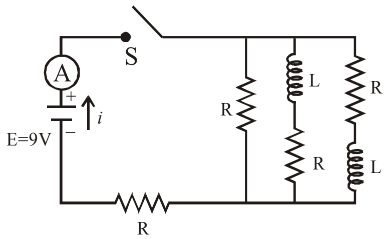
EMI & AC

1 A resonance circuit having inductance and resistance 2×10^{-4} H and 6.28 Ω respectively oscillates at 10 MHz frequency. The value of quality factor of this resonator is _______. [$\pi = 3.14$]

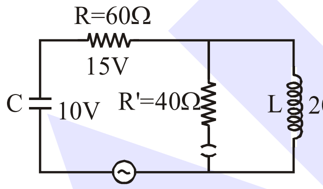
2. Figure shows a circuit that contains four identical resistors with resistance R = 2.0 Ω, two identical inductors with inductance L = 2.0 mH and an ideal battery with *emf* E = 9 V. The current '*i*' just after the switch 'S' is closed will be :



(1) 2.25 A (2) 3.0 A
(3) 3.37 A (4) 9 A

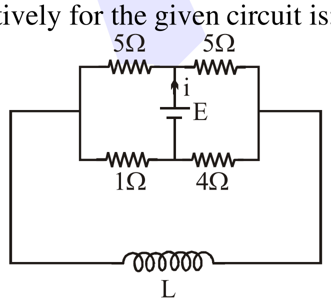
3. A series LCR circuit is designed to resonate at an angular frequency $\omega_0 = 10^5$ rad/s. The circuit draws 16 W power from 120 V source at resonance. The value of resistance 'R' in the circuit is ___Ω.

4. The angular frequency of alternating current in a L-C-R circuit is 100 rad/s. The components connected are shown in the figure. Find the value of inductance of the coil and capacity of condenser.



(1) 0.8 H and 150 μF (2) 0.8 H and 250 μF
(3) 1.33 H and 250 μF (4) 1.33 H and 150 μF

5. The current (i) at time t = 0 and t = ∞ respectively for the given circuit is:



(1) $\frac{18E}{55}, \frac{5E}{18}$ (2) $\frac{10E}{33}, \frac{5E}{18}$
(3) $\frac{5E}{18}, \frac{18E}{55}$ (4) $\frac{5E}{18}, \frac{10E}{33}$

6. A coil of inductance 2H having negligible resistance is connected to a source of supply whose voltage is given by V = 3t volt. (where t is in second). If the voltage is applied when t = 0, then the energy stored in the coil after 4s is _____ J.

7. An LCR circuit contains resistance of 110 Ω and a supply of 220 V at 300 rad/s angular frequency. If only capacitance is removed from the circuit, current lags behind the voltage by 45°. If on the other hand, only inductor is removed the current leads by 45° with the applied voltage. The rms current flowing in the circuit will be :
(1) 1A (2) 2.5 A
(3) 1.5 A (4) 2A

8. An alternating current is given by the equation $i = i_1 \sin\omega t + i_2 \cos\omega t$. The rms current will be

(1) $\frac{1}{\sqrt{2}}\left(i_1^2 + i_2^2\right)^{\frac{1}{2}}$

(2) $\frac{1}{\sqrt{2}}\left(i_1 + i_2\right)^2$

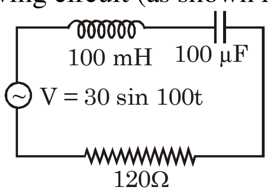
(3) $\frac{1}{2}\left(i_1^2 + i_2^2\right)^{\frac{1}{2}}$

(4) $\frac{1}{\sqrt{2}}\left(i_1 + i_2\right)$

9. In a series LCR resonant circuit, the quality factor is measured as 100. If the inductance is increased by two fold and resistance is decreased by two fold, then the quality factor after this change will be_____.

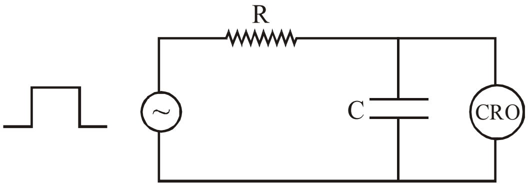
10. An aeroplane, with its wings spread 10 m, is flying at a speed of 180 km/h in a horizontal direction. The total intensity of earth's field at that part is 2.5×10^{-4} Wb/m² and the angle of dip is 60°. The emf induced between the tips of the plane wings will be :-
(1) 108.25 mV
(2) 54.125 mV
(3) 88.37 mV
(4) 62.50 mV

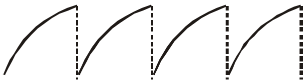
11. Find the peak current and resonant frequency of the following circuit (as shown in figure).

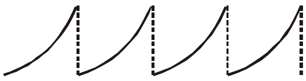


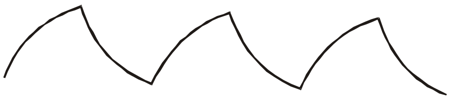
(1) 0.2 A and 50 Hz
(2) 0.2 A and 100 Hz
(3) 2 A and 100 Hz
(4) 2A and 50 Hz

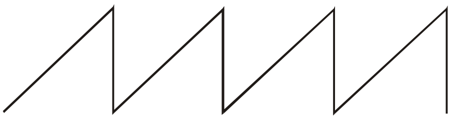
12. An RC circuit as shown in the figure is driven by a AC source generating a square wave. The output wave pattern monitored by CRO would look close to :



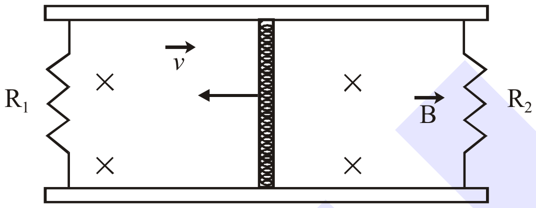
(1) 

(2) 

(3) 

(4) 

13. A conducting bar of length L is free to slide on two parallel conducting rails as shown in the figure



Two resistors R_1 and R_2 are connected across the ends of the rails. There is a uniform magnetic field $\vec{B}$ pointing into the page. An external agent pulls the bar to the left at a constant speed v.

The correct statement about the directions of induced currents I_1 and I_2 flowing through R_1 and R_2 respectively is :

(1) Both I_1 and I_2 are in anticlockwise direction

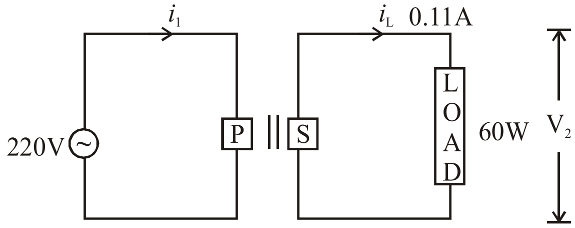
(2) Both I_1 and I_2 are in clockwise direction

(3) I_1 is in clockwise direction and I_2 is in anticlockwise direction

(4) I_1 is in anticlockwise direction and I_2 is in clockwise direction

14. A sinusoidal voltage of peak value 250 V is applied to a series LCR circuit, in which R = 8Ω, L = 24 mH and C = 60μF. The value of power dissipated at resonant condition is 'x' kW. The value of x to the nearest integer is ________.

