DPP - Daily Practice Problems

Date : | **Start Time :** | **End Time :**

PHYSICS

CP21

SYLLABUS : Alternating Current

Max. Marks : 120 **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

INSTRUCTIONS : This Daily Practice Problem Sheet contains 30 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. 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) 0.1 s (b) 0.05 s (c) 0.3 s (d) 0.15 s

2. A series R-C circuit is connected to an alternating voltage source. Consider two situations:

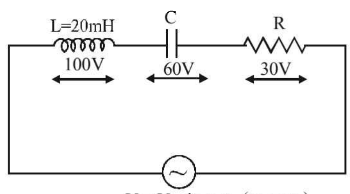
(A) When capacitor is air filled.

(B) When capacitor is mica filled.

Current through resistor is i and voltage across capacitor is V then :

(a) $V_a > V_b$ (b) $i_a > i_b$ (c) $V_a = V_b$ (d) $V_a < V_b$

3. Consider the RLC circuit shown below connected to an AC source of constant peak voltage V_0 and variable frequency ω_0. The value of L is 20 mH. For a certain value $\omega_0 = \omega_1$, rms voltage across L, C, R are shown in the diagram. At $\omega_0 = \omega_2$, it is found that rms voltage across resistance is 50V. Then



$V = V_0 \sin \omega_0 t \quad (\omega_0 = \omega_1)$

The value of ω_2 is

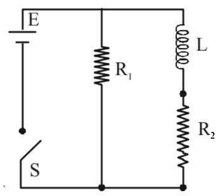
(a) $\sqrt{\frac{3}{5}}\omega_1$ (b) $\sqrt{\frac{5}{3}}\omega_1$ (c) $\frac{5}{3}\omega_1$ (d) $\frac{3}{5}\omega_1$

4. A bulb is rated at 100 V, 100 W, 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 200 V and 50 Hz.

(a) $\frac{\pi}{\sqrt{3}}$H (b) 100 H (c) $\frac{\sqrt{2}}{\pi}$H (d) $\frac{\sqrt{3}}{\pi}$H

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ

5. An inductor of inductance $L = 400$ mH and resistors of resistance $R_1 = 2\Omega$ and $R_2 = 2\Omega$ are connected to a battery of emf 12 V 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



(a) $\frac{12}{t}e^{-3t}$V (b) $6(1-e^{-t/0.2})$V
(c) $12e^{-5t}$V (d) $6e^{-5t}$V

6. 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. The ratio of reactance to resistance at the original frequency ω is

(a) $\sqrt{\frac{3}{5}}$ (b) $\sqrt{\frac{2}{5}}$ (c) $\sqrt{\frac{1}{5}}$ (d) $\sqrt{\frac{4}{5}}$

7. An ideal coil of 10H is connected in series with a resistance of 5Ω and a battery of 5V. 2second after the connection is made, the current flowing in ampere in the circuit is
(a) $(1-e^{-1})$ (b) $(1-e)$ (c) e (d) e^{-1}

8. In a series LCR circuit $R = 200\Omega$ and the voltage and the frequency of the main supply is 220V and 50 Hz respectively. On taking out the capacitance from the circuit the current lags 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
(a) 305 W (b) 210 W (c) Zero W (d) 242 W

9. A fully charged capacitor C with initial 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:

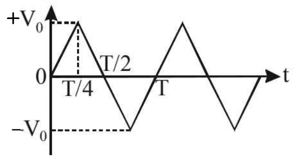
(a) $\frac{\pi}{4}\sqrt{LC}$ (b) $2\pi\sqrt{LC}$ (c) $\sqrt{LC}$ (d) $\pi\sqrt{LC}$

10. Combination of two identical capacitors, *a* resistor *R* and *a* *dc* voltage source of voltage 6V is used in an experiment on a (*C-R*) circuit. It is found that for a parallel combination of the capacitor the time in which the voltage of the fully charged combination reduces to half its original voltage is 10 second. For series combination the time for needed for reducing the voltage of the fully charged series combination by half is
(a) 10 second (b) 5 second
(c) 2.5 second (d) 20 second

