5 kHz, what should be the value of an inductance required to be connected in series so that impedance is minimum–

(A) 0.36 mH (B) 3.6 mH (C) 0.6 H (D) 3.6 H

12. In the circuit shown, when dc of 250 V is applied, one ampere current passes through the circuit and when an alternating voltage source of 250 V and 2250 rad/s is applied, current of 1.25 A flows. If maximum current flows through the circuit at a frequency of 4500 rad/s, then the value of L and C will be respectively–



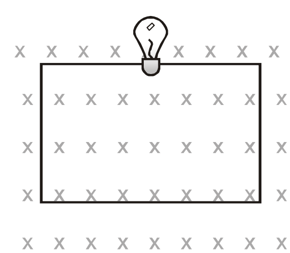
(A) 0.295 H, 10^{-4} F (B) 0.0752 H, 0.01 F
(C) 0.0392 H, 0.005 F (D) 0.0494 H, 10^{-6} F

13. An electron is moving in a circular orbit of radius R with an angular acceleration α. At the centre of the orbit is kept a conducting loop of radius r, (r<<R). The e.m.f. induced in the smaller loop due to the motion of the electron is

(A) zero, since charge on electron in constant (B) $\frac{\mu_0 er^2}{4R}\alpha$

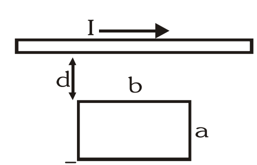
(C) $\frac{\mu_0 er^2}{4\pi R}\alpha$ (D) None of these

14. A square wire loop of 10.0 cm side lies at right angles to a uniform magnetic field of 20T. A 10V light bulb is in a series with the loop as shown in the figure. The magnetic field is decreasing steadily to zero over a time interval ΔT. The bulb will shine with full brightness if Δt is equal to



(A) 20 ms (B) 0.02 ms
(C) 2 ms (D) 0.2 ms

15. A long straight wire is parallel to one edge as in figure. If the current in the long wire is varies in time as $I = I_0e^{-t/\tau}$, what will be the induced emf in the loop?



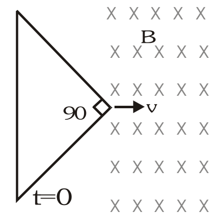
(A) $\frac{\mu_0 bI}{\pi\tau}\ell n\left(\frac{d+a}{d}\right)$ (B) $\frac{\mu_0 bI}{2\pi\tau}\ell n\left(\frac{d+a}{d}\right)$

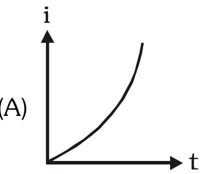
(C) $\frac{2\mu_0 bI}{\pi\tau}\ell n\left(\frac{d+a}{d}\right)$ (D) $\frac{\mu_0 bI}{\pi\tau}\ell n\left(\frac{d}{d+a}\right)$

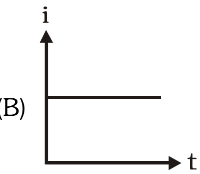
16. The magnetic flux through a stationary loop with resistance R varies during interval of time T as ϕ= at (T–t). The heat generated during this time neglecting the inductance of loop will be

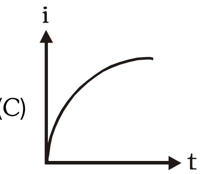
(A) $\frac{a^2T^3}{3R}$ (B) $\frac{a^2T^2}{3R}$ (C) $\frac{a^2T}{3R}$ (D) $\frac{a^2T^3}{R}$

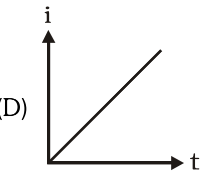
17. The figure shows an isosceles triangle wire frame with apex angle equal to $\pi/2$. The frame starts entering into the region of uniform magnetic field B with constant velocity v at t=0. The longest side of the frame is perpendicular to the direction of velocity. If i is the instantaneous current through the frame then choose the alternative showing the correct variation of i with time.



(A) 

(B) 

(C) 

(D) 

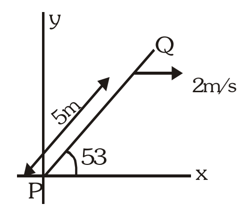
18. A square loop of side a and resistance R is moved in the region of uniform magnetic field B (loop remaining completely inside field), with a velocity v through a distance x. The work done is

(A) $\frac{B^2\ell^2vx}{R}$ (B) $\frac{2B^2\ell^2vx}{R}$ (C) $\frac{4B^2\ell^2vx}{R}$ (D) None

19. Two parallel long straight conductors lie on a smooth surface. Two other parallel conductors rest on them at right angles so as to form a square of side a initially. A uniform magnetic field B exists at right angles to the plane containing the conductors. They all start moving out with a constant velocity v. If r is the resistance per unit length of the wire the current in the circuit will be

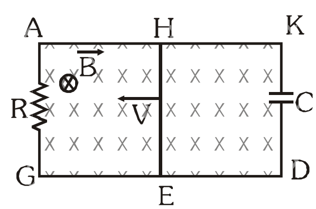
(A) $\frac{Bv}{r}$ (B) $\frac{Br}{v}$ (C) Bvr (D) Bv

20. A conducting rod PQ of length 5 m oriented as shown in figure is moving with velocity (2 m/s) $\tilde{i}$ without any rotation in a uniform magnetic field $\left(3\tilde{j}+4\tilde{k}\right)$ Tesla. Emf induced in the rod is



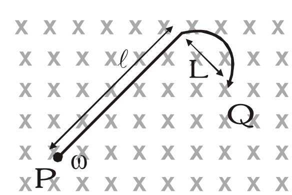
(A) 32 volt (B) 40 volt
(C) 50 volt (D) None

21. In the circuit shown in figure, a conducting wire HE is moved with a constant speed V towards left. The complete circuit is placed in a uniform magnetic field $\vec{B}$ perpendicular to the plane of the circuit directed in inward direction. The current in HKDE is



(A) clockwise (B) anticlockwise
(C) alternating (D) zero

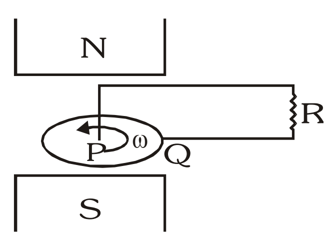
22. When a 'J' shaped conducting rod is rotating in its own plane with constant angular velocity ω, about one of its end P, in a uniform magnetic field $\vec{B}$ directed normally into the plane of paper) then magnitude of emf induced across it will be



(A) $B\omega\sqrt{L^2+\ell^2}$ (B) $\frac{1}{2}B\omega L^2$

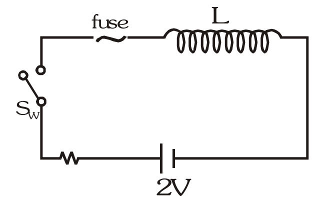
(C) $\frac{1}{2}B\omega\left(L^2+\ell^2\right)$ (D) $\frac{1}{2}B\omega\ell^2$

23. A metal disc rotates freely, between the poles of a magnet in the direction indicated. Brushes P and Q make contact with the edge of the disc and the metal axle. What current, if any, flows through R?



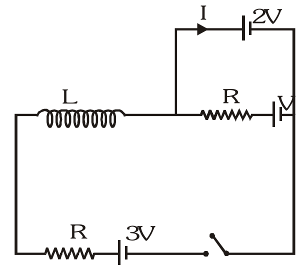
(A) a current from P to Q (B) a current from Q to P
(C) no current, because the emf in the disc is opposed by the back emf
(D) no current, because the emf induced in one side o the disc is opposed by the emf induced in the other side

24. In the circuit shown, the cell is ideal. the coil has an inductance of 4H and zero resistance. F is a fuse of zero resistance and will blow when the current through it reaches 5A. The switch is closed at t=0. The fuse will below:



(A) just after t=0 (B) after 2s
(C) after 5s (D) after 10s

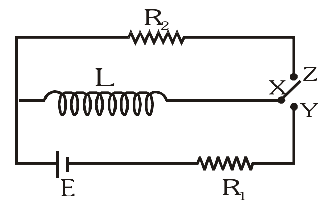
25. In the LR circuit shown, what is the variation of the current I as a function of time? The switch is closed at time t=0 sec.



(A) $\frac{V}{R}\left(1-e^{-\frac{Rt}{L}}\right)$ (B) $\frac{V}{R}e^{-\frac{Rt}{L}}$

(C) $-\frac{V}{R}e^{-\frac{Rt}{L}}$ (D) None

26. In the circuit shown, X is joined to Y for a long time and then X is joined to Z. The total heat produced in R_2 is

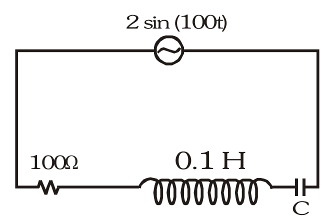


(A) $\frac{LE^2}{2R_1^2}$ (B) $\frac{LE^2}{2R_2^2}$ (C) $\frac{LE^2}{2R_1R_2}$ (D) $\frac{LE^2R_2}{2R_1^2}$

27. An induction coil stores 32 jouled of magnetic energy and dissipates energy as heat at the rate of 320 watts. When a current of 4 amperes is passed through it. Find the time constant of the circuit when the coil is joined across a battery.

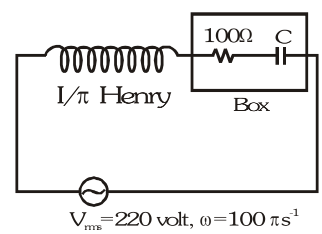
(A) 0.2 s (B) 0.1 s (C) 0.3s (D) 0.4 s

28. The power factor of the circuit is $\frac{1}{\sqrt{2}}$. The capacitance of the circuit is equal to



(A) 400 μF (B) 300 μF
(C) 500 μF (D) 200 μF

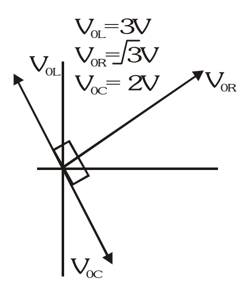
29. In the circuit, as shown in the figure, if the value of R.M.S. current is 2.2 ampere, the power factor of the box is



(A) $\frac{1}{\sqrt{2}}$ (B) 1

(C) $\frac{\sqrt{3}}{2}$ (D) $\frac{1}{2}$

30. The given figure represents the phasor diagram of a series LCR circuit connected to an ac source. At the instant t' when the source voltage is given by $V=V_0\cos\omega t'$, the current in the circuit will be



(A) $I=I_0\cos(\omega t' + \pi/6)$
(B) $I=I_0\cos(\omega t' - \pi/6)$
(C) $I = I_0\cos(\omega t' + \pi/3)$
(D) $I = I_0\cos(\omega t' - \pi/3)$

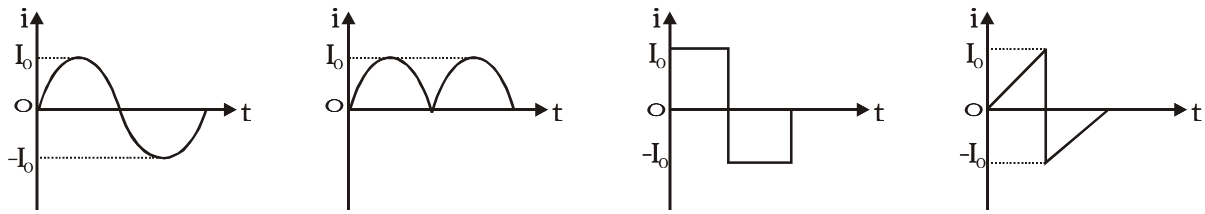
31. Power factor of an L–R series circuit is 0.6 and that of a C–R series circuit is 0.5. If the element (L,C, and R) of the two circuits are joined in series the power factor of this circuit is found to be 1. The ratio of the resistance in the L–R circuit to the resistance in the C–R circuit is

(A) $\frac{6}{5}$ (B) $\frac{5}{6}$ (C) $\frac{4}{3\sqrt{3}}$ (D) $\frac{3\sqrt{3}}{4}$

32. The effective value of current $i = 2\sin 100\pi\, t + 2\sin(100\pi t + 30)$ is

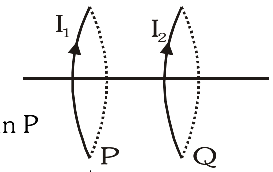
(A) $\sqrt{2}$ A (B) $2\sqrt{2+\sqrt{3}}$ (C) 4 (D) None

33. If I_1, I_2, I_3 and I_4 are the respective r.m.s. values of the time varying currents as shown in the four cases I, II, III and IV. Then identify the correct relations



(A) $I_1 = I_2 = I_3 = I_4$ (B) $I_3 > I_1 = I_2 > I_4$ (C) $I_3 > I_4 > I_2 = I_1$ (D) $I_3 > I_2 > I_1 > I_4$

34. Two circular coils P & Q are fixed coaxially & carry currents I_1 and I_2 respectively



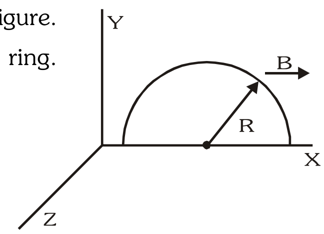
(A) If $I_2 = 0$ & P moves towards Q, a current in the same direction as I_1 is induced in Q

(B) If $I_1 = 0$ & Q moves towards P, a current in the opp. direction to that of I_2 is induced in P

(C) when I_1 # 0 and I_2 # 0 are in the same direction then the two coils tend to move apart.

