DPP - Daily Practice Problems

Date : ______ **Start Time :** ______ **End Time :** ______

PHYSICS

CP19

SYLLABUS : Alternating Current

Max. Marks : 74 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 20 Questions divided into 5 sections.
  Section I has **5** MCQs with ONLY 1 Correct Option, **3** marks for each correct answer and **–1** for each incorrect answer.
  Section II has **4** MCQs with ONE or MORE THAN ONE Correct options.
  For each question, marks will be awarded in one of the following categories:
  Full marks: **+4** If only the bubble(s) corresponding to all the correct option(s) is (are) darkened.
  Partial marks: **+1** For darkening a bubble corresponding to each correct option provided NO INCORRECT option is darkened.
  Zero marks: If none of the bubbles is darkened.
  Negative marks: **–2** In all other cases.
  Section III has **4** Single Digit Integer Answer Type Questions, **3** marks for each Correct Answer and 0 marks in all other cases.
  Section IV has Comprehension/Matching Cum-Comprehension Type Questions having **5** MCQs with ONLY ONE correct option, **3** marks for each Correct Answer and 0 marks in all other cases.
  Section V has **2** Matching Type Questions, **2** mark for the correct matching of each row and 0 marks in all other cases.
- You have to evaluate your Response Grids yourself with the help of Solutions.

Section I - Straight Objective Type

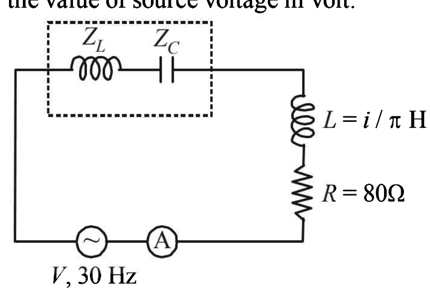
This section contains 5 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

1. In a series LCR circuit, the difference of the frequencies at which current amplitude falls to $\frac{1}{\sqrt{2}}$ of the current amplitude at resonance is

(a) $\frac{R}{2\pi L}$ (b) $\frac{R}{\pi L}$

(c) $\frac{2R}{\pi L}$ (d) $\frac{3R}{2\pi L}$

2. In figure given below if $Z_L = Z_c$ and reading of ammeter is 1A then the value of source voltage in volt.



(a) 80 (b) 60

(c) 100 (d) 40

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ

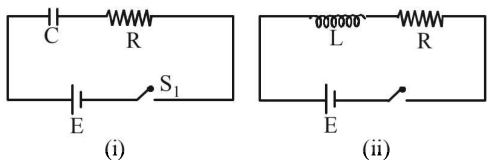
Space for Rough Work

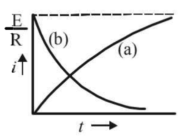
3. A resistor of resistance R, capacitor of capacitance C and inductor of inductance L are connected in parallel to AC power source of voltage $\varepsilon_0 \sin \omega t$. The maximum current through the resistance is half of the maximum current through the power source. Then value of R is

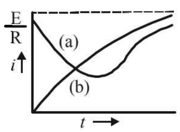
(a) $\dfrac{\sqrt{3}}{\left|\omega C - \dfrac{1}{\omega L}\right|}$ (b) $\sqrt{3}\left|\dfrac{1}{\omega C} - \omega L\right|$

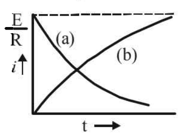
(c) $\sqrt{5}\left|\dfrac{1}{\omega C} - \omega L\right|$ (d) $2\left|\dfrac{1}{\omega C} - \omega L\right|$

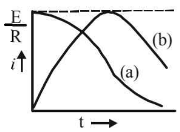
4. In the circuits (i) and (ii) switches S_1 and S_2 are closed at t = 0 and are kept closed for a long time. The variation of current in the two circuits for t ≥ 0 are roughly shown by figure (figures are schematic and not drawn to scale) :



(a)


(b)


(c)


(d)


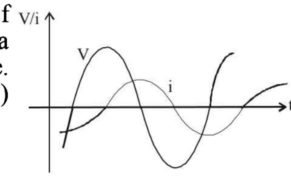
5. When resonance is produced in a series LCR circuit, then which of the following is not correct ?
(a) Current in the circuit is in phase with the applied voltage
(b) Inductive and capacitive reactances are equal
(c) If R is reduced, the voltage across capacitor will increase
(d) Impedance of the circuit is maximum

Section II - Multiple Correct Answer Type

This section contains 4 multiple correct answer(s) type questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONE OR MORE** is/are correct.