11. 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 field is

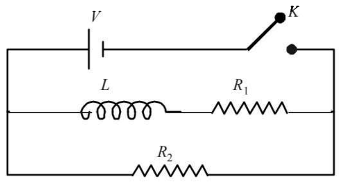
(a) $\frac{Q}{2}$ (b) $\frac{Q}{\sqrt{3}}$ (c) $\frac{Q}{\sqrt{2}}$ (d) Q

12. The voltage time (V-t) graph for triangular 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 $\frac{V_0}{\sqrt{x}}$ then find the value of x.



(a) 5 (b) 4 (c) 7 (d) 3

13. In the circuit shown below, the key K is closed at $t = 0$. The current through the battery is



(a) $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at $t = 0$ and $\frac{V}{R_2}$ at $t = \infty$

(b) $\frac{V}{R_2}$ at $t = 0$ and $\frac{V(R_1+R_2)}{R_1R_2}$ at $t = \infty$

(c) $\frac{V}{R_2}$ at $t = 0$ and $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at $t = \infty$

(d) $\frac{V(R_1+R_2)}{R_1R_2}$ at $t = 0$ and $\frac{V}{R_2}$ at $t = \infty$

RESPONSE GRID					
	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ
	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	

14. The tuning circuit of a radio receiver has a resistance of $50\,\Omega$, an inductor of 10 mH and a variable capacitor. A 1 MHz radio wave produces a potential difference of 0.1 mV. The values of the capacitor to produce resonance is (Take $\pi^2 = 10$)

(a) 2.5 pF (b) 5.0 pF (c) 25 pF (d) 50 pF

15. The instantaneous values of alternating current and voltages in a circuit are given as

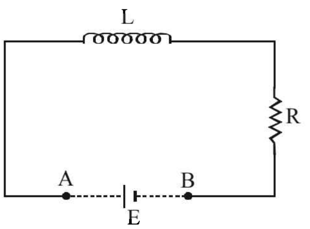
$$i = \frac{1}{\sqrt{2}}\sin(100\pi t) \text{ amper}$$

$$e = \frac{1}{\sqrt{2}}\sin(100\pi t + \pi/3) \text{ Volt}$$

The average power in Watts consumed in the circuit is :

(a) $\frac{1}{4}$ (b) $\frac{\sqrt{3}}{4}$ (c) $\frac{1}{2}$ (d) $\frac{1}{8}$

16. An inductor (L = 100 mH), a resistor (R = 100 Ω) 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



(a) 1/eA (b) eA (c) 0.1 A (d) 1 A

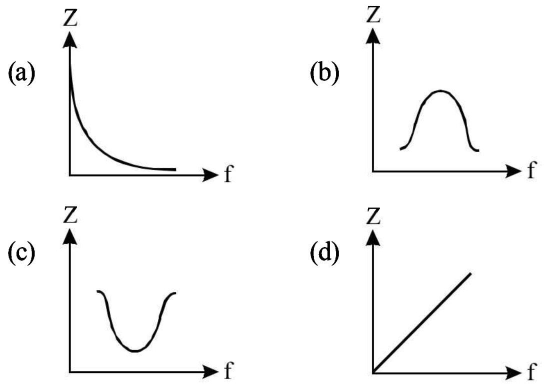
17. In an alternating current circuit in which an inductance and capacitance are joined in series, current is found to be maximum when the value of inductance is 0.5 henry and the value of capacitance is 8μF. The angular frequency of applied alternating voltage will be

(a) 5000 rad/sec (b) 4000 rad/sec
(c) 2×10^5 rad/sec (d) 500 rad/sec

18. A coil has resistance 30 ohm and inductive reactance 20 ohm at 50 Hz frequency. If an ac source, of 200 volt, 100 Hz, is connected across the coil, the current in the coil will be