15. For the given circuit, comment on the type of transformer used :



(1) Auxilliary transformer
(2) Auto transformer
(3) Step-up transformer
(4) Step down transformer

16. Amplitude of a mass-spring system, which is executing simple harmonic motion decreases with time. If mass = 500g, Decay constant = 20 g/s then how much time is required for the amplitude of the system to drop to half of its initial value ? (ln 2 = 0.693)

(1) 34.65 s (2) 17.32 s
(3) 0.034 s (4) 15.01 s

17. An AC current is given by $I = I_1 \sin\omega t + I_2 \cos\omega t$. A hot wire ammeter will give a reading :

(1) $\sqrt{\dfrac{I_1^2 - I_2^2}{2}}$

(2) $\sqrt{\dfrac{I_1^2 + I_2^2}{2}}$

(3) $\dfrac{I_1 + I_2}{\sqrt{2}}$

(4) $\dfrac{I_1 + I_2}{2\sqrt{2}}$

18. A solenoid of 1000 turns per metre has a core with relative permeability 500. Insulated windings of the solenoid carry an electric current of 5A. The magnetic flux density produced by the solenoid is :

(permeability of free space = $4\pi \times 10^{-7}$ H/m)

(1) πT (2) $2 \times 10^{-3}\,\pi$T

(3) $\dfrac{\pi}{5}$T (4) $10^{-4}\pi$T

19. A block of mass 1 kg attached to a spring is made to oscillate with an initial amplitude of 12 cm. After 2 minutes the amplitude decreases to 6 cm. Determine the value of the damping constant for this motion. (take In 2 = 0.693)

(1) 0.69×10^2 kg s^{-1} (2) 3.3×10^2 kg s^{-1}
(3) 1.16×10^2 kg s^{-1} (4) 5.7×10^{-3} kg s^{-1}

20. Match List-I with List-II

List-I	List-II
(a) Phase difference between current and voltage in a purely resistive AC circuit	(i) $\frac{\pi}{2}$; current leads voltage
(b) Phase difference between current and voltage in a pure inductive AC circuit	(ii) zero
(c) Phase difference between current and voltage in a pure capacitive AC circuit	(iii) $\frac{\pi}{2}$; current lags voltage
(d) Phase difference between current and voltage in an LCR series circuit	(iv) $\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

Choose the most appropriate answer from the options given below :

(1) (a)–(i),(b)–(iii),(c)–(iv),(d)–(ii)
(2) (a)–(ii),(b)–(iv),(c)–(iii),(d)–(i)
(3) (a)–(ii),(b)–(iii),(c)–(iv),(d)–(i)
(4) (a)–(ii),(b)–(iii),(c)–(i),(d)–(iv)

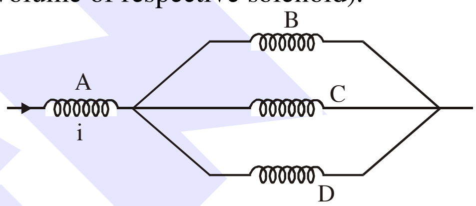
21. What happens to the inductive reactance and the current in a purely inductive circuit if the frequency is halved ?

(1) Both, inductive reactance and current will be halved.
(2) Inductive reactance will be halved and current will be doubled.
(3) Inductive reactance will be doubled and current will be halved.
(4) Both, inducting reactance and current will be doubled.

22. Seawater at a frequency f = 9 × 10^2 Hz, has permittivity $\varepsilon = 80\varepsilon_0$ and resistivity $\rho = 0.25\ \Omega$m. Imagine a parallel plate capacitor is immersed in seawater and is driven by an alternating voltage source $V(t)=V_0 \sin(2\pi ft)$. Then the conduction current density becomes 10^x times the displacement current density after time $t = \frac{1}{800}$ s. The value of x is ________

(Given : $\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ Nm^2C^{-2}$)

23. Four identical long solenoids A, B, C and D are connected to each other as shown in the figure. If the magnetic field at the center of A is 3T, the field at the center of C would be : (Assume that the magnetic field is confined with in the volume of respective solenoid).



(1) 12T (2) 6T
(3) 9T (4) 1T

24. In a scries LCR resonance circuit, if we change the resistance only, from a lower to higher value :

(1) The bandwidth of resonance circuit will increase.
(2) The resonance frequency will increase.
(3) The quality factor will increase.
(4) The quality factor and the resonance frequency will remain constant.

25. An AC source rated 220 V, 50 Hz is connected to a resistor. The time taken by the current to change from its maximum to the rms value is :

(1) 2.5 ms (2) 25 ms
(3) 2.5 s (4) 0.25 ms

26. In a series LCR circuit, the inductive reactance (X_L) is 10 Ω and the capacitive reactance (X_C) is 4 Ω. The resistance (R) in the circuit is 6 Ω. The power factor of the circuit is :

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

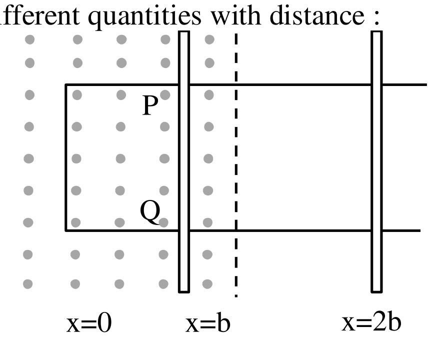
27. The time taken for the magnetic energy to reach 25% of its maximum value, when a solenoid of resistance R, inductance L is connected to a battery, is :

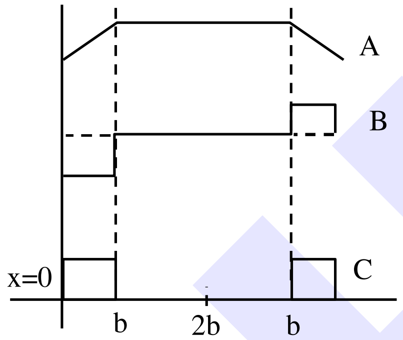
(1) $\frac{L}{R}\ell n5$ (2) infinite
(3) $\frac{L}{R}\ell n2$ (4) $\frac{L}{R}\ell n10$

28. AC voltage $V(t) = 20 \sin\omega t$ of frequency 50 Hz is applied to a parallel plate capacitor. The separation between the plates is 2 mm and the area is 1 m^2. The amplitude of the oscillating displacement current for the applied AC voltage is _______. [Take $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m]

(1) 21.14 μA (2) 83.37 μA
(3) 27.79 μA (4) 55.58 μA

29. The arm PQ of a rectangular conductor is moving from x = 0 to x = 2b outwards and then inwards from x = 2b to x = 0 as shown in the figure. A uniform magnetic field perpendicular to the plane is acting from x = 0 to x = b. Identify the graph showing the variation of different quantities with distance :





(1) A-Flux, B-Power dissipated, C-EMF
(2) A-Power dissipated, B-Flux, C-EMF
(3) A-Flux, B-EMF, C-Power dissipated
(4) A-EMF, B-Power dissipated, C-Flux

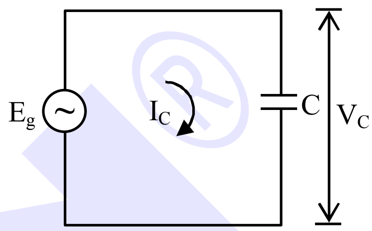
30. In an LCR series circuit, an inductor 30 mH and a resistor 1 Ω are connected to an AC source of angular frequency 300 rad/s. The value of capacitance for which, the current leads the voltage by 45° is $\frac{1}{x} \times 10^{-3}$ F. Then the value of x is ____.