(D) when I_1 # 0 and I_2 # 0 are in opposite directions then the coils tends to move apart

35. A semicircle conducting ring of radius R is placed in the xy plane, as shown in the figure. A uniform magnetic field is set up along the x–axis. No emf, will be induced in the ring. If



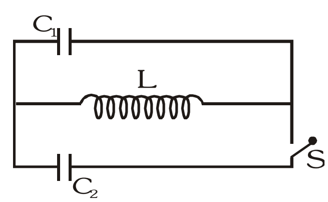
(A) it moves along the x–axis

(B) it moves along the y–axis

(C) it moves along the z–axis

(D) it remains stationary

36. At a moment (t=0) when charge on capacitor C_1 is zero, the switch is closed. If I_0 be the current through inductor at that instant, for t > 0,

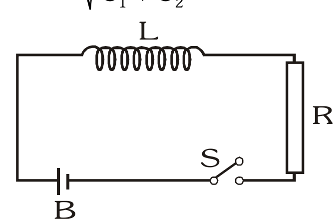


(A) maximum current through inductor equals $\dfrac{I_0}{2}$

(B) maximum current through inductor equals $\dfrac{C_1 I_0}{C_1 + C_2}$

(C) maximum charge on $C_1 = \dfrac{C_1 I_0 \sqrt{LC_1}}{C_1 + C_2}$ (D) maximum charge on $C_1 = I_0 C_1 \sqrt{\dfrac{L}{C_1 + C_2}}$

37. In figure, the switch S is closed so that a current flows in the iron–core inductor which has inductance L and the resistance R. When the switch is opened, spark is obtained in it at the contacts. The spark is due to

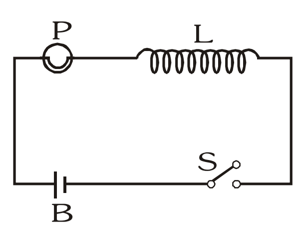


(A) a slow flux change in L

(B) a sudden increase in the emf of the battery B

(C) a rapid flux change in L (D) a rapid flux change in R

38. In figure, a lamp P is in series with an iron–core inductor L. When the switch S is closed, the brightness of the lamp rises relatively slowly to its full brightness than it would do without the inductor. This is due to



(A) the low resistance of P

(B) the induced –emf in L

(C) the low resistance of L (D) the high voltage of the battery B

39. Two coil A and B have coefficient of mutual inductance M=2H. The magnetic flux passing through coil A changes by 4 Weber in 10 seconds due to the change in current in B. Then

(A) change in current in B in this time interval is 0.5 A

(B) the change in current in B in this time interval is 2A

(C) the change in current in B in this time interval is 8A

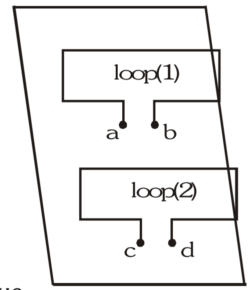
(D) a change in current of 1A in coil A will produce a change in flux passing through B by 4 Weber

40. An a.c. source of voltage V and of frequency 50Hz is connected to an inductor of 2H and negligible resistance. A current of r.m.s. value I flows in the coil. When the frequency of the voltage is changed to 400 Hz keeping the magnitude of V the same, the current is now

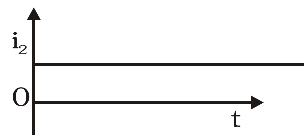
(A) 8I in phase with V (B) 4I and leading by 90 from V

(C) I/4 and lagging by 90^0 from V (D) I/8 and lagging by 90^0 from V

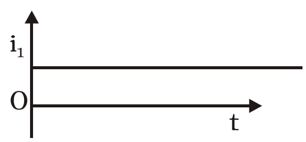
41. An electric current i_1 can flow either direction through loop (1) and induced current i_2 in loop (2). Positive i_1 is when current is from 'a' to 'b' in loop (1) and positive i_2 is when the current is from'c' to 'd' in loop (2). In an experiment,

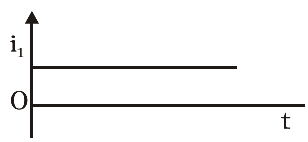


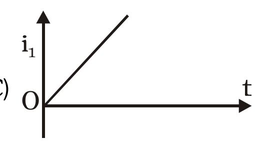
the graph of i_2 against time 't' is as shown below

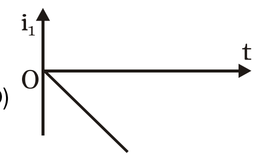


which one(s) of the following graphs could have caused i_2 to behave as give above

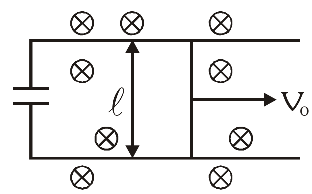
(A)


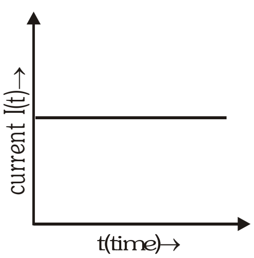
(B)


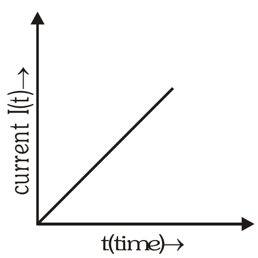
(C)


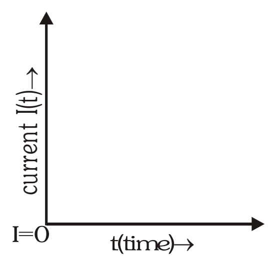
(D)


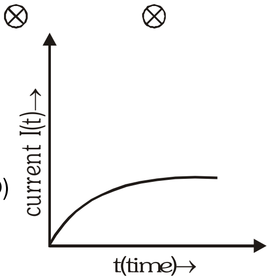
42. Two infinitely long conducting parallel rails are connected through a capacitor C as shown in the figure. A conductor of length ℓ is moved with constant speed v_0. Which of the following graph truly depicts the variation of current through the conductor with time?



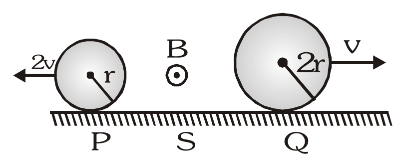
(A)


(B)


(C)


(D)


43. Two conducting rings P and Q of radii and r and 2r rotate uniformly in opposite directions with centre of mass velocities 2 v and v respectively on a conducting surface S. There is a uniform magnetic field of magnitude B perpendicular to the plane of the rings. The potential difference between the highest points of the two rings is

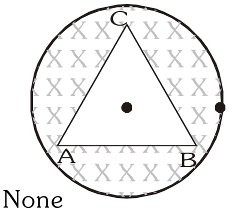


(A) zero (B) 4 Bvr (C) 8 Bvr (D) 16 Bvr

44. The magnetic field in a region is given by $\vec{B} = B_0\left(1+\frac{x}{a}\right)\tilde{k}$. A square loop of edge length d is placed with its edge along x & y axis. The loop is moved with constant velocity $\vec{V} = V_0\tilde{i}$. The emd induced in the loop is

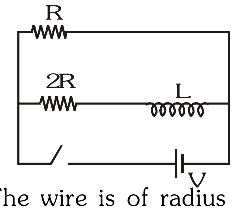
(A) $\frac{V_0B_0d^2}{a}$ (B) $\frac{V_0B_0d^2}{2a}$ (C) $\frac{V_0B_0a^2}{d}$ (D) none

45. A triangular wire frame (each side = 2m) is placed in a region of time variant magnetic field having $dB/dt = \sqrt{3}$ T/s. The magnetic field is perpendicular to the plane of the triangle. The base of the triangle AB has a resistance 1Ω while the other two sides have resistance 2Ω each. The magnitude of potential difference between the points A and B will be



(A) 0.4 V (B) 0.6 V (C) 1.2 V (D) None

46. The ratio of time constant in charging and discharging in the circuit shown in figure is



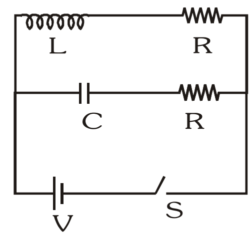
(A) 1:1 (B) 3:2

(C) 2:3 (D) 1:3

47. A long straight wire of circular cross-section is made of non-magnetic material. The wire is of radius a. The wire carries a current I which is uniformly distributed over its cross-section. The energy stored per unit length in the magnetic field contained within the wire is

(A) $U = \frac{\mu_0 I^2}{8\pi}$ (B) $U = \frac{\mu_0 I^2}{16\pi}$ (C) $U = \frac{\mu_0 I^2}{4\pi}$ (D) $U = \frac{\mu_0 I^2}{2\pi}$

48. In the circuit shown in the figure, $R = \sqrt{\frac{L}{C}}$. Switch S is closed at time t=0. The current through C and L would be equal after a time t equal to



(A) CR (B) CR ℓn (2)

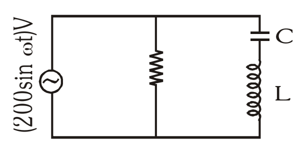
(C) $\frac{L}{R\ \ell n(2)}$ (D) LR

49. Let f = 50 Hz, and C=100 μF in an AC circuit containing a capacitor only. If the peak value of the current in the circuit is 1.57 A at t=0. The expression for the instantaneous voltage across the capacitor will be

(A) $E = 50 \sin(100\pi t - \pi/2)$ (B) $E = 100 \sin(50\pi t)$

(C) $E = 50 \sin 100\pi t$ (D) $E = 50 \sin(100\pi t + \pi/2)$

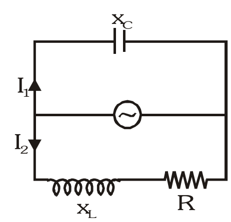
50. In the circuit diagram shown, $X_C = 100\Omega$, $X_L = 200\Omega$ and $R = 100\Omega$. The effective current through the source is



(A) 2A (B) $\sqrt{2}$A

(C) 0.5A (D) $2\sqrt{2}$A

51. In the shown AC circuit phase different between currents I_1 and I_2 is



(A) $\frac{\pi}{2} - \tan^{-1}\frac{x_L}{R}$ (B) $\tan^{-1}\frac{x_L - x_C}{R}$

(C) $\frac{\pi}{2} + \tan^{-1}\frac{x_L}{R}$ (D) $\tan^{-1}\frac{x_L - x_C}{R} + \frac{\pi}{2}$

52. For L-R circuit, the time constant is equal to

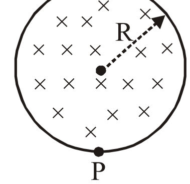
(A) twice the ratio of the energy stored in the magnetic field to the rate of the dissipation of energy in the resistance

(B) the ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance

(C) half of the ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance

(D) square of the ratio of the energy stored in the magnetic field to the rate of dissipation energy in the resistance

53. A uniform magnetic field of induction B is confined to a cylindrical region of radius R. The magnetic field is increasing at a constant rate of $\frac{dB}{dt}$ (tesla/second). An electron of charge q, placed at the point P on the periphery of the field experiences an acceleration–



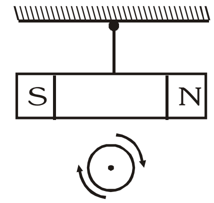
(A) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ towards left (B) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ toward right

(C) $\frac{eR}{m}\frac{dB}{dt}$ toward left (D) 0

54. A coil having n turns and resistance R Ω is connected with a galvanometer of resistance 4R Ω. This combination is moved in time t seconds from a magnetic field W_1 weber to W_2 weber. The induced current in the circuit is–

(A) $\frac{W_2 - W_1}{5Rnt}$ (B) $-\frac{n(W_2 - W_1)}{5Rt}$ (C) $-\frac{(W_2 - W_1)}{Rnt}$ (D) $-\frac{n(W_2 - W_1)}{Rt}$

55. A negative charge is given to a nonconducting loop and the loop is rotated in the plane of paper about its centre as shown in figure. The magnetic field produced by the ring affects a small magnet placed above the ring in the same plane :

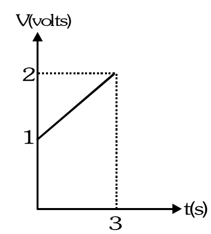


(A) the magnet does not rotate
(B) the magnetic rotates clockwise as seen from below
(C) the magnet rotates anticlockwise as seen from below
(D) no effect on magnet is there

56. A wire of fixed length is wound on a solenoid of length 'ℓ' and radius 'r'. Its self inductance is found to be L. Now if same wire is wound on a solenoid of length $\ell/2$ and radius r/2, then the self inductance will be–

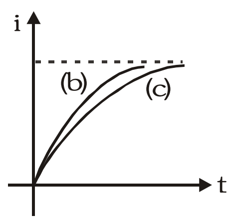
(A) 2 L (B) L (C) 4 L (D) 8 L

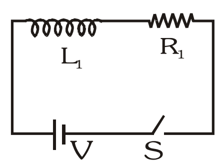
57. A circuit element is placed in a closed box. At time t=0, constant current generator supplying a current of 1 A, is connected across the box. Potential difference across the box varies according to graph shown in figure. The element in the box is

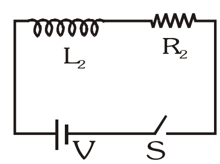


(A) resistance of 2Ω
(B) battery of emf 6V
(C) inductance of 2H
(D) capacitance of 0.5 F

58. Current growth in two L-R circuits (B) and (C) as shown in figure (A). Let L_1, L_2, R_1 and R_2 be the corresponding values in two circuits. Then

(A) 

(B) 

(C) 

(A) $R_1 > R_2$ (B) $R_1 = R_2$ (C) $L_1 > L_2$ (D) $L_1 < L_2$

59. For a LCR series circuit with an A.C. source of angular frequency ω :

(A) circuit will be capacitive if $\omega > \frac{1}{\sqrt{LC}}$ (B) circuit will be inductive if $\omega > \frac{1}{\sqrt{LC}}$

(C) power factor of circuit will by unity if capacitive reactance equals inductive reactance (D) current will be leading if $\omega > \frac{1}{\sqrt{LC}}$

BRAIN TREASURE **ANSWER KEY** EXERCISE –2

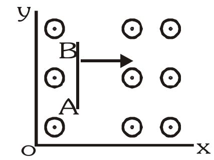
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	C,D	B	A	C	C	B	B	D	D	A,C,D	A	D	B	A	B	A	D	D	A	A
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	D	C	A	D	C	A	A	C	A	B	D	D	B	B,D	A,B,C,D	D	C	B	B	D
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	
Ans.	D	C	C	A	A	B	B	B	C	A	C	A	A	B	B	A	D	BD	BC	

EXERCISE–03 MISCELLANEOUS TYPE QUESTIONS

True/False

1. A coil of metal wire is kept stationary in a non–uniform magnetic field. An emf is induced in the coil.

2. A conducting rod AB moves parallel to the x–axis (see Fig.) in a uniform magnetic field pointing in the positive z–direction. The end A of the rod gets positively charged.