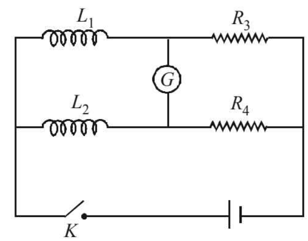
6. A series R– C circuit is connected to AC voltage source. Consider two cases; (A) when C is without a dielectric medium and (B) when C is filled with dielectric of constant 4. The current I_R through the resistor and voltage V_C across the capacitor are compared in the two cases. Which of the following is/are true?
(a) $I_R^A > I_R^B$ (b) $I_R^A < I_R^B$ (c) $V_C^A > V_C^B$ (d) $V_C^A < V_C^B$

7. Graph shows variation of source emf V and current i in a series RLC circuit, with time. Choose the correct option(s) from the following.



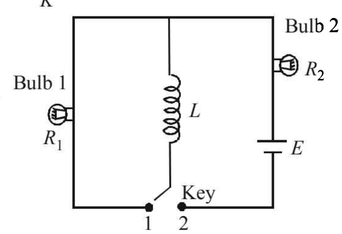
(a) To increase the rate at which energy is transferred to the resistive load, L should be decreased
(b) To increase the rate at which energy is transferred to the resistive load, C should be decreased
(c) The circuit is more inductive than capacitive
(d) The current leads the emf in the circuit

8. Two inductors of self-inductances L_1 and L_2 and of resistances R_1 and R_2 (not shown here) respectively, are connected in the circuit as shown in figure. At the instant $t = 0$, key K is closed. Choose the correct options for which the galvanometer will show zero deflection at all times after the key is closed.



(a) $\dfrac{L_1}{L_2} = \dfrac{R_3}{R_4}$
(b) $\dfrac{L_1}{L_2} = \dfrac{R_1}{R_2}$
(c) $\dfrac{R_1}{R_2} = \dfrac{R_3}{R_4}$
(d) None of these

9. Key is in position 2 for time t. Thereafter, it is in position 1. Resistance of the bulb and inductance of inductor are marked in the figure. Choose the correct alternative(s).



(a) Bulb 2 dies as soon as key is switched into position 1
(b) Time in which brightness of bulb 1 becomes half its maximum brightness does not depend on t
(c) In $t = \infty$, total heat produced in bulb 1 is $\dfrac{LE^2}{2R_2^2}$
(d) Ratio of maximum power consumption of bulbs depends on time

Section III - Integer Type

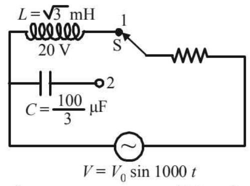
This section contains 4 questions. The answer to each of the questions is a single digit integer ranging from 0 to 9.

10. An inductor of inductance 100 mH is connected in series with a resistance, a variable capacitance and an AC source of frequency 2.0 kHz. If $(9x)$nF be the value of the capacitance so that maximum current may be drawn into the circuit then find the value of x.

RESPONSE GRID					
	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ
	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓪①②③④⑤⑥⑦⑧⑨		

Space for Rough Work

11. In the given AC circuit, when switch S is at position 1, the source emf leads current by $\frac{\pi}{6}$.



Now, if the switch is at position 2, then source e.m.f. leads current by $\frac{\pi}{x}$. Find the value of x.

12. A 100 V AC source of frequency 500 Hz is connected to LCR circuit with L = 8.1 mH, C = 12.5 μF and $R = 10\,\Omega$, all connected in series. The potential across the resistance is $25x$V. Find the value of x.