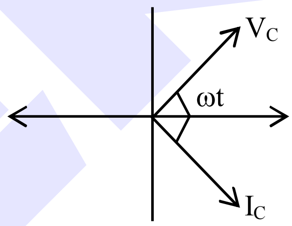
31. For a series LCR circuit with R = 100 Ω, L = 0.5 mH and C = 0.1 pF connected across 220 V–50 Hz AC supply, the phase angle between current and supplied voltage and the nature of the circuit is :

(1) 0°, resistive circuit
(2) ≈ 90°, predominantly inductive circuit
(3) 0°, resonance circuit
(4) ≈ 90°, predominantly capacitive circuit

32. A series LCR circuit of R = 5Ω, L = 20 mH and C = 0.5 μF is connected across an AC supply of 250 V, having variable frequency. The power dissipated at resonance condition is_____$\times 10^2$ W.

33. In a circuit consisting of a capacitance and a generator with alternating emf $E_g = E_{g_0} \sin\omega t$, V_C and I_C are the voltage and current. Correct phasor diagram for such circuit is :



(1)


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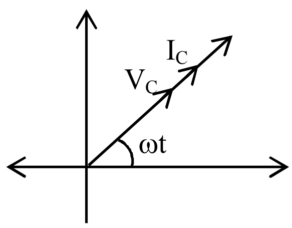

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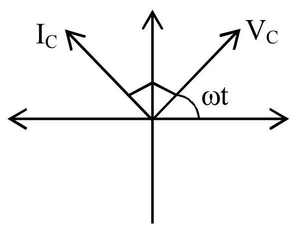

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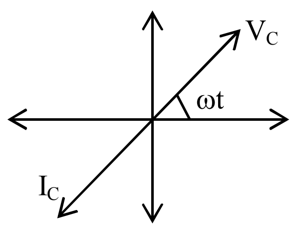


34. Match **List-I** with **List-II** :

	List–I		List–II
(a)	$\omega L > \frac{1}{\omega C}$	(i)	Current is in phase with emf
(b)	$\omega L = \frac{1}{\omega C}$	(ii)	Current lags behind the applied emf
(c)	$\omega L < \frac{1}{\omega C}$	(iii)	Maximum current occurs
(d)	Resonant frequency	(iv)	Current leads the emf

Choose the **correct** answer from the options given below :

(1) (a) – (ii) ; (b) – (i) ; (c) - (iv) ; (d) – (iii)

(2) (a) – (ii) ; (b) – (i) ; (c) - (iii) ; (d) – (iv)

(3) (a) – (iii) ; (b) – (i) ; (c) - (iv) ; (d) – (ii)

(4) (a) – (iv) ; (b) – (iii) ; (c) - (ii) ; (d) – (i)

35. An inductor of 10 mH is connected to a 20 V battery through a resistor of 10 kΩ and a switch. After a long time, when maximum current is set up in the circuit, the current is switched off. The current in the circuit after 1 μs is $\frac{x}{100}$ mA. Then x is equal to ______. (Take $e^{-1} = 0.37$)

36. A circular conducting coil of radius 1 m is being heated by the change of magnetic field $\vec{B}$ passing perpendicular to the plane in which the coil is laid. The resistance of the coil is 2 μΩ. The magnetic field is slowly switched off such that its magnitude changes in time as:

$$B = \frac{4}{\pi} \times 10^{-3} T \left(1 - \frac{t}{100}\right)$$

The energy dissipated by the coil before the magnetic field is switched off completely is E = _____ mJ.

37. A 10Ω resistance is connected across 220V – 50Hz AC supply. The time taken by the current to change from its maximum value to the rms value is:

(1) 2.5 ms (2) 1.5 ms

(3) 3.0 ms (4) 4.5 ms

38. Two circuits are shown in the figure (a) & (b). At a frequency of _______ rad/s the average power dissipated in one cycle will be same in both the circuits.

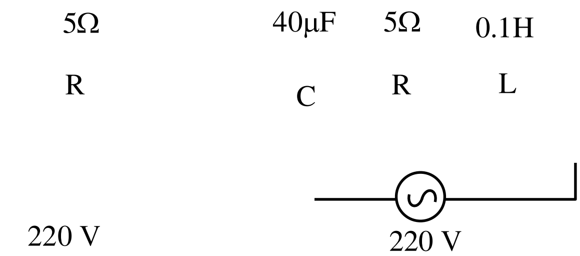


figure (a) figure (b)

39. A 0.07 H inductor and a 12 Ω resistor are connected in series to a 220 V, 50 Hz ac source. The approximate current in the circuit and the phase angle between current and source voltage are respectively. [Take π as $\frac{22}{7}$]

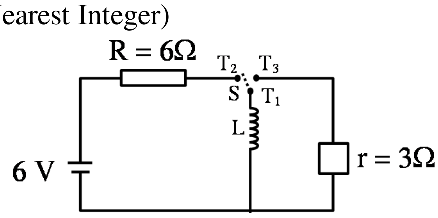
(1) 8.8 A and $\tan^{-1}\left(\frac{11}{6}\right)$

(2) 88 A and $\tan^{-1}\left(\frac{11}{6}\right)$

(3) 0.88 A and $\tan^{-1}\left(\frac{11}{6}\right)$

(4) 8.8 A and $\tan^{-1}\left(\frac{6}{11}\right)$

40. Consider an electrical circuit containing a two way switch 'S'. Initially S is open and then T_1 is connected to T_2. As the current in R = 6 Ω attains a maximum value of steady state level, T_1 is disconnected from T_2 and immediately connected to T_3. Potential drop across r = 3 Ω resistor immediately after T_1 is connected to T_3 is______V. (Round off to the Nearest Integer)

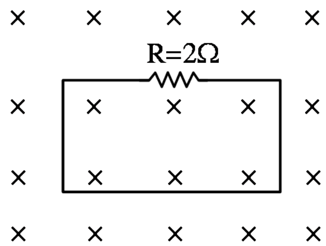


41. A 100 Ω resistance, a 0.1 μF capacitor and an inductor are connected in series across a 250 V supply at variable frequency. Calculate the value of inductance of inductor at which resonance will occur. Given that the resonant frequency is 60 Hz.