(a) 4.0 A (b) 8.0 A (c) $\frac{20}{\sqrt{13}}$ A (d) 2.0 A

19. Which one of the following curves represents the variation of impedance (Z) with frequency f in series LCR circuit?



20. The primary and secondary coil of a transformer have 50 and 1500 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, the output voltage across the secondary coil is

(a) 120 volts (b) 220 volts
(c) 30 volts (d) 90 volts

21. The primary winding of a transformer has 100 turns and its secondary winding has 200 turns. The primary is connected to an A.C. supply of 120 V and the current flowing in it is 10 A. The voltage and the current in the secondary are

(a) 240 V, 5 A (b) 240 V, 10 A
(c) 60 V, 20 A (d) 120 V, 20 A

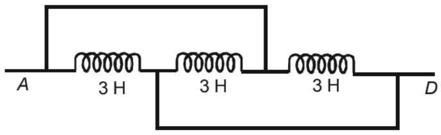
22. The current in a LR circuit builds up to $\frac{3}{4}th$ of its steady state value in 4s. The time constant of this circuit is

(a) $\frac{1}{\ell n2}s$ (b) $\frac{2}{\ell n2}s$ (c) $\frac{3}{\ell n2}s$ (d) $\frac{4}{\ell n2}s$

RESPONSE GRID	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	

23. A coil of resistance 50 Ω is connected across a 5.0 V battery. 0.1 s after the battery is connected, the current in the coil is 60 mA. Calculate the inductance of the coil.
(a) 5.5 H (b) 1.5 H (c) 2.5 H (d) 9.5 H

24. The inductance between *A* and *D* is



(a) 3.66 H (b) 9 H (c) 0.66 H (d) 1 H

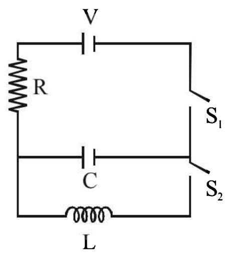
25. An LCR series circuit is connected to a source of alternating current. At resonance, the applied voltage and the current flowing through the circuit will have a phase difference of
(a) π (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{4}$ (d) 0

26. In an electrical circuit *R*, *L*, *C* and an a.c. voltage source are all connected in series. When *L* is removed from the circuit, the phase difference between the voltage the current in the circuit is $\pi/3$. If instead, *C* is removed from the circuit, the phase difference is again $\pi/3$. The power factor of the circuit is :
(a) 1/2 (b) $1/\sqrt{2}$ (c) 1 (d) $\sqrt{3}/2$

27. A 100 μF capacitor in series with a 40Ω resistance is connected to a 110 V, 60 Hz supply.
What is the maximum current in the circuit?
(a) 3.24 A (b) 4.25 A (c) 2.25 A (d) 5.20 A

28. The core of any transformer is laminated so as to
(a) reduce the energy loss due to eddy currents
(b) make it light weight
(c) make it robust and strong
(d) increase the secondary voltage

29. In an LCR circuit as shown below both switches are open initially. Now switch S_1 is closed, S_2 kept open. (q is charge on the capacitor and $\tau = RC$ is Capacitive time constant). Which of the following statement is correct?



(a) Work done by the battery is half of the energy dissipated in the resistor
(b) At, $t = \tau$, $q = CV/2$
(c) At, $t = 2\tau$, $q = CV(1 - e^{-2})$
(d) At, $t = 2\tau$, $q = CV(1 - e^{-1})$

30. An AC generator of 220 V having internal resistance r = 10Ω and external resistance R = 100Ω. What is the power developed in the external circuit?
(a) 484 W (b) 400 W (c) 441 W (d) 369 W

RESPONSE GRID					
	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ
	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ		

DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP21 - PHYSICS			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	45	Qualifying Score	60
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

1. **(a)** The charging of inductance given by,

$$i = i_0\left(1 - e^{-\frac{Rt}{L}}\right)$$

$$\frac{i_0}{2} = i_0(1 - e^{-\frac{Rt}{L}}) \Rightarrow e^{-\frac{Rt}{L}} = \frac{1}{2}$$

Taking log on both the sides,

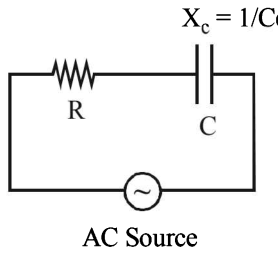
$$-\frac{Rt}{L} = \log 1 - \log 2$$

$$\Rightarrow t = \frac{L}{R}\log 2 = \frac{300 \times 10^{-3}}{2} \times 0.69$$

$\Rightarrow t = 0.1$ sec.