3. An artificial satellite with metal surface has an orbit over the equator earth's magnetism induce a current in it.

4. Two identical loops one of copper and the other of aluminium are rotated with the same speed in transverse uniform magnetic field.

   (i) induced emf will be more in copper loop.

   (ii) induced current will be more in copper loop.

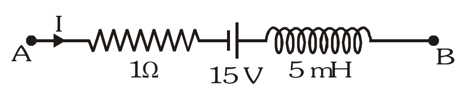
5. An alternating voltage is given by e = $200\sqrt{2}$ sin ($100\pi t$) volt. The mean voltage over a time interval of 0.02 sec may be zero.

Fill in the blanks

1. A uniformly wound solenoids coil of self–inductance 1.8 10^{-4} H and resistance 6Ω is broken up into two identical coils. These identical coils are then connected in parallel across a 15 V battery of negligible resistance. The time constant for the current in the circuit is .... s and the steady state current through the battery is .... A.

2. In a straight conducting wire, a constant current is flowing from left to right due to a source of emf. When the source is switched–off, the direction of the induced current in the wire will be....................

3. The network shown in figure is part of a complete circuit. If at a certain instant the current (I) is 5A and is decreasing at a rate of 10^3. As then $V_B - V_A$ = ... V



4. The time required for a 50 Hz. a.c. to change from zero to the r.m.s. value is ....

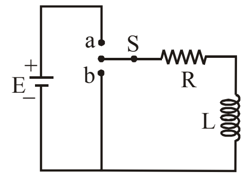
5. Average value of sinusoidal A.C. of peak value I_0 over 0 to π is.....................

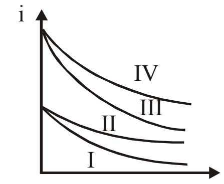
Match the column

1. Instantaneous voltage and instantaneous current in an L–R circuit in AC is V = 100 sin (100 t) and i = 10 sin ($100t - \pi/4$). Match the following table :

	Column–I		Column–II
(A)	R	(p)	$\frac{1}{10\sqrt{2}}$ SI unit
(B)	X_L	(q)	$5\sqrt{2}$ SI unit
(C)	L	(r)	$10\sqrt{2}$ SI unit
(D)	average power in one cycle	(s)	None

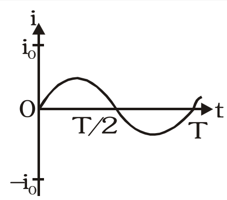
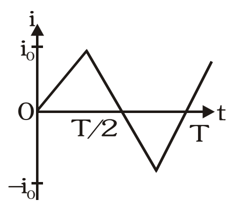
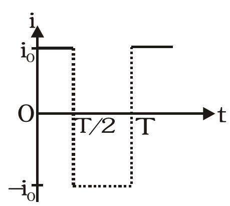
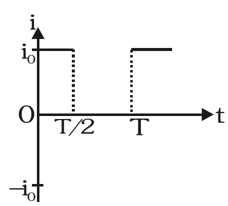
2. The switch S in the circuit is connected with point 'a' for a very long time, then it is shifted to position 'b'. The resulting current through the inductor is shown by curves in the graph for four sets of values for the resistance R and inductance L (given in the left column). Which set corresponds with which curve?





	Column I		Column II
(A)	R_0 and L_0	(p)	I
(B)	$2R_0$ and L_0	(q)	II
(C)	R_0 and $2L_0$	(r)	III
(D)	$2R_0$ and $2L_0$	(s)	IV

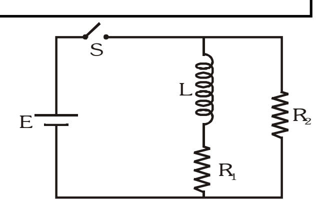
3. In column–I, variation of current i with time t is given in figures. In column–II root mean square current i_{rms}, and average current is given. Match the column–I with corresponding quantities given in column–II.

	Column I		Column II
(A)		(p)	$i_{rms} = \frac{i_0}{\sqrt{3}}$
(B)		(q)	Average current for positive half cycle is i_0
(C)		(r)	Average current for positive half cycle is $\frac{i_0}{2}$
(D)		(s)	Full cycle average current is zero

4. In the circuit shown in figure

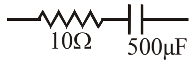
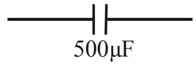
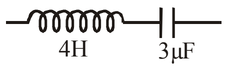
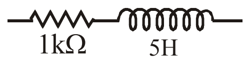
$E = 18V$, $L = 2H$, $R_1 = 3\Omega$, $R_2 = 6\Omega$.

Switch S is closed at t = 0. Match the following :

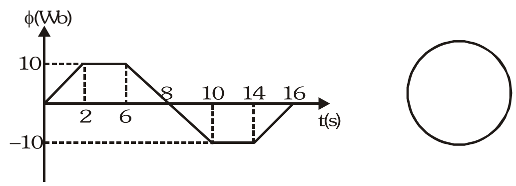


	Column–I		Column–II
(A)	Current through R_1 at $t = 0$	(p)	6A
(B)	Current through R_1 at $t = \infty$	(q)	3A
(C)	Current through R_2 at $t = 0$	(r)	Zero
(D)	Current through R_2 at $t = \infty$	(s)	Infinite

5.

	Circuit component across an ac source (ω = 200 rad/sec)		Phase difference between current and source voltage
(A)		(p)	$\frac{\pi}{2}$
(B)		(q)	$\frac{\pi}{6}$
(C)		(r)	$\frac{\pi}{4}$
(D)		(s)	$\frac{\pi}{3}$
(E)		(t)	None of the above

6. Magnetic flux in a circular coil of resistance 10Ω changes with time as shown in figure. ⊗ direction indicates a direction perpendicular to paper inwards. Match the following table :



	Column–I		Column–II
(A)	At 1s induced	(p)	clockwise current is
(B)	At 5s induced	(q)	anticlockwise current is
(C)	At 9s induced	(r)	zero current is
(D)	At 15 s induced	(s)	2A current is
		(t)	None

Assertion–Reason

1. **Statement–1** : If a charged particle is released from rest in a time varying magnetic field, it moves in a circle.

and

Statement–2 : In time varying magnetic field electric field is induced.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1

(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

2. **Statement–1** : A system cannot have mutual inductance without having self inductance.

and

Statement–2 : If mutual inductance of system is zero, its self inductances must be zero.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1

(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

3. **Statement–1** : An electric lamp is connected in series with a long solenoid of copper with air core and then connected to AC source. If an iron rod is inserted in solenoid the lamp will become dim.

and

Statement–2 : If an iron rod is inserted in solenoid, the inductance of solenoid increases.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

4. **Statement–1** : The alternating current cannot be used to conduct electrolysis.

and

Statement–2 : The ions due to their inertia, cannot follow the changing $\vec{E}$

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

5. **Statement–1** : AC source is connected across a circuit. Real power dissipated in circuit is P. The power is dissipated only across resistance.

and

Statement–2 : Inductor and capacitor will not consume any real power in AC circuit.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

6. An inductor, capacitor and resistance are connected in series. The combination is connected across AC source.

Statement–1 : Peak current through each remains same.

and

Statement–2 : Average power delivered by source is equal to average power developed across resistance.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

7. **Statement–1** : The possibility of an electric bulb fusing is higher at the time of switching ON and OFF.

and

Statement–2 : Inductive effects produce a surge at the time of switch–off and switch–on.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

8. **Statement–1** : At any instant, if the current through an inductor is zero, then the induced emf may not be zero

and

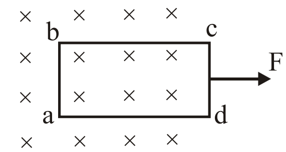
Statement–2 : An inductor tends to keep the flux (i.e. current) constant

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

Comprehension based question

Comprehension#1

A rectangular frame of wire abcd has dimensions 32 cm 8.0 cm and a total resistance of 2.0 Ω. It is pulled out of a magnetic field B = 0.020 T by applying a force of 3.2 10^{-5} N (figure). It is found that the frame moves with constant speed.



1. The constant speed of the frame is–

(A) 25 m/s (B) 20 m/s (C) 16 m/s (D) 7.5 m/s

2. The emf induced in the loop is–

(A) 8.0 10^{-2} V (B) 5.0 10^{-2} V (C) 2.0 10^{-2} V (D) 4.0 10^{-2} V

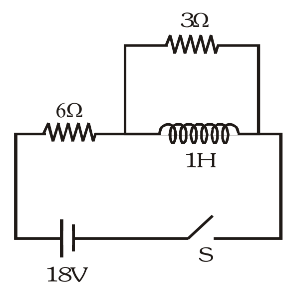
3. The potential difference between the points a and b is equal to–

(A) 4.8 10^{-2} V (B) 3.6 10^{-2} V (C) 2.4 10^{-2} V (D) 1.6 10^{-2} V

Comprehension#2

In an L–R circuit current growth takes place according to the law : $i = i_0(1 - e^{-t/\tau_L})$

Here i_0 is the steady state current (at $t \to \infty$) given by $\frac{V}{R}$. V is the applied voltage and R the resistance of circuit. $\tau_L = \frac{L}{R}$ is called time constant. Potential difference across inductor is given by $V_L = L\frac{di}{dt}$, where L is the inductance.



At time t = 0, an inductor offers infinite resistance (in dc) and at t = ∝ it offers zero resistance. Time constant of a circuit can be obtained by $\tau_L = \frac{L}{R_{net}}$, where R_{net} is the net resistance across inductor after short circulating the battery.

In the circuit shown in figure switch S is closed at time t = 0.

1. Current i from the battery at time t is given by :–

(A) $3(1 - e^{-2t})$ (B) $3 + e^{-2t}$ (C) $3(1 - e^{-t/9})$ (D) $3 - e^{-2t}$

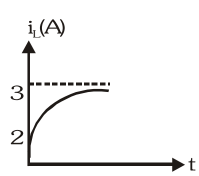
2. Potential difference across 3Ω resistance at time t is given by :–

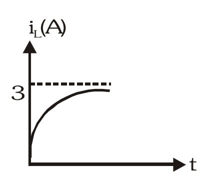
(A) $9e^{-2t}$ (B) $6e^{-2t}$ (C) $3e^{-2t}$ (D) $18(1 - e^{-t/9})$

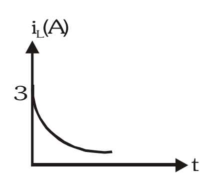
3. At what time current through 3Ω resistance and 1H inductor are equal ?

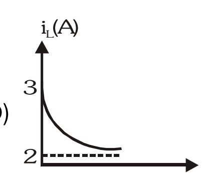
(A) $\ln\sqrt{\frac{5}{3}}$ (B) $\ln\left(\frac{8}{3}\right)$ (C) $\ln\left(\frac{5}{3}\right)$ (D) $\ln\sqrt{\frac{8}{3}}$

4. Taking left to right current through the inductor as positive current, current through inductor varies with time t as :–

(A)


(B)


(C)


(D)


Comprehension#3

(i) When a charged capacitor is connected to an inductor and allowed to discharge, the charge starts oscillating simple harmonically. The differential equation of these oscillations is : $\frac{d^2q}{dt^2} = -\left(\frac{1}{LC}\right)q$

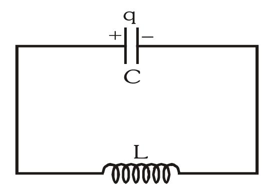
(ii) As in normal SHM, kinetic energy and potential energy remains constant. In the oscillations of charge $\frac{1}{2}Li^2 + \frac{1}{2}CV^2$ = constant.

1. Comparing the L–C oscillations with the oscillations of a spring–block system (force constant of spring = k and mass of block = m), the physical quantity mk is similar to :–

(A) CL (B) $\frac{1}{CL}$ (C) $\frac{C}{L}$ (D) $\frac{L}{C}$

Comprehension#4

In an L–C circuit shown in figure : C=1F, L = 4H. At time t = 0, charge in the capacitor is 4C and it is decreasing at a rate of $\sqrt{5}C/s$.



1. Maximum charge in the capacitor can be :–

(A) 6C (B) 8C (C) 10C (D) 12C

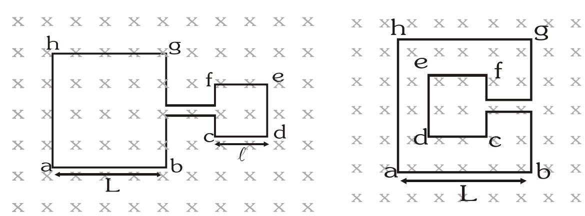
2. Charge in the capacitor will be maximum after time t = ... second.