(1) 0.70 H (2) 70.3 mH

(3) 7.03×10^{-5} H (4) 70.3 H

42. In the given figure the magnetic flux through the loop increases according to the relation $\phi_B(t) = 10t^2 + 20t$, where ϕ_B is in milliwebers and t is in seconds. The magnitude of current through $R = 2\Omega$ resistor at t = 5 s is _______ mA.



43. An inductor coil stores 64 J of magnetic field energy and dissipates energy at the rate of 640 W when a current of 8A is passed through it. If this coil is joined across an ideal battery, find the time constant of the circuit in seconds :

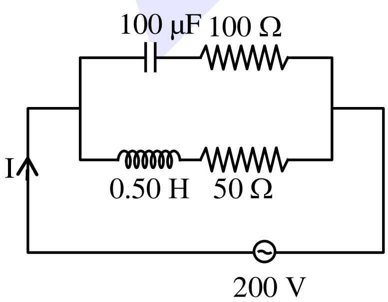
(1) 0.4 (2) 0.8 (3) 0.125 (4) 0.2

44. A series LCR circuit driven by 300 V at a frequency of 50 Hz contains a resistance R = 3 kΩ, an inductor of inductive reactance $X_L = 250\,\pi\Omega$ and an unknown capacitor. The value of capacitance to maximize the average power should be : (Take $\pi^2 = 10$)

(1) 4 μF (2) 25 μF

(3) 400 μF (4) 40 μF

45. In the given circuit the AC source has $\omega = 100$ rad s^{-1}. Considering the inductor and capacitor to be ideal, what will be the current I flowing through the circuit?

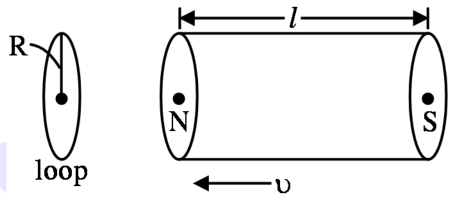


(1) 5.9 A (2) 4.24 A

(3) 0.94 A (4) 6 A

46. A circular coil of radius 8.0 cm and 20 turns is rotated about its vertical diameter with an angular speed of 50 rad s^{-1} in a uniform horizontal magnetic field of 3.0×10^{-2} T. The maximum emf induced the coil will be .... $\times 10^{-2}$ volt (rounded off to the nearest integer)

47. A bar magnet is passing through a conducting loop of radius R with velocity υ. The radius of the bar magnet is such that it just passes through the loop. The induced e.m.f. in the loop can be represented by the approximate curve :



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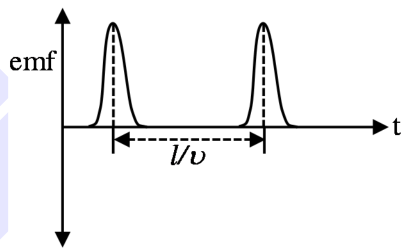

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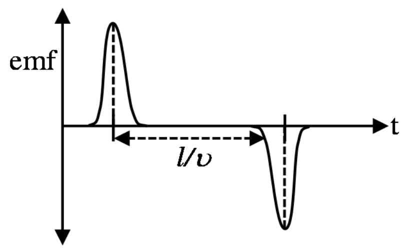

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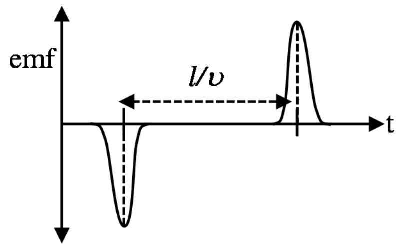

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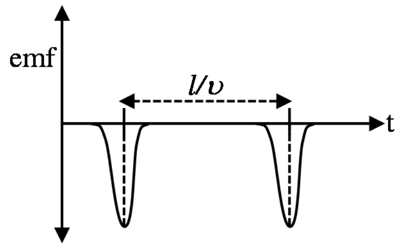
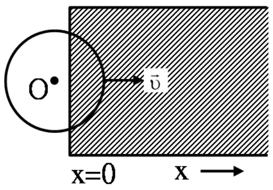


48. The alternating current is given by

$$i = \left\{\sqrt{42}\sin\left(\frac{2\pi}{T}t\right) + 10\right\}A$$

The r.m.s. value of this current is .... A.

49. A constant magnetic field of 1 T is applied in the x > 0 region. A metallic circular ring of radius 1m is moving with a constant velocity of 1 m/s along the x-axis. At t = 0s, the centre of O of the ring is at x = – 1m. What will be the value of the induced emf in the ring at t = 1s? (Assume the velocity of the ring does not change.)



(1) 1 V (2) 2π V
(3) 2 V (4) 0 V

50. An ac circuit has an inductor and a resistor of resistance R in series, such that $X_L = 3R$. Now, a capacitor is added in series such that $X_C = 2R$. The ratio of new power factor with the old power factor of the circuit is $\sqrt{5}:x$. The value of x is ______.

51. A small square loop of side 'a' and one turn is placed inside a larger square loop of side b and one turn (b >> a). The two loops are coplanar with their centres coinciding. If a current I is passed in the square loop of side 'b', then the coefficient of mutual inductance between the two loops is :

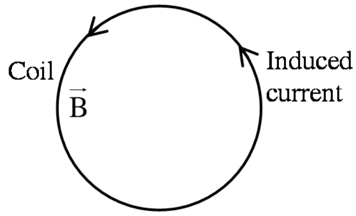
(1) $\frac{\mu_0}{4\pi}8\sqrt{2}\frac{a^2}{b}$ (2) $\frac{\mu_0}{4\pi}\frac{8\sqrt{2}}{a}$

(3) $\frac{\mu_0}{4\pi}8\sqrt{2}\frac{b^2}{a}$ (4) $\frac{\mu_0}{4\pi}\frac{8\sqrt{2}}{b}$

52. In an ac circuit, an inductor, a capacitor and a resistor are connected in series with $X_L = R = X_C$. Impedance of this circuit is :

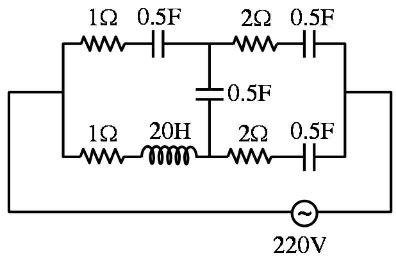
(1) $2R^2$ (2) Zero (3) R (4) $R\sqrt{2}$

53. A coil is placed in a magnetic field $\vec{B}$ as shown below :

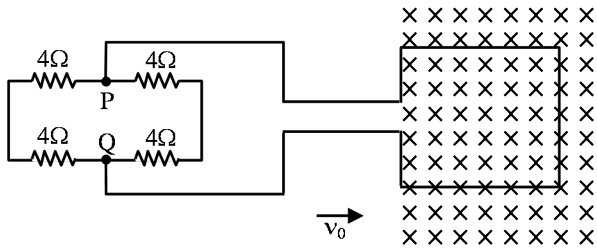


A current is induced in the coil because $\vec{B}$ is :
(1) Outward and decreasing with time
(2) Parallel to the plane of coil and decreasing with time
(3) Outward and increasing with time
(4) Parallel to the plane of coil and increasing with time

54. At very high frequencies, the effective impendance of the given circuit will be ____ Ω.

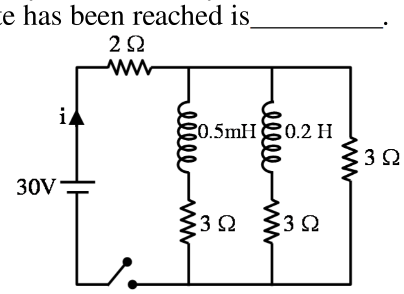


55. A square loop of side 20 cm and resistance 1Ω is moved towards right with a constant speed v_0. The right arm of the loop is in a uniform magnetic field of 5T. The field is perpendicular to the plane of the loop and is going into it. The loop is connected to a network of resistors each of value 4Ω. What should be the value of v_0 so that a steady current of 2 mA flows in the loop ?