2. **(a)** For series R – C circuit, capacitive reactance,

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



$$\text{Current } i = \frac{V}{Z_c} = \frac{V}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}}$$

$$V_c = iX_c = \frac{V}{\sqrt{R^2 + \left(\frac{1}{C\omega}\right)^2}} \times \frac{1}{C\omega}$$

$$V_c = \frac{V}{\sqrt{(RC\omega)^2 + 1}}$$

If we fill a di-electric material like mica instead of air then capacitance $C\uparrow \Rightarrow V_c\downarrow$

So, $V_a > V_b$

3. **(a)** If voltage across resistor is 50V then this should be the resonance condition.

At resonance, $X_L = X_C$

$$\omega_2 L = \frac{1}{\omega_2 C}\ ;\ \omega_2 = \frac{1}{\sqrt{LC}}$$

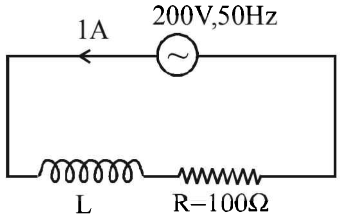
Also, At $\omega = \omega_1$

$$I = \frac{100}{X_L} = \frac{60}{X_C}\ ;\ \frac{100}{\omega_1 L} = \frac{60}{1/\omega_1 C}$$

$$C = \frac{100}{\omega_1^2 L \times 60} = \frac{5}{3\omega_1^2 L}$$

$$\omega_2 = \frac{1}{\sqrt{L \times \frac{5}{3\omega_1^2 L}}} = \sqrt{\frac{3}{5}}\,\omega_1$$

4. **(d)**



From the rating of the bulb, the resistance of the bulb can be calculated.

$$R = \frac{V_{rms}^2}{P} = 100\Omega$$

For the bulb to be operated at its rated value the rms current through it should be 1A

$$\text{Also, } I_{rms} = \frac{V_{rms}}{Z}$$

$$\therefore \quad 1 = \frac{200}{\sqrt{100^2 + (2\pi 50.L)^2}}$$

$$L = \frac{\sqrt{3}}{\pi} H$$

5. **(c)** Growth in current in LR_2 branch when switch is closed is given by

$$i = \frac{E}{R_2}[1 - e^{-R_2 t/L}]$$

$$\Rightarrow \frac{di}{dt} = \frac{E}{R_2}.\frac{R_2}{L}.e^{-R_2 t/L} = \frac{E}{L}e^{-\frac{R_2 t}{L}}$$

Hence, potential drop across L

$$= \left(\frac{E}{L}e^{-R_2 t/L}\right)L = Ee^{-R_2 t/L}$$

$$= 12e^{-\frac{2t}{400 \times 10^{-3}}} = 12e^{-5t}V$$

6. **(a)** At angular frequency ω, the current in RC circuit is given by

$$i_{max} = \frac{V_{max}}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}} \quad ....(i)$$

$$\text{Also } \frac{i_{rms}}{2} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\frac{\omega}{3}C}\right)^2}} = \frac{V_{max}}{\sqrt{R^2 + \frac{9}{\omega^2 C^2}}} \quad .....(ii)$$

From equation (i) and (ii) we get

$$3R^2 = \frac{5}{\omega^2C^2} \Rightarrow \frac{\frac{1}{\omega C}}{R} = \sqrt{\frac{3}{5}} \Rightarrow \frac{X_C}{R} = \sqrt{\frac{3}{5}}$$