(A) $2\sin^{-1}\left(\frac{2}{3}\right)$ (B) $2\cos^{-1}\left(\frac{2}{3}\right)$ (C) $2\tan^{-1}\left(\frac{2}{3}\right)$ (D) none of these

Note : That $\sin^{-1}\left(\frac{2}{3}\right)$, $\cos^{-1}\left(\frac{2}{3}\right)$ or $\tan^{-1}\left(\frac{2}{3}\right)$ are in radian.

Comprehension#5

The adjoining figure shows two different arrangements in which two square wire frames are placed in a uniform constantly decreasing magnetic field B.



1. The value of magnetic flux in each case is given by

(A) Case I : $\Phi = \pi\left(L^2 + \ell^2\right)B$, Case II $\Phi = \pi\left(L^2 - \ell^2\right)B$

(B) Case I : $\Phi = \pi\left(L^2 + \ell^2\right)B$, Case II : $\Phi = \pi\left(L^2 + \ell^2\right)B$

(C) Case I : $\Phi = \left(L^2 + \ell^2\right)B$, Case II : $\Phi = \left(L^2 - \ell^2\right)B$ (D) Case I : $\Phi = \left(L + \ell\right)^2 B$, Case II: $\Phi = \left(L - \ell\right)^2 B$

2. The direction of induced current in the case I is

(A) from a to b and c to d (B) from a to b and from f to e

(C) from b to a and from d to c (D) from b to a and from e to f

3. The direction of induced current in the case II is

(A) from a to b and from c to d (B) from b to a and from f to e

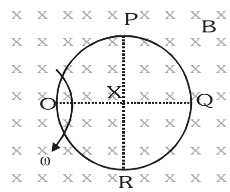
(C) from b to a and from c to d (D) from a to b and from d to c

4. If I_1 and I_2 are the magnitudes of induced current in the cases I and II, respectively, then

(A) $I_1 = I_2$ (B) $I_1 > I_2$ (C) $I_1 < I_2$ (D) nothing can be said

Comprehension#6

A conducting ring of radius a is rotated about a point O on its periphery as shown in the figure in a plane perpendicular to uniform magnetic field B which exists everywhere. The rotational velocity is ω.



1. Choose the correct statemnt(s) related to the potential of the points P, Q and R

(A) $V_P - V_O > 0$ and $V_R - V_O < 0$
(B) $V_P = V_R > V_O$
(C) $V_O > V_P = V_Q$
(D) $V_Q - V_P = V_P - V_O$

2. Choose the correct statement(s) related to the magnitude of potential differences

(A) $V_P - V_O = \frac{1}{2}B\omega a^2$
(B) $V_P - V_Q = \frac{1}{2}B\omega a^2$
(C) $V_Q - V_O = 2B\omega a^2$
(D) $V_P - V_R = 2B\omega a^2$

3.. Choose the correct statement(s) related to the induced current in the ring

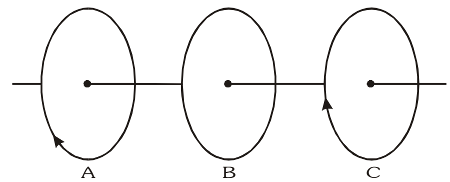
(A) current flows from $Q \to P \to O \to R \to Q$
(B) Current flows from $Q \to R \to O \to P \to Q$
(C) Current flows from $Q \to P \to O$ and from $Q \to R \to O$
(D) No current flows

MISCELLANEOUS TYPE QUESTION — **ANSWER KEY** — EXERCISE -3

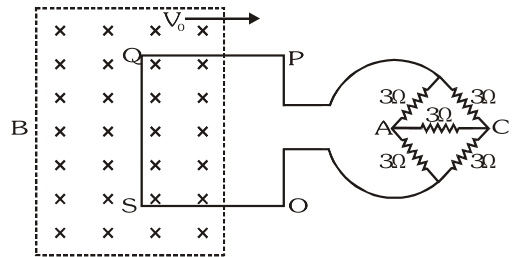
- ***True / False*** 1.F 2. T 3. F 4. (i)F (ii) T 5. F
- ***Fill in the Blanks*** 1. 3 10^{-5}, 10 2. Left to right 3. 15
  4. 2.5 10^{-3} s 5. $2I_0/\pi$
- ***Match the Column*** 1. (A) q (B) q (C) p (D) s 2. (A) r (B) p (C) s (D) q
  3. (A) s (B) p,r,s (C) q,s (D) q 4. (A) r (B) p (C) q (D) q
  5. (A) q,r (B) p,s (C) p,r (D) q,s 6. (A) q (B) r (C) p (D) q
- ***Assertion – Reason*** 1. D 2. C 3. A 4. A 5. A
  6. B 7. A 8. B
- ***Comprehension*** Comp.#1 : 1. A 2. D 3. B Comp #2 : 1.D2. B 3. A
  Comp#3 : 1. D Comp#4 : 1. A 2. D
  Comp#5 : 1. C 2. C 3. B 4. B Comp #6 : 1. B,D 2. C 3. D

EXERCISE–04 [A] CONCEPTUAL SUBJECTIVE EXERCISE

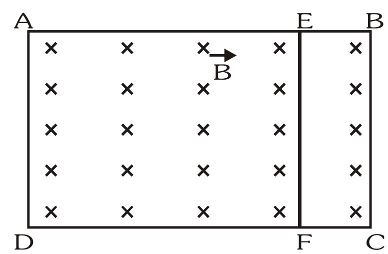
1. Three identical closed coils A, B and C are placed with their planes parallel to one another. Coils A and C carry equal currents as shown in figure. Coils B and C are fixed in position and coil A is moved towards B with uniform motion. Is there any induced current in B? If no, give reasons. If yes, mark the direction of the induced current in the diagram.



2. A square metal wire loop of side 10 cm and resistance 1 Ω is moved with a constant velocity v_0 in a uniform magnetic field of induction B = 2 weber / m^2 as shown in the figure. The magnetic field lines are perpendicular to the plane of the loop (directed into the paper). The loop is connected to a network of resistors each of value 3Ω .The resistance of the lead wires OS and PQ are negligible. What should be the speed of the loop so as to have a steady current of 1 mA in the loop. Give the direction of current in the loop.



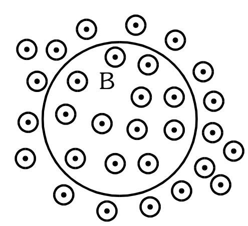
3. A rectangular frame ABCD, made of a uniform metal wire, has a straight connection between E and F made of the same wire, as shown in figure AEFD is a square of side 1 m and EB = FC = 0.5 m. The entire circuit is placed in a steadily increasing, uniform magnetic field directed into the plane of the paper and normal to it. The rate of change of the magnetic field is 1 T/s. The resistance per unit length of the wire is 1 Ω/m. Find the magnitude and directions of the currents in the segments AE, BE and EF.



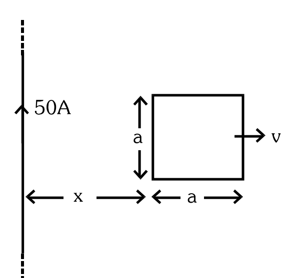
4. A 5 Ω coil of 100 turns and diameter 6 cm, is placed between the poles of a magnet so that the flux is maximum through its area. When the coil is suddenly removed from the field of the magnet, a charge of $\left(\frac{\pi}{100}\right)$ C flows through a 895 Ω galvanometer connected to the coil. Compute B between the poles of the magnet.

5. The current in solenoid of radius 'R' and having 'n' turns per unit length is given by $i = i_0 \sin\omega t$. A coil having N turns wound around it near the centre. Find the induced emf in the coil.

6. A circular loop is placed in a uniform magnetic field B directed vertically upward. What will be the direction of induced current in the loop, if
(i) B increases
(ii) B decrease
(iii) The loop contracts
(iv) The loop stretched



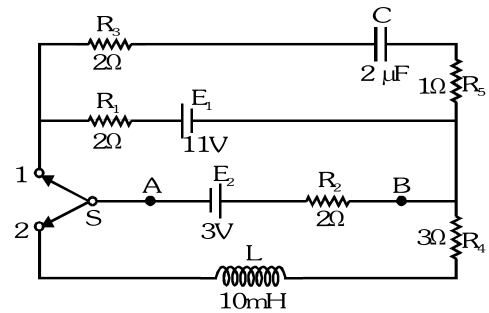
7. Evaluate the induced emf in the loop if the long wire carries a current of 50 A and the loop has an instantaneous velocity v = 10 m/sec at the location x=0.2m as shown in figure. (Take a = 0.1 m)



8. An a.c. generator consists of a coil of 50 turns and area 2.5 m^2 rotating at an angular speed of 60 rad sec^{-1} in a uniform magnetic field B = 0.30 T between two fixed pole pieces. The resistance of the circuit including that of the coil is 500Ω.
(i) Find the maximum current drawn from the generator.
(ii) What will be the orientation of the coil w.r.t. the magnetic field to have
(A) maximum magnetic flux (B) zero magnetic flux.
(iii) Would the generator work if the coil were stationary and instead the poles were rotated with same speed as above.

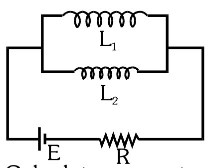
9. The primary and secondary coils of transformer have 50 and 5000 turns respectively. If the magnetic flux ϕ linked with the primary coil is given by $\phi = \phi_0 + 4t$, where ϕ is in webers, t is time in seconds and ϕ_0 is a constant then calculate the output voltage across the secondary coil.

10. A circuit containing a two position switch S is shown in figure.



(i) The switch S is in position 1. Find the potential difference $V_A - V_B$ and the rate of production of joule heat in R_1.
(ii) If now the switch S is put in position 2 at t = 0. Find :
(A) steady current in R_4 and
(B) the time when current in R_4 is half the steady value. Also calculate the energy stored in the inductor L at that time.

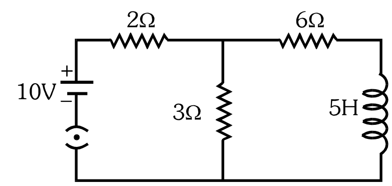
11.



Calculate following in steady state for given circuit.

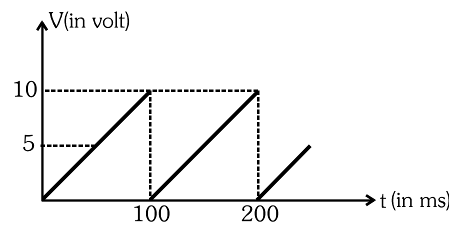
(i) Current in L_1 (ii) Current in R

12. Calculate current, which given by battery for the following circuit.



(i) Just after closing of the key.
(ii) Some time after closing of the key

13. A periodic voltage wave form has been shown in fig. Determine.



(i) Frequency of the wave form.
(ii) Average value.

14. An alternating current is given by $I = I_1\cos\omega t + I_2\sin\omega t$. Calculate its rms value.

15. The current and voltage in a circuit is given by i = 3.5 sin (628t + 30) A , V = 28 sin (628t–30) volt
Find (i) time period of current (ii) phase difference between voltage and current.

16. The source voltage and current in the circuit are represented by the following equations

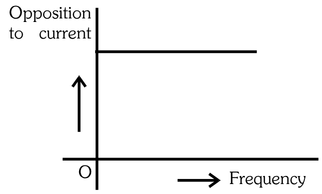
$$E = 110\sin\left(\omega t + \frac{\pi}{6}\right) \text{ volt}, \quad I = 5\sin\left(\omega t - \frac{\pi}{6}\right) \text{ ampere}$$

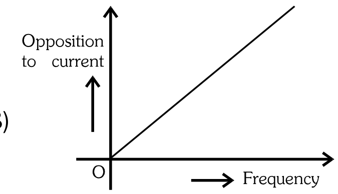
Find :– (i) Impedance of circuit. (ii) Power factor with nature

17. An inductance has a resistance of 100 Ω. When a.c. signal of frequency 1000 Hz is applied to the coil, the applied voltage leads the current by 45 . Calculate the self inductance of the coil.

18. When an alternating voltage of 220V is applied across a device X, a current of 0.5 A flows through the circuit and is in phase with the applied voltage. When the same voltage is applied across another device Y, the same current again flows through the circuit but it leads the applied voltage by π/2 radians.
(i) Name the devices X and Y.
(ii) Calculate the current flowing in the circuit when same voltage is applied across the series combination of X and Y.

19. The given graphs (A) and (B) represent the variation of the opposition offered by the circuit element to the flow of alternating current, with frequency of the applied emf. Identify the circuit element corresponding to each graph.

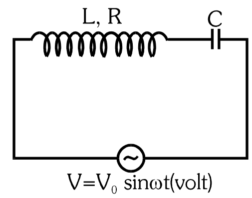
(A)


(B)


20. A choke coil of resistance R and inductance L is connected in series with a capacitor C and complete combination is connected to a.c. voltage, Circuit resonates when angular frequency of supply is $\omega = \omega_0$.

(i) Find out relation between ω_0, L and C

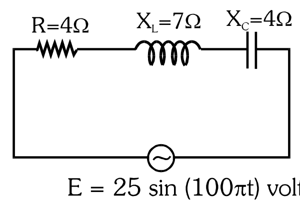
(ii) What is phase difference between V and I at resonance, is it changes when resistance of choke coil is zero.



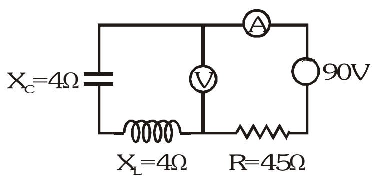
21. In a series LCR circuit as shown in fig.