(1) 1 m/s (2) 1 cm/s
(3) 10^2 m/s (4) 10^{-2} cm/s

56. For the given circuit the current *i* through the battery when the key in closed and the steady state has been reached is__________.



(1) 6 A (2) 25 A
(3) 10 A (4) 0 A

SOLUTION

1 Official Ans. by NTA (2000)

Sol. Given : $L = 2 \times 10^{-4}$ H

$R = 6.28\ \Omega$

$f = 10$ MHz $= 10^7$ Hz

Since quality factor,

$$Q = \omega_0 \frac{L}{R} = 2\pi f \frac{L}{R}$$

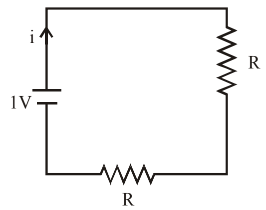
$$\therefore Q = 2\pi \times 10^7 \times \frac{2\times10^{-4}}{6.28}$$

$Q = 2 \times 10^3 = 2000$

$\therefore$ Ans. is 2000

2. Official Ans. by NTA (1)

Sol. Just after the switch is closed, inductor will behave like infinite resistance (open circuit) so the circuit will look like



$$i = \frac{9}{R+R} = \frac{9}{4} = 2.25$$

Option (1) is correct.

3. Official Ans. by NTA (900)

Sol. At resonance

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P} = \frac{(120)^2}{16} = 900\Omega$$

4. Official Ans. by NTA (2)

Sol. Current through 60Ω resistance $= \frac{15}{60} = \frac{1}{4}$ A

thus capacitor current $= \frac{1}{4}$ A

$\because\ V_C = I X_C$

$$10 = \frac{1}{4} \times \frac{1}{\omega C}$$

$$\therefore C = \frac{1}{40\omega} = \frac{1}{4000} = 250\ \mu F$$

Now,

current through 40Ω resistance $= \frac{20}{40} = \frac{1}{2}$ A

thus current through inductor $= \frac{1}{2} - \frac{1}{4} = \frac{1}{4}$ A

$$V_L = IX_L = \frac{1}{4} \times \omega L$$

$$20 = \frac{1}{4} \times 100 \times L$$

$\Rightarrow L = 0.8$ H

5. Official Ans. by NTA (4)

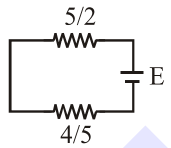
Sol. At t = 0, current through inductor is zero,

hence $R_{eq} = (5+1) \parallel (5+4) = \frac{18}{5}$

$$i_1 = \frac{E}{18/5} = \frac{5E}{18}$$

At $t = \infty$, inductor becomes a simple wire and now the circuit will be as shown in figure

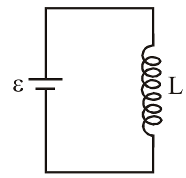
hence $R_{eq} = (5\|5) + (4\|1) = \frac{33}{10}$; $(\| \Rightarrow$ parallel)



$$i_2 = \frac{E}{33/10} = \frac{10E}{33}$$

6. Official Ans. by NTA (144)

Sol. $\varepsilon = \frac{L\,dI}{dt}$



$$3\int_0^4 t\ dt = 2\int_0^I dI$$

$$\frac{3}{2}\times 16 = 2I$$

$I = 12$

$$V = \frac{1}{2}LI^2 = \frac{1}{2}\times 2(12)^2 = 144\ J$$

7. Official Ans. by NTA (4)

Sol. $\tan 45° = \frac{1}{\omega CR} = \frac{\omega L}{R} \Rightarrow X_L = X_C$

$\Rightarrow$ resonance

$$i = \frac{V}{R} = \frac{220}{110} = 2A$$

8. Official Ans. by NTA (1)

Sol. $i = i_1 \sin\omega t + i_2 \sin(\omega t + 90)$

$$i = \sqrt{i_1^2 + i_2^2}\ \sin(\omega t + \phi)$$

$$i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{\sqrt{i_1^2 + i_2^2}}{\sqrt{2}}$$

9. Official Ans. by NTA (283)

Sol. $$Q = \frac{X_L}{R} = \frac{\omega L}{R} = \frac{1}{\sqrt{LC}}\frac{L}{R} = \frac{\sqrt{L}}{R\sqrt{C}}$$

$$Q' = \frac{\sqrt{2L}}{\left(\frac{R}{2}\right)\sqrt{C}} = 2\sqrt{2}Q = 2\sqrt{2}(100)$$

$= 282.84$

10. Official Ans. by NTA (1)

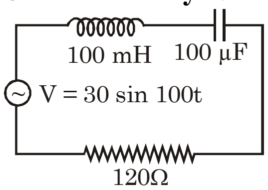
Sol. $\in = [\vec{B}\vec{V}\vec{L}] = BVL \sin\theta$

$= (2.5 \times 10^{-4}T)\left(180 \times \frac{5}{18} m/s\right)(10m)\sin 60°$

$= 108.25 \times 10^{-3}V$

11. Official Ans. by NTA (1)

Sol.



as given $z = \sqrt{(x_L - x_C)^2 + R^2}$

$x_L = \omega_L = 100 \times 100 \times 10^{-3} = 10\Omega$

$x_C = \frac{1}{\omega_C} = \frac{1}{100 \times 100 \times 10^{-6}} = 10\Omega$

$z = \sqrt{(10-100)^2 + R^2} = \sqrt{90^2 + 120^2}$

$= 30 \times 5 = 150\Omega$

$i_{peak} = \frac{\Delta v}{z} = \frac{30}{150} = \frac{1}{5} amp = 0.2 amp$

& For resonant frequency

$\Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow \omega^2 = \frac{1}{LC} \Rightarrow \omega = \frac{1}{\sqrt{LC}}$

$\& \ f = \frac{1}{2\pi\sqrt{LC}} \Rightarrow \frac{1}{2\pi\sqrt{100 \times 10^{-3} \times 100 \times 10^{-6}}}$

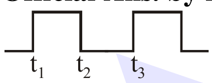
$= \frac{100\sqrt{10}}{2\pi} = \frac{100\pi}{2\pi} = 50Hz$

as $\sqrt{10} \approx \pi$

Answer (1)

12. Official Ans. by NTA (3)

Sol.