13. A 60 Hz AC source of voltage 160 V impressed across an LR-circuit results in a current of 2 A. If the power dissipation is 200 W the maximum value of the back emf arising in the inductance is $25x$ V. Find the value of x.

Section IV - Comprehension/Matching Cum-Comprehension Type

Directions (Qs. 14 and 15) : Based upon the given paragraph, 2 multiple choice questions have to be answered. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

PARAGRAPH

In a series L-R circuit, connected with a sinusoidal A.C. source, the maximum potential difference across L and R are respectively 3 volts and 4 volts.

14. At an instant the potential difference across resistor is 2 volts. The potential difference in volt, across the inductor at the same instant will be
    (a) 3 cos 30° (b) 3 cos 60°
    (c) 3 cos 45° (d) 3 cos 15°

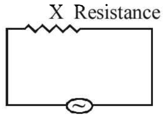
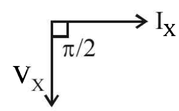
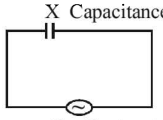
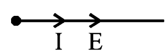
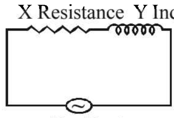
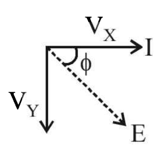
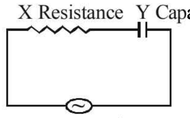
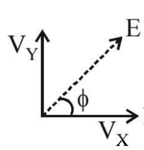
15. At the same instant, the magnitude of the potential difference in volt, across the A.C. source may be
    (a) $4+3\sqrt{3}$ (b) $\frac{4+3\sqrt{3}}{2}$ (c) $1+\frac{\sqrt{3}}{2}$ (d) $2+\frac{\sqrt{3}}{2}$

Directions (Qs. 16-18) : This passage contains a table having 3 columns and 4 rows. Based on the table, there are three questions. Each question has four options (a), (b), (c) and (d) **ONLY ONE** of these four options is correct.

Alternating current in a circuit may be controlled by resistance, inductance and capacitance. Column II and Column III represents the phasor diagram and impedance of an AC-circuit containing different elements respectively. The applied emf (E) and current produced (I) may be represented as

$E = E_0 \sin \omega t$ and $I = I_0 \sin(\omega t + \phi)$ with $I_0 = E_0/Z$ (Z = impedance)

Here 'X' and 'Y' have different meaning with different units for different circuits shown in the column I.

	Column I		Column II		Column III
I.	X Resistance  $E = E_0 \sin \omega t$ Resistor only	(i)		(P)	$Z = \frac{1}{\omega X}$
II.	X Capacitance  $E = E_0 \sin \omega t$ Capacitor only	(ii)		(Q)	$Z = X$
III.	X Resistance Y Inductance  $E = E_0 \sin \omega t$ L-R series circuit	(iii)		(R)	$Z = \sqrt{x^2 + \omega^2 Y^2}$
IV.	X Resistance Y Capacitance  $E = E_0 \sin \omega t$ C-R series circuit	(iv)		(S)	$Z = \sqrt{x^2 + \frac{1}{\omega^2 Y^2}}$

RESPONSE GRID	11. ⓪①②③④⑤⑥⑦⑧⑨ 12. ⓪①②③④⑤⑥⑦⑧⑨
	13. ⓪①②③④⑤⑥⑦⑧⑨ 14. ⓐⓑⓒⓓ 15. ⓐⓑⓒⓓ

Space for Rough Work

16. If the potential difference across the capacitor of capacitance Y unit shown in the C-R series circuit is $\frac{E}{\sqrt{(XY\omega)^2+1}}$ then the correct matching for the circuit is

(a) IV (iii) Q (b) IV (iii) S (c) III (iv) S (d) IV (ii) P

17. Which of the following shows the correct matching for L-R series circuit?

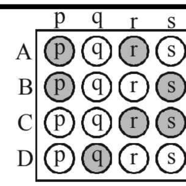
(a) III (iii) R (b) III (iv) R (c) III (i) P (d) III (ii) Q