7. **(a)** $I = I_o\left(1-e^{-\frac{R}{L}t}\right)$

(When current is in growth in LR circuit)

$$= \frac{E}{R}\left(1-e^{-\frac{R}{L}t}\right) = \frac{5}{5}\left(1-\mathrm{e}^{-\frac{5}{10}\times 2}\right)$$

$$= (1-e^{-1})$$

8. **(d)** When capacitance is taken out, the circuit is LR.

$$\therefore \tan\phi = \frac{\omega L}{R}$$

$$\Rightarrow \omega L = R\tan\phi = 200\times\frac{1}{\sqrt{3}} = \frac{200}{\sqrt{3}}$$

Again , when inductor is taken out, the circuit is CR.

$$\therefore \quad \tan\phi = \frac{1}{\omega CR}$$

$$\Rightarrow \frac{1}{\omega c} = R\tan\phi = 200\times\frac{1}{\sqrt{3}} = \frac{200}{\sqrt{3}}$$

Now, $Z = \sqrt{R^2+\left(\frac{1}{\omega C}-\omega L\right)^2}$

$$= \sqrt{(200)^2+\left(\frac{200}{\sqrt{3}}-\frac{200}{\sqrt{3}}\right)^2} = 200\,\Omega$$

Power dissipated = $V_{rms}I_{rms}\cos\phi$

$$= V_{rms}.\frac{V_{rms}}{Z}.\frac{R}{Z}\left(\because \cos\phi = \frac{R}{Z}\right)$$

$$= \frac{V^2_{rms}R}{Z^2} = \frac{(220)^2\times 200}{(200)^2}$$

$$= \frac{220\times 220}{200} = 242\text{ W}$$

9. **(a)** Energy stored in magnetic field = $\frac{1}{2}$ Li^2

Energy stored in electric field = $\frac{1}{2}\frac{q^2}{C}$

$$\therefore \frac{1}{2}Li^2 = \frac{1}{2}\frac{q^2}{C}$$

Also $q = q_0\cos\omega t$ and $\omega = \frac{1}{\sqrt{LC}}$

On solving $t = \frac{\pi}{4}\sqrt{LC}$

10. **(c)** Time constant for parallel combination

$= 2RC$

Time constant for series combination

$$= \frac{RC}{2}$$

In first case :

$$V = V_0 e^{-\frac{t_1}{2RC}} = \frac{V_0}{2} \qquad \text{...(1)}$$

In second case :

$$V = V_0 e^{-\frac{t_2}{(RC/2)}} = \frac{V_0}{2} \qquad \text{....(2)}$$

From (1) and (2)

$$\frac{t_1}{2RC} = \frac{t_2}{(RC/2)}$$

$$\Rightarrow t_2 = \frac{t_1}{4} = \frac{10}{4} = 2.5\text{ sec.}$$

11. **(c)** When the capacitor is completely charged, the total energy in the LC circuit is with the capacitor and that energy is $E = \frac{1}{2}\frac{Q^2}{C}$

When half energy is with the capacitor in the form of electric field between the plates of the capacitor we get

$\frac{E}{2} = \frac{1}{2}\frac{Q'^2}{C}$ where Q' is the charge on one plate of the capacitor

$$\therefore \frac{1}{2}\times\frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{Q'^2}{C} \Rightarrow Q' = \frac{Q}{\sqrt{2}}$$

12. **(d)** $V = \frac{V_0}{T/4}t \Rightarrow V = \frac{4V_0}{T}t$

$$\Rightarrow V_{rms} = \sqrt{<V^2>} = \frac{4V_0}{T}\sqrt{<t^2>} = \frac{4V_0}{T}\left\{\frac{\int_0^{T/4} t^2 dt}{\int_0^{T/4} dt}\right\}^{1/2} = \frac{V_0}{\sqrt{3}}$$