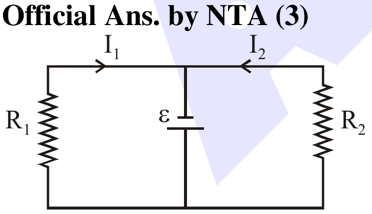


For $t_1 - t_2$ Charging graph

$t_2 - t_3$ Discharging graph

13. Official Ans. by NTA (3)

Sol.



14. Official Ans. by NTA (4)

Sol. At resonance power (P)

$P = \frac{(V_{rms})^2}{R}$

$P = \frac{(250/\sqrt{2})^2}{8} = 3906.25 W$

$\approx 4 kW$

15. Official Ans. by NTA (3)

Sol. $V_S = \frac{P}{i} = \frac{60}{0.11} = 545.45$

$V_P = 220$

$V_S > V_P$

$\Rightarrow$ Step up transformer

16. Official Ans. by NTA (1)

Sol. $A = A_0 e^{-\gamma t} = A_0 e^{-\frac{bt}{2m}}$

$\frac{A_0}{2} = A_0 e^{-\frac{bt}{2m}}$

$\frac{bt}{2m} = \ln 2$

$t = \frac{2m}{b}\ln 2 = \frac{2 \times 500 \times 0.693}{20}$

t = 34.65 second.

17. Official Ans. by NTA (2)

Sol. $I = I_1 \sin \omega t + I_2 \cos \omega t$

$\therefore I_0 = \sqrt{I_1^2 + I_2^2}$

$\therefore I_{rms} = \frac{I_0}{\sqrt{2}} = \sqrt{\frac{I_1^2 + I_2^2}{2}}$

18. Official Ans. by NTA (1)

Sol. $B = \mu nI = \mu_0 \mu_r nI$

$B = 4\pi \times 10^{-7} \times 500 \times 1000 \times 5$

$B = \pi$ Tesla

19. Official Ans. by NTA (Bonus)

Sol. $A = A_0 e^{-\gamma t}$

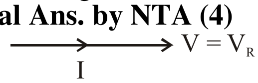
$\ln 2 = \frac{b}{2m} \times 120$

$\frac{0.693 \times 2 \times 1}{120} = b$

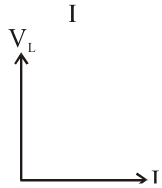
1.16×10^{-2} kg/sec.

20. Official Ans. by NTA (4)

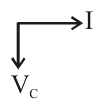
Sol. (4) (a)



(b)



(c)



(d) $\tan\phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$

21. Official Ans. by NTA (2)

Sol. (2) $X_L = \omega L$

$i = \frac{V_0}{\omega L}$

22. Official Ans. by NTA (6)

Sol. $J_c = \frac{E}{\rho} = \frac{V}{\rho d}$

$J_d = \frac{1}{A}\frac{dq}{dt}$

$= \frac{C}{A}\frac{dV_c}{dt} = \frac{\in}{d}\frac{dV_c}{dt}$

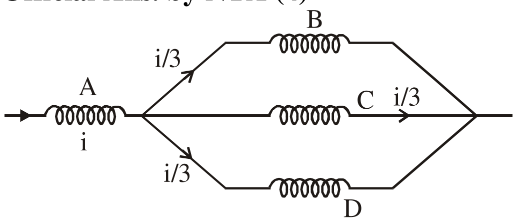
$\Rightarrow \frac{V_0 \sin 2\pi ft}{\rho d} = 10^x \times \frac{80\varepsilon_0}{d} V_0 (2\pi f) \cos 2\pi ft$

$\tan\left(2\pi \times \frac{900}{800}\right) = 10^x \times \frac{40}{9\times 10^9} \times 900$

$= x = 6$

23. Official Ans. by NTA (4)

Sol.



$\phi \propto i$

$\Rightarrow B \propto i$

so, field at centre of C = $\frac{3}{3} = 1T$

24. Official Ans. by NTA (1)

Sol. Bandwidth = R/L

Bandwidth $\propto$ R

So bandwidth will increase

25. Official Ans. by NTA (1)

Sol. $i = i_0 \cos(\omega t)$

$i = i_0$ at $t = 0$

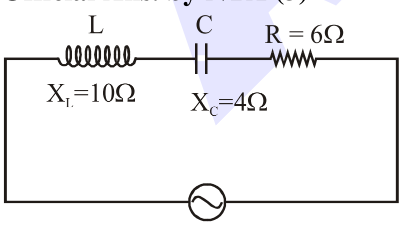
$i = \frac{i_0}{\sqrt{2}}$ at $\omega t = \frac{\pi}{4}$

$t = \frac{\pi}{4\omega} = \frac{\pi}{4(2\pi f)} = \frac{1}{8f}$

$t = \frac{1}{400} = 2.5$ ms

26. Official Ans. by NTA (3)

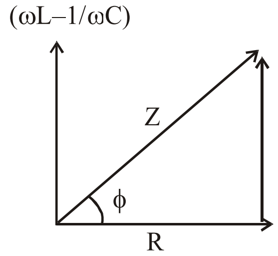
Sol.



We know that power factor is $\cos\phi$,

$\cos\phi = \frac{R}{Z}$ ... (1)

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ ... (2)



$\Rightarrow Z = \sqrt{6^2 + (10-4)^2}$

$\Rightarrow Z = 6\sqrt{2}$ | $\cos\phi = \frac{6}{6\sqrt{2}}$

$\cos\phi = \frac{1}{\sqrt{2}}$

27. Official Ans. by NTA (3)

Sol. Magnetic energy = $\frac{1}{2}Li^2 = 25\%$

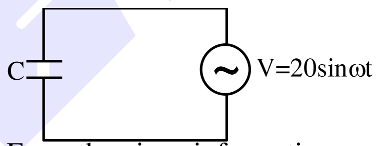
ME $\Rightarrow 25\% \Rightarrow i = \frac{i_0}{2}$

$i = i_0(1 - R^{-Rt/L})$ for charging

$t = \frac{L}{R}\ell n2$

28. Official Ans. by NTA (3)

Sol.



From the given information,

$C = \frac{\in_0 A}{d} = \frac{\in_0 \times 1}{2\times 10^{-3}} F$

$\therefore X_C = \frac{1}{\omega C} = \frac{2\times 10^{-3}}{2\times 50\pi \times \in_0} = \frac{2\times 10^{-3}}{25\times 4\pi \in_0}\Omega$

$\therefore X_C = \frac{2\times 10^{-3}}{25} \times 9\times 10^9 = \frac{18}{25}\times 10^6 \Omega$

$\therefore i_0 = \frac{V_0}{X_C} = \frac{20\times 25}{18}\times 10^{-6} A = 27.47\ \mu A.$

The value of amplitude of displacement current will be same as value of amplitude of conventional current.

Hence option 3.

29. Official Ans. by NTA (3)

Sol. As rod moves in field area increases upto x = b then field is absent and again flux is generated on return journey from x = b to x = 0. Thus plot A for flux.