(i) Find heat developed is 80 seconds

(ii) Find wattless current

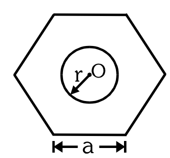


22. What will be the reading of the voltmeter and the ammeter shown in fig ?

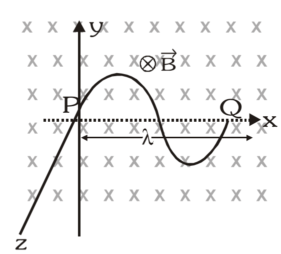


23. In an alternating circuit connected to an emf of 100 volt and frequency 50Hz, a resistance of 10 ohm and an inductance of $\frac{1}{10\pi}$ H are connected in series. Find out the power dissipated in the circuit.

24. Derive an expression of mutual inductance for shown concentric co–planner circular and regular hexagonal loops (a >> r) :

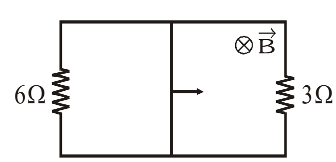


25. A wire forming one cycle of sine curve is moved in x-y plane with velocity $\vec{v} = v_x\tilde{i} + v_y\tilde{j}$. There exist a magnetic field $\vec{B} = -B_0\tilde{k}$. Find the motional emf develop across the ends PQ of wire.

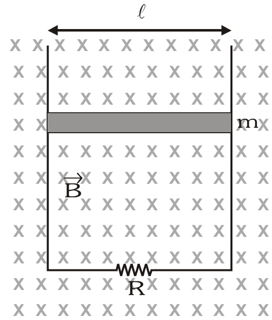


26. A rectangular loop with a sliding connector of length ℓ = 1.0 m is situated in a uniform magnetic field B =2T perpendicular to the plane of loop. Resistance of connector is r = 2Ω.

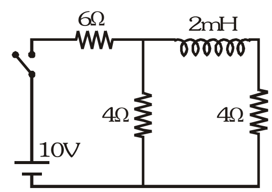
Two resistance of 6Ω and 3Ω are connected as shown in figure. Find the external force required to keep the connector moving with a constant velocity v = 2 m/s.



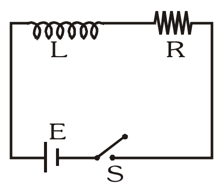
27. A horizontal wire is free to slide on the vertical rails of a conducting frame as shown in figure. The wire has a mass m and length ℓ and the resistance of the circuit is R. If a uniform magnetic field B is directed perpendicular to the frame, then find the terminal speed of the wire as it falls under the force of gravity.



28. In the given circuit, find the ratio of i_1 to i_2 where i_1 is the initial (at t=0) current and i_2 is steady state (at t=∞) current through the battery.



29. In the circuit shown in figure switch S is closed at time t=0. Find the charge which passes through the battery in one time constant.



30. In a L-R decay circuit, the initial current at t=0 is I. Find the total charge that has flown through the resistor till the energy in the inductor has reduced to one-fourth its initial value.

CONCEPTUAL SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE-4(A)

1. Yes, in the direction opposite to A **2.** 0.02 m/s, direction of induced current is clockwise

3. $\frac{7}{22}$ A(E to A), $\frac{6}{22}$ A(B to E), $\frac{1}{22}$ A(F to E) **4.** 10^2T **5.** $\mu_0 nN(\pi R^2)\ I_0\ \omega \cos \omega t$

6. (i) clockwise (ii) Anticlockwise (iii) Anticlockwise (iv) clockwise **7.** $\frac{50}{3}$ μV

8. **(i)** 4.5 A **(ii)** Flux is maximum when plane of coil is at 90 to the magnetic field, Flux is zero when plane of coil is at 0 to the magnetic field. **(iii)** Yes, It will work. **9.** 400V

10. (i) –5V,24.5W (ii) (A) 0.6A (B) 1.38 10^{-3}s, 4.5 10^{-4}J **11.** (i) $\left(\frac{L_2}{L_1+L_2}\right)\left(\frac{E}{R}\right)$ (ii) $\frac{E}{R}$

12. (i) 2A (ii) 2.5A **13.** (i) 10Hz (ii) 5V **14.** $\sqrt{\frac{I_1^2+I_2^2}{2}}$ **15.** (i) 0.01 s (ii) 60 **16.** (i) 22Ω (ii) $\frac{1}{2}$ (lagging)

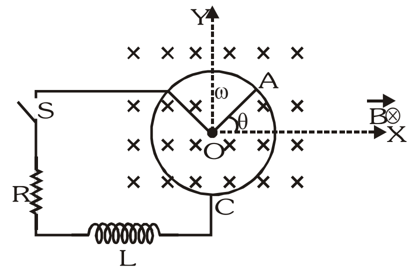
17. 15.9 mH **18.** (i) X is resistor and Y is capacitor (i) 0.35 A **19.**(i) risistor (ii) Inductor

20. (i) $\omega_0 = \frac{1}{\sqrt{LC}}$ (ii) ϕ = 0, No, it is always zero **21.** (i) 4000 J (ii) 2.12 A **22.** 2A, 0V **23.** 500 watt

24. $\frac{\sqrt{3}\mu_0 r^2}{a}$ **25.** $\lambda v_y B_0$ **26.** 2N **27.** $\frac{mgR}{B^2L^2}$ **28.** 0.8 **29.** $\frac{EL}{eR^2}$ **30.** $\frac{LI}{2R}$

EXERCISE–04 [B] BRAIN STORMING SUBJECTIVE EXERCISE

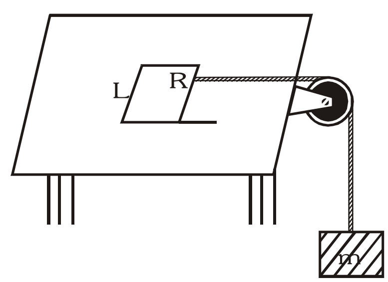
1. A metal rod OA and mass m and length r kept rotating with a constant angular speed ω in a vertical plane about 1 horizontal axis at the end O. The free end A is arranged to slide without friction along a fixed conducting circular ring in the same plane as that rotation. A uniform and constant magnetic induction $\vec{B}$ is applied perpendicular and into the plane of rotation as shown in figure.



An inductor L and an external resistance R are connected through a switch S between the point O and a point C on the ring to form an electrical circuit. Neglect the resistance of the ring and the rod. Initially, the switch is open. (i) What is the induced emf across the terminals of the switch? (ii) The switch S is closed at time t = 0. (A) Obtain an expression for the current as a function of time. (B) In the steady state, obtain the time dependence of the torque required to maintain the constant angular speed. Given that the rod OA was along the positive x–axis at t = 0.

2. A solenoid has an inductance of 10 H and a resistance of 2 Ω. It is connected to a 10 V battery. How long will it take for the magnetic energy to reach 1/4 of its maximum value ?

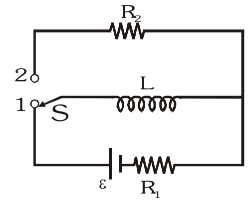
3. A pair of parallel horizontal conducting rails of negligible resistance shorted at one end is fixed on a table. The distance between the rails is L. A conducting massless rod of resistance R can slide on the rails frictionlessly. The rod is tied to a massless string which passes over a pulley fixed to the edge of the table. A mass m tied to the other end of the string hangs vertically. A constant magnetic field B exists perpendicular to the table. If the system is released from rest. Calculate : (i) the terminal velocity achieved by the rod, and (ii) the acceleration of the mass at the instant when the velocity of the rod is half the terminal velocity.



4. An infinitesimally small bar magnet of dipole moment $\vec{M}$ is pointing and moving with the speed v in the $\vec{X}$ – direction. A small closed circular conducting loop of radius a and negligible self–inductance lies in the y–z plane with its centre at x = 0, and its axis coinciding with the x–axis . Find the force opposing the motion of the magnet, if the resistance of the loop is R. Assume that the distance x of the magnet from the centre of the loop is much greater than a.

5. A metal rod of resistance 20Ω is fixed along a diameter of a conducting ring of radius 0.1 m and lies on x-y plane. There is a magnetic field $\vec{B} = (50T)\hat{k}$. The ring rotates with an angular velocity $\omega = 20 rad/sec$ about its axis. An external resistance of 10Ω is connected across the centre of the ring and rod. Find the current through external resistance.

6. In the circuit shown, initially the switch is in position 1 for a long time. Then the switch is shifted to position 2 for a long time. Find the total heat produced in R_2.

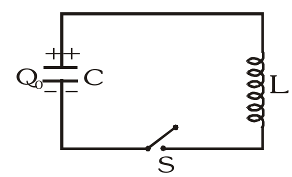


7. There exists a uniform cylindrically symmetric magnetic field directed along the axis of a cylinder but varying with time as B= kt. If an electron is released from rest in this field at a distance of 'r' from the axis of cylinder, its acceleration, just after it is released would be (e and m are the electronic charge and mass respectively).

8. Two coils, 1 & 2, have a mutual inductance = M and resistance R each. A current flows in coil 1, which varies with time as : $I_1 = kt^2$, where k is a constant and 't' is time. Find the total charge that has flown through coil 2, between t=0 and t=T.

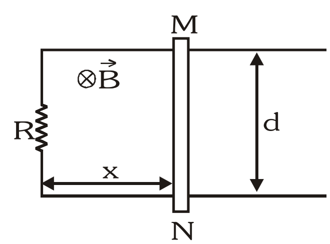
9. A charged ring of mass m=50 gm, charge 2 coulomb and radius R=2m is placed on a smooth horizontal surface. A magnetic field varying with time at a rate of (0.2 t) Tesla / sec is applied on to the ring in a direction normal to the surface of ring. Find the angular speed trained in a time t_1 = 10 sec.

10. A capacitor C with a charge Q_0 is connected across an inductor through a switch S. If at t=0, the switch is closed, then find the instantaneous charge q on the upper plate of capacitor.

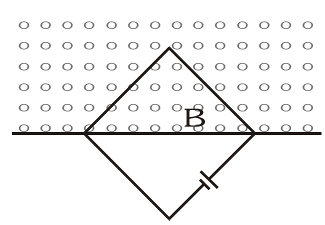


11. A uniform but time varying magnetic field B = Kt - C; $(0 \le t \le C/K)$, where K and C are constants and t is time, is applied perpendicular to the plane of the circular loop of radius 'a' and resistance R. Find the total charge that will pass around the loop.

12. Two long parallel rails, a distance ℓ apart and each having a resistance λ per unit length are joined at one end by a resistance R. A perfectly conducting rod MN of mass m is free to slide along the rails without friction. There is a uniform magnetic field of induction B normal to the plane of the paper and directed into the paper. A variable force F is applied to the rod MN such that, as the rod moves, a constant current i flows through R. Find the velocity of the rod and the applied force F as function of the distance x of the rod from R.



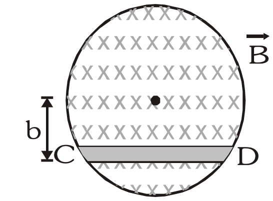
13. A square wire loop with 2 m sides in perpendicular to a uniform magnetic field, with half the area of the loop in the field. The loop contains a 20V battery with negligible internal resistance. If the magnitude of the field varies with time according to B = 0.042 - 0.87 t, with B in tesla & t in second.



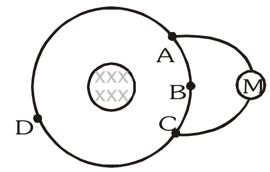
(i) What is the total emf in the circuit?

(ii) What is the direction of the current through the battery?

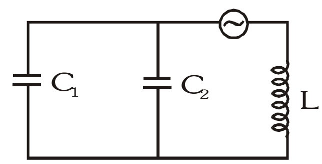
14. A uniform magnetic field $\vec{B}$ fills a cylindrical volumes of radius R. A metal rod CD of length ℓ is placed inside the cylinder along a chord of the circular cross-section as shown in the figure. If the magnitude of magnetic field increases in the direction of field at a constant rate dB/dt, find the magnitude and direction of the EMF induced in the rod.



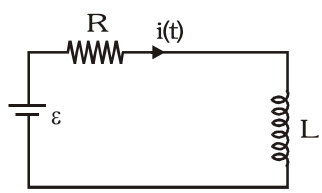
15. A variable magnetic field creates a constant emf E in a conductor ABCDA. The resistance of portion ABC, CDA and AMC are R_1, R_2 and R_3 respectively. What current will be shown by meter M? The magnetic field is concentrated near the axis of the circular conductor.



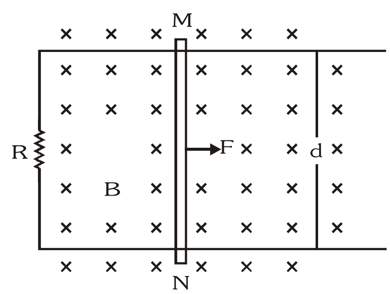
16. Consider the circuit shown in figure. The oscillating source of emf deliver a sinusoidal emf of amplitude e_{max} and frequency ω to the inductor L and two capacitors C_1 and C_2. Find the maximum instantaneous current in each capacitor.



17. Suppose the emf of the battery, the circuit shown varies with time t so the current is given by i(t) = 3 + 5t, where i is in amperes & t is in seconds. Take R=4Ω, L = 6H & find an expression for the battery emf as function of time.



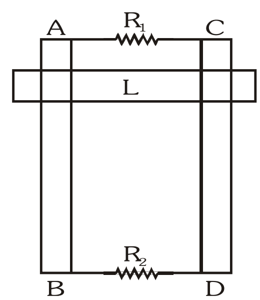
18. Two long parallel horizontal rails, a distance d apart and each having a resistance λ per unit length, are joined at one end by a resistance R. A perfectly conducting rod MN of mass m is free to slide along the rails without friction (see figure). There is a uniform magnetic field of induction B normal to the plane of the paper and directed into the paper. A variable force F is applied to the rod such that, as the rod moves a constant current flows through R.