13. **(b)** At $t = 0$, no current will flow through L and R_1

$$\therefore \text{Current through battery} = \frac{V}{R_2}$$

At $t = \infty$,

effective resistance, $R_{eff} = \frac{R_1R_2}{R_1+R_2}$

$$\therefore \text{Current through battery} = \frac{V}{R_{eff}}$$

$$= \frac{V(R_1+R_2)}{R_1R_2}$$

14. **(a)** L = 10 mHz = 10^{-2} Hz

f = 1MHz = 10^6 Hz

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$f^2 = \frac{1}{4\pi^2 LC}$$

$$\Rightarrow C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4\times10\times10^{-2}\times10^{12}} = \frac{10^{-12}}{0.4} = 2.5\ pF$$

15. (d) The average power in the circuit where $\cos\phi$ = power factory

$$<P> = V_{rms} \times I_{rms} \cos\phi$$

$$\phi = \pi/3 = \text{phase difference} = \frac{180}{3} = 60$$

$$V_{rms} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} = \frac{1}{2}\text{volt}$$

$$I_{rms} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} = \left(\frac{1}{2}\right)A$$

$$\cos\phi = \cos\frac{\pi}{3} = \frac{1}{2}$$

$$<P> = \frac{1}{2}\times\frac{1}{2}\times\frac{1}{2} = \frac{1}{8}W$$

16. (a) Initially, when steady state is achieved,

$$i = \frac{E}{R}$$

Let E is short circuited at $t = 0$. Then

At $t = 0$, $i_0 = \frac{E}{R}$

Let during decay of current at any time the current flowing is $-L\frac{di}{dt} - iR = 0$

$$\Rightarrow \frac{di}{i} = -\frac{R}{L}dt \Rightarrow \int_{i_0}^{i}\frac{di}{i} = \int_0^t -\frac{R}{L}dt$$

$$\Rightarrow \log_e\frac{i}{i_0} = -\frac{R}{L}t \Rightarrow i = i_0\, e^{-\frac{R}{L}t}$$

$$\Rightarrow i = \frac{E}{R}e^{-\frac{R}{L}t} = \frac{100}{100}e^{\frac{-100\times10^{-3}}{100\times10^{-3}}} = \frac{1}{e}$$

17. (d) Current is maximum when $X_L = X_C$

$$\Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.5\times8\times10^{-6}}}$$

$$= \frac{1}{2\times10^{-3}} = 500\text{ rad/s.}$$

18. (a) If $\omega = 50\times2\pi$ then $\omega L = 20\Omega$

If $\omega' = 100\times2\pi$ then $\omega' L = 40\Omega$

Current flowing in the coil is

$$I = \frac{200}{Z} = \frac{200}{\sqrt{R^2+(\omega' L)^2}} = \frac{200}{\sqrt{(30)^2+(40)^2}}$$

I = 4A.

19. (c) Impedance at resonant frequency is minimum in series LCR circuit.

$$\text{So, } Z = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$$

20. (a) Since $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

Where

N_s = No. of turns across primary coil = 50

N_p = No. of turns across secondary coil = 1500

and $V_p = \frac{d\phi}{dt} = \frac{d}{dt}(\phi_0 + 4t) = 4$

$$\Rightarrow V_s = \frac{1500}{50}\times4 = 120\text{ V}$$

21. (a) $\frac{E_s}{E_p} = \frac{n_s}{n_p}$ or $E_s = E_p \times\left(\frac{n_s}{n_p}\right)$

$$\therefore\ E_s = 120\times\left(\frac{200}{100}\right) = 240\text{V}$$

$\frac{\mathbf{I}_p}{\mathbf{I}_s} = \frac{n_s}{n_p}$ or $\mathbf{I}_s = \mathbf{I}_p\left(\frac{n_p}{n_s}\right)$ $\therefore\ \mathbf{I}_s = 10\left(\frac{100}{200}\right) = 5$ amp