$\Rightarrow e = -\frac{d\phi}{dt} \Rightarrow$ curve B for emf

$\Rightarrow$ Power dissipated = vi $\Rightarrow$ curve C for power dissipated

30. Official Ans. by NTA (3)

Sol. $\tan\phi = \frac{x_C - x_L}{R}$

$\tan 45 = \frac{x_C - x_L}{R}$

$x_C - x_L = R$

$\frac{1}{\omega C} - \omega L = R$

$\frac{1}{\omega C} - 300 \times 0.03 = 1$

$\frac{1}{\omega C} = 10$

$C = \frac{1}{10\omega} = \frac{1}{10 \times 300}$; $C = \frac{1}{3} \times 10^{-3}$

X = 3

31. Official Ans. by NTA (4)

Sol. R = 100Ω

$X_L = \omega L = 50\pi \times 10^{-3}$

$X_C = \frac{1}{\omega C} = \frac{10^{11}}{100\pi}$

$X_C >> X_L$ & $|X_C - X_L| >> R$

32. Official Ans. by NTA (125)

Sol. $X_L = X_C$ (due to resonance)

$Z = R$ so $i_{rms} = \frac{V}{Z} = \frac{V}{R}$

$\frac{V^2}{R} = \frac{250 \times 250}{5} = 125 \times 10^2$ W

33. Official Ans. by NTA (3)

Sol. In capacitor, current lead voltage by $\frac{\pi}{2}$

34. Official Ans. by NTA (1)

Sol. (a) For $x_L > x_C$, voltage leads the current
(ii)
(b) For $x_L = x_C$, voltage & current are in same phase
(i)
(c) For $x_L < x_C$, current leads the voltage
(iv)
(d) For resonant frequency $x_L = x_C$, current is maximum
(iii)

35. Official Ans. by NTA (74)

Sol. $I_{max} = \frac{V}{R} = \frac{20V}{10K\Omega} = 2mA$

For LR – decay circuit

$I = I_{max}\, e^{-Rt/L}$

$I = 2mA\, e^{\frac{-10\times10^3\times1\times10^{-6}}{10\times10^{-3}}}$

$I = 2mA\ e^{-1}$

$I = 2 \times 0.37$ mA

$I = \frac{74}{100}$ mA

$\boxed{x = 74}$

36. Official Ans. by NTA (80)

Sol. $\phi = \vec{B}.\vec{S}$

$\phi = \frac{4}{\pi} \times 10^{-3}\left(1 - \frac{t}{100}\right).\pi R^2$

$\phi = 4 \times 10^{-3} \times (1)^2 \left(1 - \frac{t}{100}\right)$

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

$\varepsilon = \frac{-d}{dt}\left(4 \times 10^{-3}\left(1 - \frac{t}{100}\right)\right)$

$\varepsilon = 4 \times 10^{-3}\left(\frac{1}{100}\right) = 4 \times 10^{-5}$ **V**

When B = 0

$1 - \frac{t}{100} = 0$

t = 100 sec

Heat = $\frac{\varepsilon^2}{R} t$

Heat = $\frac{(4 \times 10^{-5})^2}{2 \times 10^{-6}} \times 100$ J

Heat = $\frac{16 \times 10^{-10} \times 100}{2 \times 10^{-6}}$ J

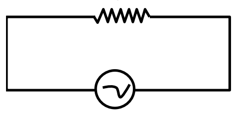
Heat = 0.08 J

Heat = 80 mJ

37. Official Ans. by NTA (1)

Sol.

10Ω



V = 220V/50Hz

$\Rightarrow i = i_0 \sin\omega t$

When $i = i_0$

$i_0 = i_0 \sin\omega t_1 \Rightarrow \omega t_1 = \frac{\pi}{2}$ … (i)

When $i = \frac{i_0}{\sqrt{2}}$

$\frac{i_0}{\sqrt{2}} = i_0 \sin\omega t_2 \Rightarrow \omega t_2 = \frac{\pi}{4}$ … (ii)

Time taken by current from maximum value to rms value

$\Rightarrow (t_1 - t_2) = \frac{\pi}{2\omega} - \frac{\pi}{4\omega} = \frac{\pi}{4\omega} = \frac{\pi}{4 \times 2\pi f}$

$= \frac{1}{8 \times 50} = \frac{1}{400}$ sec = 2.5 ms

38. Official Ans. by NTA (500)

Sol. For figure (a)

$$P_{avg} = \frac{v_{rms}^2}{R}$$

$$\frac{v_{rms}^2}{Z^2} \times R = \frac{v_{rms}^2}{R} \times 1$$

$$R^2 = Z^2$$

$$25 = \left(\sqrt{(x_C - x_L)^2 + 5^2}\right)^2$$

$$25 = (x_c - x_L)^2 + 25$$

$$x_c = x_L \Rightarrow \frac{1}{\omega C} = \omega L$$

$$\omega^2 = \frac{1}{LC} = \frac{10^6}{0.1 \times 40}$$

$$\omega = 500$$

39. Official Ans. by NTA (1)

Sol. $\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$

$$X_L = \omega L$$

$$X_L = 2 \times \frac{22}{7} \times 50 \times 0.07 = 22\,\Omega$$

$$\phi = \tan^{-1}\left(\frac{22}{12}\right) \qquad R = 12\ \Omega$$

$$\phi = \tan^{-1}\left(\frac{11}{6}\right)$$

$$Z = \sqrt{X_L^2 + R^2} = 25.059$$

$$I = \frac{V}{Z} = \frac{220}{25.059} = 8.77\,A$$

40. Official Ans. by NTA (3)

Sol. When T_1 and T_2 are connected, then the steady state current in the inductor $I = \frac{6}{6} = 1A$

When T_1 and T_3 are connected then current through inductor remains same. So potential difference across 3Ω

$V = Ir = 1 \times 3 = 3$ volt

41. Official Ans. by NTA (4)

Sol. $C = 0.1\ \mu F = 10^{-7}$ F

Resonant frequency = 60 Hz

$$\omega_o = \frac{1}{\sqrt{LC}}$$

$$2\pi f_o = \frac{1}{\sqrt{LC}} \Rightarrow L = \frac{1}{4\pi^2 f_o^2 C}$$

by putting values $L \simeq 70.3$ Hz.