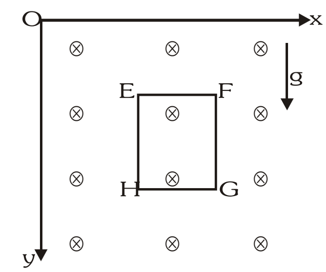
(i) Find the velocity of the rod and the applied force F as functions of the distance x of the rod from R.

(ii) What fraction of the work done per second by F is converted into heat?

19. Two parallel vertical metallic rails AB and CD are separated by 1 m. They are connected at two ends by resistance R_1 and R_2 as shown in figure. A horizontal metallic bar of mass 0.2 kg slides without friction vertically down the rails under the action of gravity. There is a uniform horizontal magnetic field of 0.6 T perpendicular to the plane of the rails. It is observed that when the terminal velocity is attained, the powers dissipated in R_1 and R_2 are 0.76 W and 1.2 W respectively. Find the terminal velocity of the bar L and the values of R_1 and R_2.



20. A magnetic field $B = (B_0 y / a)\vec{k}$ is acting into the paper in the +z direction.



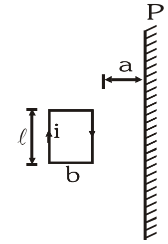
B_0 and a are positive constants. A square loop EFGH of side a, mass m and resistance R in x–y plane starts falling under the influence of gravity. Note the directions of x and y in the figure. find :

(i) the induced current in the loop and indicate its direction.

(ii) the total Lorentz force acting on the loop and indicate its direction.

(iii) an expression for the speed of the loop v (t) and its terminal velocity.

21. A rectangular loop with current I has dimension as shown in figure. Find the magnetic flux ϕ through the infinite region to the right of line PQ.



BRAIN STORMING SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE–4(B)

1. (i) $E = \frac{1}{2}B\omega r^2$ (ii) (A) $I = \frac{B\omega r^2(1-e^{\frac{-Rt}{L}})}{2R}$ (B) $\tau = \frac{mgr}{2}\cos\omega t + \frac{\omega B^2 r^4}{4R}$

2. $t = \frac{L}{R}\ell n2 = 3.47$ sec

3. (i) $V_{terminal} = \frac{mgR}{B^2L^2}$, (ii) $\frac{g}{2}$

4. $F = \frac{2I}{4}\frac{\mu_0^2 M^2 a^4 V}{Rx^8}$ (Repulsion)

5. $\frac{1}{3}A$

6. $\frac{L\varepsilon^2}{2R_1^2}$

7. $\frac{erK}{2m}$

8. $\frac{kMT^2}{R}$

9. 200 rad/s

10. $Q_0 \sin\left[\frac{1}{\sqrt{LC}}t + \frac{\pi}{2}\right]$

11. $\frac{C\pi a^2}{R}$

12. $\frac{I(R+2\lambda x)}{Bd}$ $\frac{2I^2 m\lambda(R+2\lambda x)}{B^2d^2}$

13. (i) 21.74V (ii) anticlockwise

14. $\frac{\ell}{2}\frac{dB}{dt}\sqrt{R^2 - L^2/4}$

15. $\frac{ER_1}{R_1R_2 + R_2R_3 + R_3R_1}$

16. $(I_1)_{max}\ \frac{E_{max}}{\frac{C_2}{C_1}\left(1+\frac{C_1}{C_2}\right)\left[\omega L - \frac{1}{\omega(C_1+C_2)}\right]}$, $(I_2)_{max}\ \frac{E_{max}}{\left(1+\frac{C_1}{C_2}\right)\left[\omega L - \frac{1}{\omega(C_1+C_2)}\right]}$

17. 42 + 20t volt

18. (i) $v = \frac{(R+2\lambda x)i}{Bd}$; $F = \frac{2\lambda i^2 m}{B^2d^2}(R + 2\lambda x) + idB$ (ii) $\frac{B^3d^3}{B^3d^3 + 2m\lambda\tau(R+2\lambda x)}$

19. v = 1 m/s, $R_1 = 0.47\ \Omega$, $R_2 = 0.3\Omega$

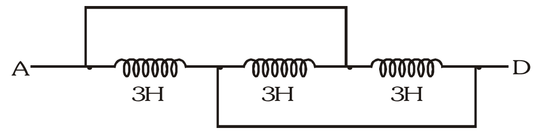
20. (i) $i = \frac{B_0 av}{R}$ anticlockwise (ii) $\vec{F} = -\frac{B_0^2a^2}{R}\hat{j}$ (iii) $v = \frac{g}{k}(1-e^{-kT})$ where $k = \frac{B_0^2a^2}{mR}$, $v_t = \frac{g}{k} = \frac{gmR}{B_0^2a^2}$

21. $\frac{\mu_0}{2\pi}IL\ell n\frac{a+b}{a}$

EXERCISE–05(A) PREVIOUS YEARS QUESTIONS

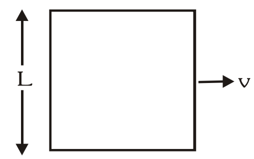
ELECTROMAGNETIC INDUCTION

1. The inductance between A and D is- [AIEEE - 2002]



(1) 3.66 H (2) 9 H (3) 0.66 H (4) 1 H

2. A conducting square loop of side L and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B constant in time and space, pointing perpendicular and into the plane at the loop exists everywhere with half the loop outside the field, as shown in figure. The induced emf is- [AIEEE - 2002]



(1) zero
(2) RvB
(3) $\frac{vBL}{R}$
(4) vBL

3. In a transformer, number of turns in the primary are 140 and that in the secondary are 280. If current in primary is 4A, then that in the secondary is- [AIEEE - 2002]

(1) 4 A (2) 2 A (3) 6 A (4) 10 A

4. The core of any transformer is laminated so as to- [AIEEE - 2003]

(1) reduce the energy loss due to eddy currents (2) make it light weight
(3) make it robust and strong (4) increase the secondary voltage

5. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon- [AIEEE - 2003]

(1) the rates at which currents are changing in the two coils
(2) relative position and orientation of the two coils
(3) the materials of the wires of the coils
(4) the currents in the two coils

6. When the current changes from +2A to – 2A in 0.05 s, an emf of 8V is induced in a coil. The coefficient of self-induction of the coil is- [AIEEE - 2003]

(1) 0.2 H (2) 0.4 H (3) 0.8 H (4) 0.1 H

7. A coil having n turns and resistance R Ω is connected with a galvanometer of resistance 4RΩ. This combination is moved in time t seconds from a magnetic field W_1 weber to W_2 weber. The induced current in the circuit is- [AIEEE - 2004]

(1) $\frac{W_2 - W_1}{5Rnt}$ (2) $-\frac{n(W_2 - W_1)}{5Rt}$ (3) $-\frac{(W_2 - W_1)}{Rnt}$ (4) $-\frac{n(W_2 - W_1)}{Rt}$

8. In a uniform magnetic field of induction B, a wire in the form of semicircle of radius r rotates about the diameter of the circle with angular frequency ω. If the total resistance of the circuit is R, the mean power generated per period of rotation is- [AIEEE - 2004]

(1) $\frac{B\pi r^2\omega}{2R}$ (2) $\frac{(B\pi r^2\omega)^2}{8R}$ (3) $\frac{(B\pi r\omega)^2}{2R}$ (4) $\frac{(B\pi r\omega^2)^2}{8R}$

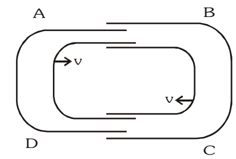
9. A metal conductor of length 1 m rotates vertically about one of its ends at angular velocity 5 radians per second. If the horizontal component of earth's magnetic field is 0.2 10^{-4} T, then the emf developed between the two ends of the conductor is- [AIEEE - 2004]

(1) 5 μ V (2) 50 μV (3) 5 mV (4) 50 mV

10. A coil of inductance 300 mH and resistance 2Ω is connected to a source of voltage 2V. The current reaches half of its steady state value in- **[AIEEE - 2005]**

(1) 0.05 s (2) 0.1 s (3) 0.15 s (4) 0.3 s

11. One conducting U-tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field B is perpendicular to the plane of the figure. If each tube moves towards the other at a constant speed v, then the emf induced in the circuit in terms of B, ℓ and v, where ℓ is the width of each tube, will be- **[AIEEE - 2005]**

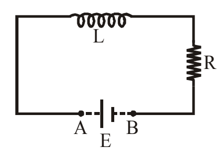


(1) $B\ell v$ (2) $-B\ell v$ (3) zero (4) $2B\ell v$

12. The flux linked with a coil at any instant 't' is given by :$\phi = 10t^2 - 50t + 250$.The induced emf at t = 3s is- **[AIEEE - 2006]**

(1) – 190 V (2) – 10 V (3) 10 V (4) 190 V

13. An inductor (L = 100 mH), a resistor (R = 100Ω) and a battery (E = 100 V) are initially connected in series as shown in the figure. After a long time the battery is disconnected after short circuiting the points A and B. The current in the circuit 1 ms after the short circuit is- **[AIEEE - 2006]**



(1) 1/e A (2) e A (3) 0.1 A (4) 1 A

14. The rms value of the electric field of the light coming from the sun is 720 N/C. The average total energy density of the electromagnetic wave is **[AIEEE-2006]**

(1) 4.58 10^{-6} J/m^3 (2) 6.37 10^{-9} J/m^3 (3) 81.35 10^{-12} J/m^3 (4) 3.3 10^{-3} J/m^3

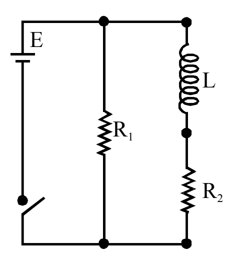
15. An ideal coil of 10 H is connected in series with a resistance of 5Ω and a battery of 5 V.2s after the connection is made, the current flowing (in ampere) in the circuit is- **[AIEEE - 2007]**

(1) (1 – e) (2) e (3) e^{-1} (4) $(1 - e^{-1})$

16. Two coaxial solenoids are made by winding thin insulated wire over a pipe of cross-sectional area A = 10 cm^2 and length = 20 cm. If one of the solenoids has 300 turns and the other 400 turns, their mutual inductance is $\left(\mu_0 = 4\pi \times 10^{-7}\,\mathrm{TmA^{-1}}\right)$ **[AIEEE - 2008]**

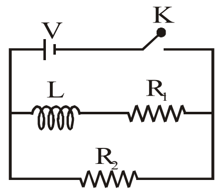
(1) $2.4\ \pi \times 10^{-5}$ H (2) $4.8\ \pi \times 10^{-4}$H (3) $4.8\ \pi \times 10^{-5}$H (4) $2.4\ \pi \times 10^{-4}$H

17. An inductor of inductance L = 400 mH and resistors of resistances R_1 = 2Ω and R_2 = 2Ω are connected to a battery of emf 12V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at t = 0. The potential drop across L as a function of time is:- **[AIEEE - 2009]**



(1) $6(1 - e^{-t/0.2})$V (2) $12e^{-5t}$ V (3) $6e^{-5t}$ V (4) $\frac{12}{t}e^{-3t}$V

18. In the circuit show below, the key K is closed at t = 0. The current through the battery is : [AIEEE - 2010]



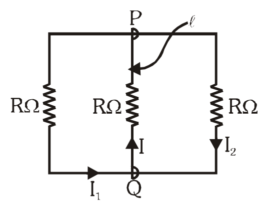
(1) $\dfrac{V(R_1+R_2)}{R_1R_2}$ at t = 0 and $\dfrac{V}{R_2}$ at t = ∞

(2) $\dfrac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at t = 0 and $\dfrac{V}{R_2}$ at t = ∞

(3) $\dfrac{V}{R_2}$ at t = 0 and $\dfrac{V(R_1+R_2)}{R_1R_2}$ at t = ∞

(4) $\dfrac{V}{R_2}$ at t = 0 and $\dfrac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at t = ∞

19. A rectangular loop has a sliding connector PQ of length ℓ and resistance RΩ and it is moving with a speed v as shown. The set-up is placed in a uniform magnetic field going into the plane of the paper. The three currents I_1, I_2 and I are :- [AIEEE - 2010]



(1) $I_1 = I_2 = \dfrac{B\ell v}{6R}$, $I = \dfrac{B\ell v}{3R}$

(2) $I_1 = -I_2 = \dfrac{B\ell v}{R}$, $I = \dfrac{2B\ell v}{R}$

(3) $I_1 = I_2 = \dfrac{B\ell v}{3R}$, $I = \dfrac{2B\ell v}{3R}$

(4) $I_1 = I_2 = I = \dfrac{B\ell v}{R}$

20. A boat is moving due east in a region where the earth's magnetic field is 5.0 10^{-5} $NA^{-1}m^{-1}$ due north and horizontal. The boat carries a vertical aerial 2m long. If the speed of the boat is 1.50 ms^{-1}, the magnitude of the indueced emf in the wire of aerial is :- [AIEEE - 2011]

(1) 0.50 mV (2) 0.15 mV (3) 1 mV (4) 0.75 mV

21. A horizontal straight wire 20 m long extending from east to west is falling with a speed of 5.0 m/s, at right angles to the horizontal component of the earth's magnetic field 0.30 10^{-4} Wb/m^2. The instantaneous value of the e.m.f. induced in the wire will be :- [AIEEE - 2011]

(1) 6.0 mV (2) 3 mV (3) 4.5 mV (4) 1.5 mV

22. A coil is suspended in a uniform magnetic field, with the plane of the coil parallel to the magnetic lines of force. When a current is passed through the coil it starts oscillating; it is very difficult to stop. But if an aluminium plate is placed near to the coil, it stops. This is due to :- [AIEEE - 2012]