22. (b) We know that, $i = i_0(1-e^{-t/\tau})$

or $\frac{3}{4}i_0 = i_0(1-e^{-4/\tau})$

or $e^{-4/\tau} = \frac{1}{4}$

or $e^{4/\tau} = 4$

$\therefore\ \frac{4}{\tau} = \ln 4$

or $\tau = \frac{2}{\ln 2}s$

23. (a) $I_0 = \frac{E}{R} = \frac{5}{50} = 0.1$ A

$I = 60$ mA $= 60\times10^{-3}$ A, $t = 0.1$

Now, $I = I_0\left(1 - e^{-\frac{R}{L}t}\right)$

$$\therefore\ 60\times10^{-3} = 0.1\left(1-e^{-\frac{50}{L}\times0.1}\right) = 0.1\left(1-e^{-\frac{5}{L}}\right)$$

or $1 - e^{-5/L} = 0.6$

$\therefore\ e^{-5/L} = 1 - 0.6 = 0.4 = \frac{4}{10}$ or $e^{5/L} = 10/4$

Taking log of both sides

$$\frac{5}{L} = 2.303\,[\log_{10}10 - \log_{10}4]$$

$= 2.303\,[1.0000 - 0.6021] = 2.303\times0.3979 = 0.9164$

$$\therefore\ L = \frac{5}{0.9164} = 5.5\text{H}$$

24. (d) These three inductors are connected in parallel. The equivalent inductance L_p is given by

$$\frac{1}{L_p}=\frac{1}{L_1}+\frac{1}{L_2}+\frac{1}{L_3}=\frac{1}{3}+\frac{1}{3}+\frac{1}{3}=\frac{3}{3}=1$$

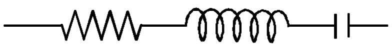
$$\therefore L_p=1$$

25. (d) At resonance, $\omega L=\frac{1}{\omega C}$. The circuit behaves as if it contains R only. So, phase difference = 0

At resonance, impedance is minimum Z_{min} = R and current is maximum, given by

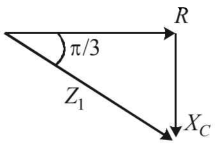
$$I_{max}=\frac{E}{Z_{min}}=\frac{E}{R}$$

It is interesting to note that before resonance the current leads the applied emf, at resonance it is in phase, and after resonance it lags behind the emf. LCR series circuit is also called as acceptor circuit and parallel LCR circuit is called rejector circuit.

26. (c) 

when L is removed from the circuit

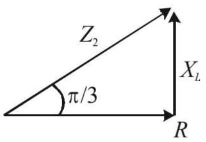
$$\frac{X_C}{R}=\tan\frac{\pi}{3}$$



$$X_C=R\tan\frac{\pi}{3} \quad ...(1)$$

when C is remove from the circuit

$$\frac{X_L}{R}=\tan\frac{\pi}{3}$$



$$X_C=R\tan\frac{\pi}{3} \quad ...(2)$$

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

power factor $\cos\phi=\frac{R}{Z}=1$

27. (a) Here, C = 100 μF = 100 × 10^{-6} F, R = 40 Ω, V_{rms} = 110 V, f = 60 Hz

Peak voltage,

$$V_0=\sqrt{2}\ .\ V_{rms}=100\sqrt{2}=155.54\text{ V}$$

Circuit impedance,

$$Z=\sqrt{R^2+\frac{1}{\omega^2C^2}}$$

$$=\sqrt{40^2+\frac{1}{(2\times\pi\times 60\times 100\times 10^{-6})^2}}$$

$$=\sqrt{1600+703.60}=\sqrt{2303.60}=48\ \Omega$$

hence, maximum current in coil,

$$I_0=\frac{V_0}{Z}=\frac{155.54}{48}=3.24\text{ A}$$

28. (a) Laminated core provide less area of cross-section for the current to flow. Because of this, resistance of the core increases and current decreases thereby decreasing the eddy current losses.

29. (c) Charge on he capacitor at any time t is given by q = CV $(1-e^{t/\tau})$

at t = 2τ

q = CV $(1-e^{-2})$

30. (b) V = 200V; r = 10Ω

R' = 10 + 100Ω = 110Ω

$$I=\frac{V}{R'}=\frac{220}{100}=2A$$

$P=I^2R=4\times 100=400\ W$