42. Official Ans. by NTA (60)

Sol. $|\epsilon| = \frac{d\phi}{dt} = 20t + 20$ mV

$$|i| = \frac{|\epsilon|}{R} = 10t + 10 \text{ mA}$$

at t = 5

$|i| = 60$ mA

43. Official Ans. by NTA (4)

Sol. $U = \frac{1}{2}Li^2 = 64 \Rightarrow L = 2$

$$i^2R = 640$$

$$R = \frac{640}{(8)^2} = 10$$

$$\tau = \frac{L}{R} = \frac{1}{5} = 0.2$$

Option (4)

44. Official Ans. by NTA (1)

Sol. For maximum average power

$$X_L = X_C$$

$$250\pi = \frac{1}{2\pi(50)C}$$

$$C = 4 \times 10^{-6}$$

Option (1)

45. Official Ans. by NTA (DROP)

Sol. $Z_C = \sqrt{\left(\frac{1}{\omega C}\right)^2 + R^2}$

$= \sqrt{\left(\frac{1}{100 \times 100 \times 10^{-6}}\right)^2 + 100^2}$

$Z_C = \sqrt{(100)^2 + (100)^2} = 100\sqrt{2}$

$Z_L = \sqrt{(\omega L)^2 + R^2}$

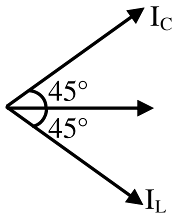
$\sqrt{(100 \times 0.5)^2 + 50^2} = 50\sqrt{2}$

$i_C = \frac{200}{z_C} = \frac{200}{100\sqrt{2}} = \sqrt{2}$

$i_L = \frac{200}{z_L} = \frac{200}{50\sqrt{2}} = 2\sqrt{2}$

$\cos\phi_1 = \frac{100}{10\sqrt{2}} = \frac{1}{\sqrt{2}} \Rightarrow \phi_1 = 45°$

$\cos\phi_2 = \frac{50}{50\sqrt{2}} = \frac{1}{\sqrt{2}} \Rightarrow \phi_2 = 45°$



$I = \sqrt{I_C^2 + I_L^2} = \sqrt{2+8} = \sqrt{10}$

I = 3.16 A

Ans. 3.16

46. Official Ans. by NTA (60)

Sol. Maximum emf $\varepsilon = N\,\omega AB$

$N = 20,\ \omega = 50,\ B = 3 \times 10^{-2}\,T$

$\varepsilon = 20 \times 50 \times \pi \times (0.08)^2 \times 3 \times 10^{-2}$

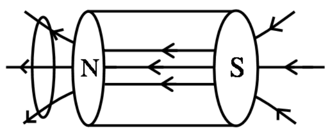
$= 60.28 \times 10^{-2}$

Rounded off to nearest integer = 60

Ans.60

47. Official Ans. by NTA (3)

Sol.



→ When magnet passes through centre region of solenoid , no current / Emf is induced in loop.

→ While entering flux increases so negative induced emf

48. Official Ans. by NTA (11)

Sol. $f_{rms}^2 = f_{1\,rms}^2 + f_{2\,rms}^2$

$= \left(\frac{\sqrt{42}}{\sqrt{2}}\right)^2 + 10^2$

$= 121 \Rightarrow f_{rms} = 11$ A

49. Official Ans. by NTA (3)

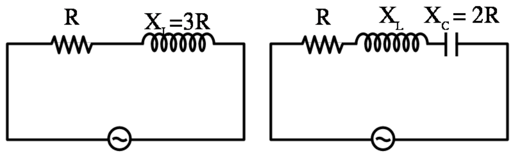
Sol. emf = BLV

= 1.(2R) .1

= 2 V

50. Official Ans. by NTA (1)

Sol.

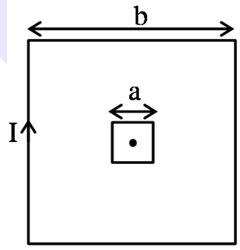


$\cos\phi = \frac{R}{\sqrt{R^2 + 3R^2}} = \frac{1}{\sqrt{10}}$ $\quad$ $\cos\phi' = \frac{R}{\sqrt{R^2 + R^2}} = \frac{1}{\sqrt{2}}$

$\frac{\cos\phi'}{\cos\phi} = \frac{\sqrt{10}}{\sqrt{2}} = \frac{\sqrt{5}}{1}$ $\quad$ $\therefore x = 1$

51. Official Ans. by NTA (1)

Sol.



$B = \left[\frac{\mu_0}{4\pi}\frac{I}{b/2} \times 2\sin 45\right] \times 4$

$\phi = 2\sqrt{2}\frac{\mu_0}{\pi}\frac{I}{b} \times a^2$

$\therefore M = \frac{\phi}{I} = \frac{2\sqrt{2}\mu_0 a^2}{\pi b} = \frac{\mu_0}{4\pi} 8\sqrt{2}\frac{a^2}{b}$

Option (1)

52. Official Ans. by NTA (3)

Sol. $Z = \sqrt{(X_L - X_C)^2 + R^2} = R \quad \because X_L = X_C$

Option (3)

53. Official Ans. by NTA (1)

Sol. $\vec{B}$ must not be parallel to the plane of coil for non zero flux and according to lenz law if B is outward it should be decreasing for anticlockwise induced current.

54. Official Ans. by NTA (2)

Sol. $X_L = 2\pi fL$

f is very large

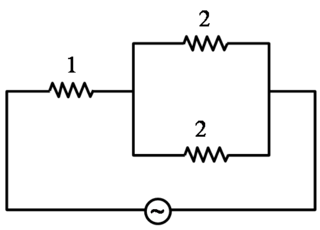
$\therefore$ X_L is very large hence open circuit.

$$X_C = \frac{1}{2\pi fC}$$

f is very large.

$\therefore$ X_C is very small, hence short circuit.

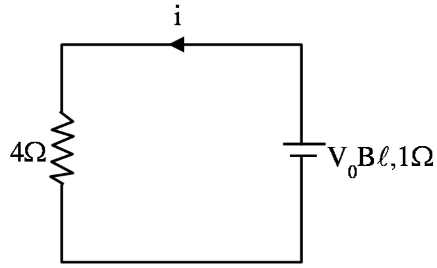
Final circuit



$$Z_{eq} = 1 + \frac{2 \times 2}{2 + 2} = 2$$

55. Official Ans. by NTA (2)

Sol. Equivalent circuit



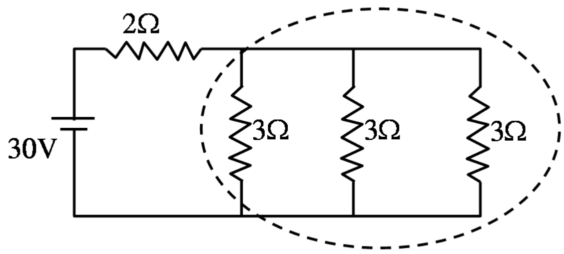
$$i = \frac{V_0B\ell}{4+1} \Rightarrow V_0 = \frac{5(2mA)}{5\times .2} = 10^{-2}\text{ m/s} = 1\text{ cm/s}$$

Option (2)

56. Official Ans. by NTA (3)

Sol. In steady state, inductor behaves as a conducting wire.

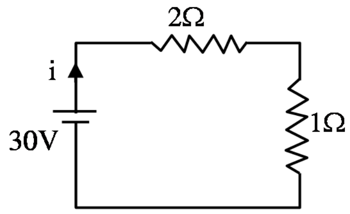
So, equivalent circuit becomes



Parallel (R_{eq})

$$\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1 \Rightarrow R_{eq} = 1\Omega$$

$\Rightarrow$ Circuit becomes



$$\Rightarrow i = \frac{30}{3} = 10A$$