(1) Electromagnetic induction in the aluminium plate giving rise to electromagnetic damping
(2) Development of air current when the plate is placed
(3) Induction of electrical charge on the plate
(4) Shielding of magnetic lines of force as aluminium is a paramagnetic material

23. A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is :- [AIEEE - 2013]

(1) 9.1 10^{-11} weber (2) 6 10^{-11} weber (3) 3.3 10^{-11} weber (4) 6.6 10^{-9} weber

ALTERNATING CURRENT

24. The power factor of an AC circuit having resistance R and inductance L (connected in series) and an angular velocity ω is- [AIEEE - 2002]

(1) $\frac{R}{\omega L}$ (2) $\frac{R}{(R^2+\omega^2 L^2)^{1/2}}$ (3) $\frac{\omega L}{R}$ (4) $\frac{R}{(R^2-\omega^2 L^2)^{1/2}}$

25. A metal wire of linear mass density of 9.8 g/m is stretched with a tension of 10 kg-wt between two rigid supports 1 m apart. The wire passes at its middle point between the poles of a permanent magnet and it vibrates in resonance when carrying an alternating current of frequency n. The frequency n of the alternating source is- [AIEEE - 2003]

(1) 50 Hz (2) 100 Hz (3) 200 Hz (4) 25 Hz

26. In an oscillating LC circuit the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic fields is- [AIEEE - 2003]

(1) Q/2 (2) $Q/\sqrt{3}$ (3) $Q/\sqrt{2}$ (4) Q

27. Alternating current can not be measured by DC ammeter because- [AIEEE - 2004]

(1) AC cannot pass through DC ammeter

(2) AC changes direction

(3) average value of current for complete cycle is zero

(4) DC ammeter will get damaged

28. In an LCR series ac circuit, the voltage across each of the components. L, C and R is 50 V. The voltage across the LC combination will be- [AIEEE - 2004]

(1) 50 V (2) $50\sqrt{2}$ V (3) 100 V (4) 0

29. In an LCR circuit, capacitance is changed from C to 2C. For the resonant frequency to remain unchanged, the inductance should be changed from L to- [AIEEE - 2004]

(1) 4 L (2) 2L (3) L/2 (4) L/4

30. The self-inductance of the motor of an electric fan is 10 H. In order to impart maximum power at 50 Hz, it should be connected to a capacitance of- [AIEEE - 2005]

(1) 4 μF (2) 8 μF (3) 1 μF (4) 2 μF

31. A circuit has a resistance of 12 Ω and an impedance of 15 Ω. The power factor of circuit will be- [AIEEE - 2005]

(1) 0.8 (2) 0.4 (3) 1.25 (4) 0.125

32. The phase difference between the alternating current and emf is π/2. which of the following cannot be the constituent of the circuit ? [AIEEE - 2005]

(1) C alone (2) R, L (3) L, C (4) L alone

33. In a series resonant LCR circuit, the voltage across R is 100 volts and R = 1 kΩ with C = 2μF. The resonant frequency ω is 200 rad/s. At resonance the voltage across L is- **[AIEEE - 2006]**

(1) 2.5 10^{-2} V (2) 40 V (3) 250 V (4) 4 10^{-3} V

34. 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- **[AIEEE - 2006]**

(1) NABRω (2) NAB (3) NABR (4) NABω

35. In an AC circuit the voltage applied is $E = E_0 \sin\omega t$. The resulting current in the circuit is $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$. The power consumption in the circuit is given by- **[AIEEE - 2007]**

(1) $P = \frac{E_0 I_0}{\sqrt{2}}$ (2) P = zero (3) $P = \frac{E_0 I_0}{2}$ (4) $P = \sqrt{2}\, E_0 I_0$

36. In a series LCR circuit R = 200Ω and the voltage and the frequency of the main supply is 220 V and 50 Hz respectively. On taking out the capacitance from the circuit the current lages behind the voltage by 30 . On taking out the inductor from the circuit the current leads the voltage by 30 . The power dissipated in the LCR circuit is : **[AIEEE - 2010]**

(1) 242 W (2) 305 W (3) 210 W (4) Zero W

37. A fully charged capacitor C with intial charge q_0 is connected to a coil of self inductance L at t = 0. The time at which the energy is stored equally between the electric and the magnetic fields is :- **[AIEEE - 2011]**

(1) $2\pi\sqrt{LC}$ (2) $\sqrt{LC}$ (3) $\pi\sqrt{LC}$ (4) $\frac{\pi}{4}\sqrt{LC}$

ANSWER-KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	4	2	1	2	4	2	2	2	2	4	2	1	1	4	4	2	3	3	2
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37			
Ans.	2	1	1	2	1	3	3	4	3	3	1	2	3	4	2	1	4			

EXERCISE–05(B) PREVIOUS YEARS QUESTIONS

MCQ's (only one correct answers)

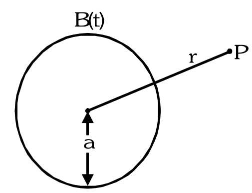
1. A Metal rod moves at a constant velocity in a direction perpendicular to its length. A constant uniform magnetic field exist in space in a direction perpendicular to the rod as well as its velocity. Select the correct statement (s) from the following : [IIT-JEE 1998]
(A) The entire rod is at the same electric potential
(B) There is an electric field in the rod
(C) The electric potential is highest at the centre of the rod and decreases towards its ends
(D) The electric potential is lowest at the centre of the rod and increases towards its ends.

2. A small square loop of wire of side ℓ is placed inside a large square loop of wire of side $L(L>>\ell)$. The loop are coplanar and their centres coincide. The mutual inductance of the system is proportional to :
(A) ℓ/L (B) ℓ^2/L (C) L/ℓ (D) L^2/ℓ [IIT-JEE 1998]

3. Two identical circular loops of metal wire are lying on a table without touching each other. Loop A carries a current which increases with time. In response, the loop B : [IIT-JEE 1999]
(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

4. A coil of inductance 8.4 mH and resistance 6Ω is connected to a 12 V battery. The current in the coil is one. A at approximately the time : [IIT-JEE 1999]
(A) 500 s (B) 20 s (C) 35 ms (D) 1 ms

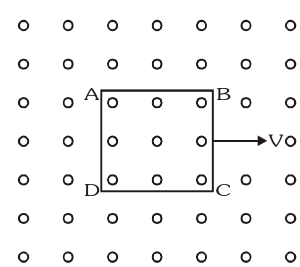
5. A uniform but time–varying magnetic field B(t) exists in a circular region of radius a and is directed into the plane of the paper as shown. The magnitude of the induced electric field at point P at a distance r from the centre of the circular region :



(A) is zero (B) decreases as $1/r$
(C) increases as r (D) decreases as $1/r^2$ [IIT-JEE 2000]

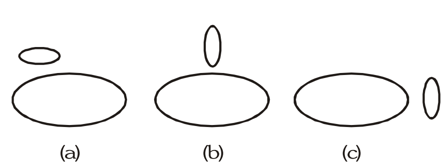
6. A coil of wire having finite inductance and resistance has a conducting ring placed co–axially within it. The coil is connected to a battery at time t = 0, so that a time dependent current I_1 (t) starts flowing through the coil. If I_2 (t) is the current induced in the ring and B(t) is the magnetic field at the axis of the coil due to I_1 (t) then as a function of time (t > 0), the product I_2 (t) B (t) : [IIT-JEE 2000]
(A) increases with time (B) decreases with time
(C) does not vary with time (D) passes through a maximum

7. A metallic square loop ABCD is moving in its own plane with velocity v in a uniform magnetic field perpendicular to its plane as shown in the figure. Electric field is induced : [IIT-JEE 2001]

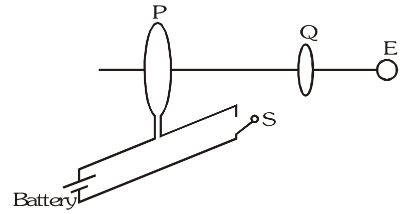


(A) in AD, but not in BC
(B) in BC, but not in AC
(C) neither in AD nor in BC
(D) in both AD and BC

8. Two circular coils can be arranged in any of the three situations shown in the figure. their mutual inductance will be : [IIT-JEE 2001]
(A) maximum in situation (A)
(B) maximum in situation (B)
(C) maximum in situation (C)
(D) the same in all situations



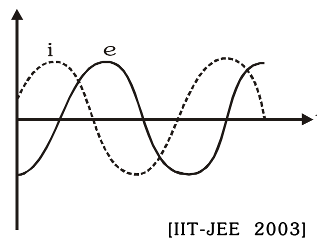
9. As shown in the figure, P and Q are two coaxil conducting loops separated by some distance. When the switch S is closed, a clockwise current I_p flows in P (as seen by E) and an induced current I_{Q_1} flows in Q. The switch remains closed for a long time. When S is opened, a current I_{Q_2} flows in Q. Then the direction I_{Q_1} and I_{Q_2} (as seen by E) are :



(A) respectively clockwise and anticlockwise
(B) both clockwise
(C) both anticlockwise
(D) respectively anticlockwise and clockwise [IIT-JEE 2002]

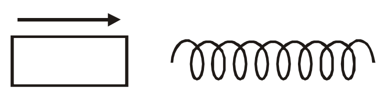
10. A short–circuited coil is placed in a time varying magnetic field. Electrical power is dissipated due to the current induced in the coil. If the number of turns were to quadrupled and the wire radius halved, the electrical power dissipated would be : [IIT-JEE 2002]
(A) halved (B) the same (C) doubled (D) quadrupled

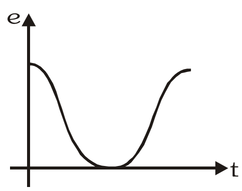
11. When an AC source of emf $e = E_0 \sin(100t)$ is connected across a circuit, the phase difference between the emf e and the current i in the circuit is observed to be $\frac{\pi}{4}$, as shown in the diagram. If the circuit consists possibly only of R–C or R–L or L–C in series, find the relationship between the two elements :

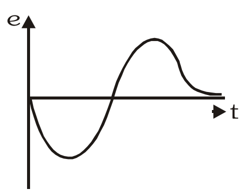


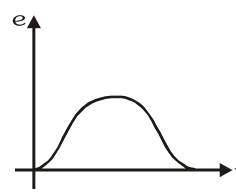
(A) $R = 1k\Omega$, $C = 10\ \mu F$ (B) $R = 1k\Omega$, $C = 1\ \mu F$
(C) $R = 1k\Omega$, $L = 10\ H$ (D) $R = 1k\Omega$, $L = 1\ H$ [IIT-JEE 2003]

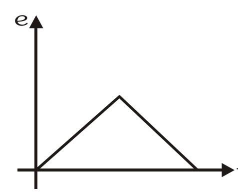
12. The variation of induced emf (e) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as : [IIT-JEE 2004]



(A) 

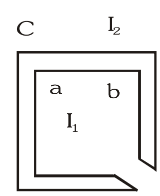
(B) 

(C) 

(D) 

13. An infinitely long cylinder is kept parallel to an uniform magnetic field B directed along positive z–axis. The direction of induced current as seen from the z–axis will be : [IIT-JEE 2005]
(A) clockwise of the +ve z–axis (B) anticlockwise of the +ve z–axis
(C) zero (D) along the magnetic field

14. The figure shows certain wire segments joined together to form a coplanar loop. The loop is placed in a perpendicular magnetic field in the direction going into the plane of the figure. The magnitude of the field increases with time. I_1 and I_2 are the currents in the segments ab and cd. Then

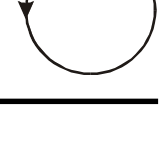


(A) $I_1 > I_2$
(B) $I_1 < I_2$
(C) I_1 is in the direction ba and I_2 is in the direction cd
(D) I_1 is in the direction ab and I_2 is in the direction dc [IIT-JEE 2009]

15. An AC voltage source of variable angular frequency ω and fixed amplitude V_0 is connected in series with a capacitance C and an electric bulb of resistance R (inductance zero). When ω is increased [IIT-JEE 2010]
(A) the bulb glows dimmer (B) the bulb glows brighter
(C) total impedance of the circuit is unchanged (D) total impedance of the circuit increases

MCQs with one or more than one correct answer

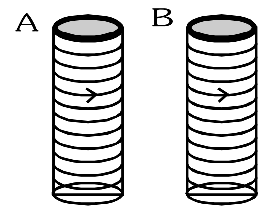
1. A field line shown in the figure. This field cannot represent.



(A) magnetic field (B) electrostatic field
(C) induced electric field (D) gravitational field [IIT-JEE 2006]

2. The SI unit of inductance, the Henry can be written as [IIT-JEE 1998]
(A) weber / ampere (B) volt-second / ampere (C) joule / (ampere)^2 (D) ohm-second

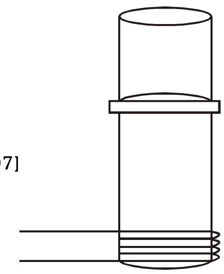
3. Two metallic rings A and B, identical in shape and size but having different resistivities ρ_A and ρ_B, are kept on top of two identical solenoids as shown in the figure. When current I is switched on in both the solenoids in identical manner, the rings A and B jump to heights h_A and h_B, respectively, with $h_A > h_B$. The possible relation(s) between their resistivities and their masses m_A and m_B is (are) :- [IIT-JEE 2009]



(A) $\rho_A > \rho_B$ and $m_A = m_B$ (B) $\rho_A < \rho_B$ and $m_A = m_B$
(C) $\rho_A > \rho_B$ and $m_A > m_B$ (D) $\rho_A < \rho_B$ and $m_A < m_B$

Assertion and Reason

1. **Statement–I** : A vertical iron rod has a coil of wire wound over it at the bottom end. An alternating current flows in the coil. The rod goes through a conducting ring as shown in the figure. The ring can float at a certain height above the coil.
Because : [IIT-JEE 2007]
Statement–II : In the above situation, a current is induced in the ring which interacts with the horizontal component of the magnetic field to produce an average force in the upward direction.