18. Which of the following is wrongly matched?

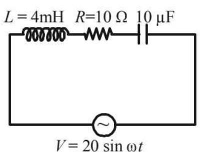
(a) I (ii) Q (b) II (i) P (c) IV (iv) R (d) IV (iii) S

Section V - Matrix-Match Type

This section contains 2 questions. It contains statements given in two columns, which have to be matched. Statements in column I are labelled as A, B, C and D whereas statements in column II are labelled as p, q, r and s. The answers to these questions have to be appropriately bubbled as illustrated in the following example. If the correct matches are A-p, A-r, B-p, B-s, C-r, C-s and D-q, then the correctly bubbled matrix will look like the following:

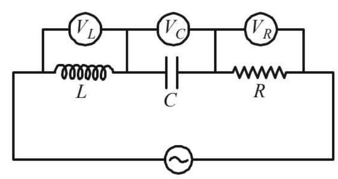


19. Consider the circuit shown in figure given below and match the columns.



Column-I		Column-II
(A) For ω = 5,000 rad/sec	(p)	The current in circuit leads the voltage
(B) For ω = 2,500 rad/sec	(q)	The current and voltage in circuit are in same phase
(C) For ω = 75,00 rad/sec	(r)	The peak current in circuit is less than 2A
(D) For ω = 5,000 rad/sec and $R = 20\Omega$ in place of 10Ω	(s)	Voltage in circuit leads the current.

20. In an LCR sereis circuit connected to an ac source, the supply voltage is $V = V_0 \sin\left(100\pi t + \frac{\pi}{6}\right)$. $V_L = 40\ V$, $V_R = 40V$, $Z = 5\Omega$ and $R = 4\Omega$. Match the two columns.



Column I		Column II
(A) Peak current (in A)	(p)	$10\sqrt{2}$
(B) V_0 (in volts)	(q)	$50\sqrt{2}$
(C) Effective value of applied voltage (in volts)	(r)	50
(D) X_C (in Ω)	(s)	1

RESPONSE GRID	
	16. ⓐⓑⓒⓓ 17. ⓐⓑⓒⓓ 18. ⓐⓑⓒⓓ
	19. A - ⓟⓠⓡⓢ; B - ⓟⓠⓡⓢ; C - ⓟⓠⓡⓢ; D - ⓟⓠⓡⓢ
	20. A - ⓟⓠⓡⓢ; B - ⓟⓠⓡⓢ; C - ⓟⓠⓡⓢ; D - ⓟⓠⓡⓢ

DAILY PRACTICE PROBLEM DPP CP19 - PHYSICS			
Total Questions	20	Total Marks	74
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	24	Qualifying Score	35

$$\text{Net Score} = \sum_{i=I}^{V}\left[\left(\text{correct}_i \times MM_i\right) - \left(In_i - NM_i\right)\right]$$

Space for Rough Work

1. (a) At resonance

$$I_R=\frac{E_0}{R}\Rightarrow\frac{I_R}{\sqrt{2}}=\frac{E_0}{\sqrt{2}R}=\frac{E_0}{\sqrt{R^2+\left(\omega L-\frac{1}{\omega C}\right)^2}}$$

$$\Rightarrow \omega_1 L-\frac{1}{\omega_1 C}=-R \text{ and } \omega_2 L-\frac{1}{\omega_2 C}=+R$$

$$\Rightarrow L(\omega_1+\omega_2)=\left(\frac{\omega_1+\omega_2}{\omega_1\omega_2}\right)\frac{1}{C}\Rightarrow\omega_1\omega_2=\frac{1}{LC}$$

and $L(\omega_2-\omega_1)+\left(\frac{\omega_2-\omega_1}{\omega_1\omega_2}\right)\frac{1}{C}=2R$

Putting value of $\omega_1\ \omega_2$ we get

$$\omega_2-\omega_1=\frac{R}{L}\Rightarrow f_2-f_1=\frac{R}{2\pi L}$$

2. (c) If $Z_L=Z_C$ current will be same,

So, $V_{Z_L}=V_{Z_C}$;