Match the column

1. You are given many resistances, capacitors and inductors. These are connected to a variable DC voltage source (the first two circuits) or an AC voltage source of 50 Hz frequency (the next three circuits) in different ways as shown in **Column II**. When a current I (steady state for DC or rms for AC) flows through the circuit, the corresponding voltage V_1 and V_2 (indicated in circuits) are related as shown in **Column I**. Match the two [IIT-JEE 2010]

Column I

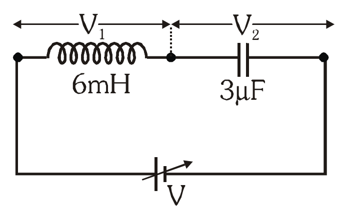
(A) $I \neq 0$, V_1 is proportional to I

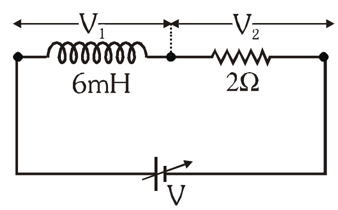
(B) $I \neq 0$, $V_2 > V_1$

(C) $V_1 = 0$, $V_2 = V$

(D) $I \neq 0$, V_2 is proportional to I

Column II

(p)


(q)


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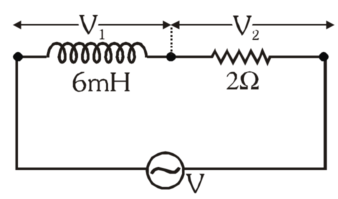

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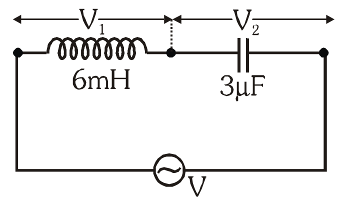
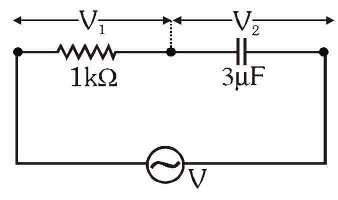


(t)


Comprehension Based Question

Comprehension#1

Modern trains are based on Maglev technology in which trains are magnetically leviated, which runs its EDS Maglev system. There are coils on both sides of wheels. Due to motion of train, current induces in the coil of track which levitate it. This is in accordance with Lenz's law. If trains lower down then due to Lenz's law a repulsive force increases due to which train gets uplifted and if it goes much high then there is a net downward force due to gravity. The advantage of Maglev train is that there is no friction between the train and the track, there by reducing power consumption and enabling the train to attain very high speeds.Disadvantage of Maglev train is that as it slows down the electromagnetic forces decreases and it becomes difficult to keep it leviated and as it moves forward according to Lenz law there there is an electromagnetic drag force. **[IIT-JEE 2006]**

1. What is the advantage of this system ?

(A) no friction hence reduced power consumption
(B) no electric power is used
(C) gravitation force is zero
(D) electrostatic force draws the train

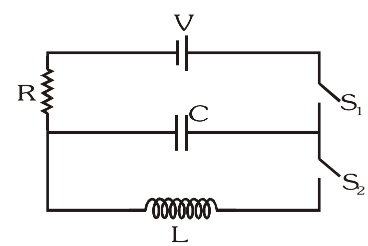
2. What is the disadvantage of this system :–

(A) By Lenz's law train experience a drag
(B) Friction force create a drag on the train
(C) Retardation
(D) Train experiences upward force according to Lenz's law

3 Which force causes the train to elevate up ?

(A) electrostatic force
(B) time varying electric field
(C) magnetic force
(D) induced electric field

Comprehension#2



The capacitor of capacitance C can be charged (with the help of a resistance R) by a voltage source V, by closing switch S_1 while keeping switch S_2 open. The capacitor can be connected in series with on inductor L by closing switch S_2 and opening S_1. **[IIT-JEE 2006]**

1. Initially, the capacitor was uncharged. Now, switch S_1 is closed and S_2 is kept open. If time constant of this circuit is τ, then :-

(A) after time interval τ, charge on the capacitor is CV/2
(B) after time interval 2τ, charge on the capacitor is $CV(1 - e^{-2})$
(C) the work done by the voltage source will be half on the heat dissipated when the capacitor is fully charged
(D) after time interval 2τ, charge on the capacitor is $CV(1 - e^{-1})$

2. After the capacitor gets fully charged S_1 is opened and S_2 is closed so that the inductor is connected in series with the capacitor. Then, :- **[IIT-JEE 2006]**

(A) at t = 0, energy stored in the circuit is purely in the form of magnetic energy
(B) at any time t >0, current in the circuit is in the same direction
(C) at t > 0, there is no exchange of energy between the inductor and capacitor
(D) at any time t > 0, maximum instantaneous current in the circuit may $V\sqrt{\frac{C}{L}}$

3. If the total charge stored in the LC circuit is Q_0, then for $t \geq 0$: **[IIT-JEE 2006]**

(A) the charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} + \frac{t}{\sqrt{LC}}\right)$

(B) the charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} - \frac{t}{\sqrt{LC}}\right)$

(C) the charge on the capacitor is $Q = -LC\frac{d^2Q}{dt^2}$ (D) the charge on the capacitor is $Q = -\frac{1}{\sqrt{LC}}\frac{d^2Q}{dt^2}$

Comprehension#3

A point charge Q is moving in a circular orbit of radius R in the x-y plane with an angular velocity ω. This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. A uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of the orbit remains constant. The application of the magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It is known that for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant γ. **[IIT-JEE 2013]**

1. The change in the magnetic dipole moment associated with the orbit, at the end of the time interval of the magnetic field change is

(A) $-\gamma BQR^2$ (B) $-\gamma\frac{BQR^2}{2}$ (C) $\gamma\frac{BQR^2}{2}$ (D) γBQR^2

2. The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the magnetic field change is

(A) $\frac{BR}{4}$ (B) $\frac{BR}{2}$ (C) BR (D) 2BR

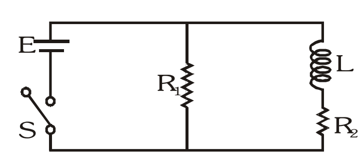
Subjective Problems

1. A thermocole vessel contains 0.5 kg of distilled water at 30 C. A metal coil of area 5 10^{-3} m^2, number of turns 100, mass 0.06 kg and resistance 1.6 Ω is lying horizontally at the bottom of the vessel. A uniform time varying magnetic field is set–up to pass vertically through the coil at time t = 0. The field is first increased from 0 to 0.8 T at a constant rate between 0 and 0.2 s and then decreased to zero from zero at the same rate between 0.2 and 0.4 s. The cycle is repeated 12000 times. Make sketches of the current through the coil and the power dissipated in the coil as a function of time for the first two cycles. Clearly indicate the magnitudes of the quantities on the axes. Assume that no heat is lost to the vessel or the surroundings. Determine the final temperature of the water under thermal equilibrium. Specific heat of metal.

= 500 J/kg – K and the specific heat of water **[IIT-JEE 2000]**

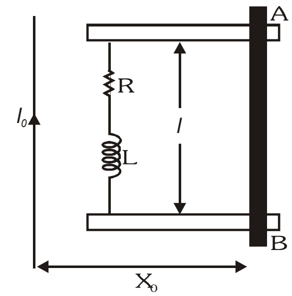
= 4200 J/kg – K. Neglect the inductance of coil.

2. An inductor of inductance L = 400 mH and resistors of resistances R_1 = 2Ω and R_2 = 2Ω are connected to a battery of emf E = 12 V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at time t = 0.



What is the potential drop across L as a function of time? After the steady state is reached, the switch is opened. What is the direction and the magnitude of current through R_1 as a function of time? **[IIT-JEE 2001]**

3. A metal bar AB can slide on two parallel thick metallic rail separated by a distance ℓ A resistance R and an inductance L are connected to the rails as shown in the figure. A long straight wire, carrying a constant current I_0 is placed in the plane of the rails and perpendicular to them as shown. The bar AB is held at rest at a distance x_0 from the long wire. At t = 0, it made to slide on the rails away from the wire. Answer the following questions. **[IIT-JEE 2002]**

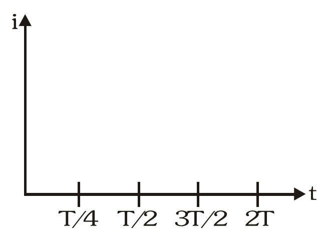


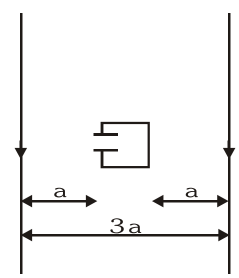
(i) Find a relation among i, $\frac{di}{dt}$ and $\frac{d\phi}{dt}$, where i is the current in the circuit and ϕ is the flux of the magnetic field due to the long wire through the circuit.

(ii) It is observed that at time t = T, the metal bar AB is at a distance of $2x_0$ from the long wire and the resistance R carries a current i_1. Obtain an expression for the net charge that has flown through resistance R from t = 0 to t = T.

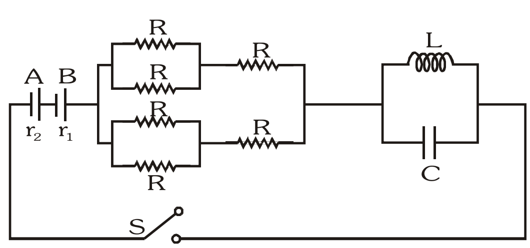
(iii) The bar is suddenly stopped at time T. The current through resistance R is found to be $i_1/4$ at time 2T. Find the value of L/R in terms of the other given quantities.

4. Two infinitely long parallel wires carrying currents $I = I_0 \sin \omega t$ in opposite directions are placed a distance 3a apart. A square loop of side a of negligible resistance with a capacitor of capacitance C is placed in the plane of wires as shown. find the maximum current in the square loop. Also sketch the graph showing the variation of charge on the upper plate of the capacitor as a function of time for one complete cycle taking anticlockwise direction for the current in the loop as positive. **[IIT-JEE 2003]**

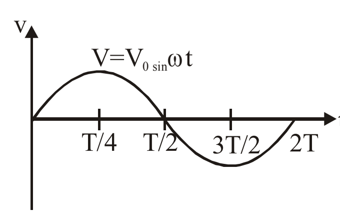




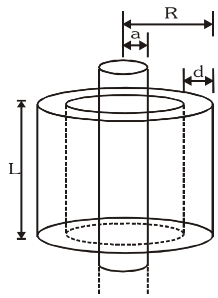
5. In the circuit shown A and B are two cells of same emf E but different internal resistances r_1 and r_2 ($r_1 > r_2$) respectively. Find the value of R such that the potential difference across the terminals of cell A is zero a long time after the key K is closed. **[IIT-JEE 2004]**



6. In an L–R series circuit, a sinusoidal voltage $V = V_0 \sin \omega t$ is applied. It is given that L = 35 mH, R = 11 Ω, V_{rms} = 220 V, $\omega/2\pi$ = 50 Hz and π = 22/7. Find the amplitude of current in the steady state and obtain the phase difference between the current and the voltage. Also plot the variation of current for one cycle on the given graph. **[IIT-JEE 2004]**



7. A long solenoid of radius a and number of turns per unit length n is enclosed by cylindrical shell of radius R thickness d (d << R) and length L. A variable current $i = i_0 \sin \omega t$ flows through the coil. If the resistivity of the material of cylindrical shell is ρ, find the induced current in the shell. **[IIT-JEE 2005]**



8. An inductor of inductance 2.0 mH is connected across a charged capacitor of capacitance 5.0 μF and the resulting L–C circuit is set oscillating at its natural frequency. Let Q denote the instantaneous charge on the capacitor and I the current in the circuit. It is found that the maximum value of Q is 200 μC. **[IIT-JEE 2006]**

(i) When Q = 100 μC, what is the value of $|dI/dt|$?

(ii) When Q = 200 μC, what is the value of I?

(iii) Find the maximum value of I.

(iv) When I is equal to one–half its maximum value, what is the value of $|Q|$?

PREVIOUS YEARS QUESTIONS — EXERCISE –5

- **MCQ's (Only one correct)**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15.
B	B	C	D	B	D	D	A	D	B	A	B	C	D	B

- **MCQ's (One or more than one answer may be correct)** 1. B,D 2. A,B,C,D 3. B,D
- **Assertion-Reason** 1. A
- **Match the column** 1. (A)–rst, (B) –qrst, (C) –q, (D) –qrst
- **Comprehension Based**

Comprehension #1 : 1. A 2. D 3. C

Comprehension #2 : 1. B 2. D 3. C

Comprehension #3 : 1. B 2. B

- **Subjective Questions**

1. 35.6 C

2. 12 e^{-5t},6 e^{-10t}

3. (i) $\frac{d\phi}{dt} = iR + L\frac{di}{dt}$ (ii) $\frac{1}{R}\left[\frac{\mu_0 I_0 \ell}{2\pi}\ell n(2) - Li_1\right]$ (iii) $\frac{T}{\ell n(4)}$

4. $i_{max} = \frac{\mu_0 a C I_0 \omega^2 \ell n(2)}{\pi}$

5. $R = \frac{4}{3}(r_1 - r_2)$

6. 20A, $\frac{\pi}{4}$ $\because$ Steady state current $i = 20 \sin\pi(100\,t - \frac{1}{4})$

7. $I = \frac{(\mu_0 n i_0 \omega \cos \omega t)\pi a^1 (Ld)}{2\pi\rho R}$

8. (i) 10^4 A/s (ii) Zero (iii) 2.0 A (iv) 1.732 10^{-4} C