$\therefore\quad V_L=1\times 2\pi\times 30\times\frac{1}{\pi}=60$ Volt

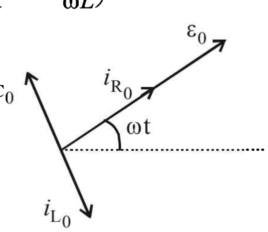
$V_R=80\times 1=80$ Volt;

$V=\sqrt{V_L^2+V_R^2}=\sqrt{(80)^2+(60)^2}=100$ Volt

3. (a) $$\frac{i_{R_0}}{\sqrt{(i_{R_0})^2+(i_{c_0}-i_{L_0})^2}}=\frac{1}{2}$$

$$\Rightarrow\frac{\varepsilon_0/R}{\sqrt{(\varepsilon_0/R)^2+\left(\varepsilon_0\omega C-\frac{\varepsilon_0}{\omega L}\right)^2}}=\frac{1}{2}$$

$$\Rightarrow R=\frac{\sqrt{3}}{\left(\omega C-\frac{1}{\omega L}\right)}$$



4. (c) For capacitor circuit, $i=i_0e^{-t/RC}$

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

Hence graph (c) correctly depicts i versus t graph.

5. (d) Impedance (Z) of the series LCR circuit is

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

At resonance, $X_L=X_C$

Therefore, $Z_{minimum}=R$

6. (a,c) We know that $Z=\sqrt{R^2+\left(\frac{1}{WC}\right)^2}$

The capacitance in case B is four times the capacitance in case A

$\therefore$ Impedance in case B is less then that of case A $(Z_B<Z_A)$

Now $I=\frac{V}{Z}$

$\therefore I_R^A<I_R^B$. option (a) is correct.

$\therefore V_R^A<V_R^B$.

$\Rightarrow\quad V_C^A>V_C^B$

[$\because$ If V is the applied potential difference access series R-C circuit then $V=\sqrt{V_R^2+V_C^2}$]

$\therefore$ (c) is the correct option.

7. (a,b,c)

It is apparent from the graph that emf attains its maximum value before the current does, therefore current lags behind emf in the circuit. Nature of the circuit is inductive.

Value of power factor cos ϕ increases by either deceasing L of increasing C.

8. (a, b, c, d)

Since there is no current through BD therefore points B and D are at the same potential

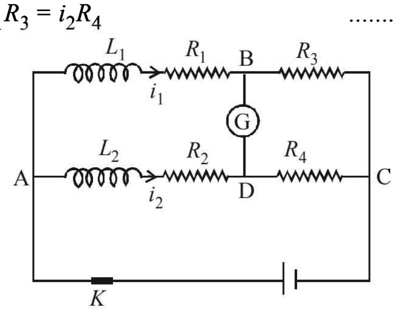
$V_B=V_D$

Potential difference, $V_{AB}=V_{AD}$

$$L_1\frac{di_1}{dt}+i_1R_1=L_2\frac{di_2}{dt}+i_2R_2 \quad ....(1)$$

Similarly, $V_{BC}=V_{DC}$

$$i_1R_3=i_2R_4 \quad ....(2)$$



From equations (1) and (2),

$$\frac{di_1}{dt}R_3 = \frac{di_2}{dt}R_4$$

or $\frac{di_1}{dt} = \frac{R_4}{R_3}\frac{di_2}{dt}$ and $i_1 = i_2\frac{R_4}{R_3}$

$$L_1\frac{R_4}{R_3}\frac{di_2}{dt} + i_2\frac{R_1R_4}{R_3} = L_2\frac{di_2}{dt} + i_2R_2$$

$$\left(L_1\frac{R_4}{R_3} - L_2\right)\frac{di_2}{dt} = i_2\left[R_2 - \frac{R_1R_4}{R_3}\right] \quad ....(3)$$

At $t = 0,\ i_2 = 0$

$\therefore \quad L_1\frac{R_4}{R_3} - L_2 = 0$ as $\frac{di_2}{dt} \neq 0$

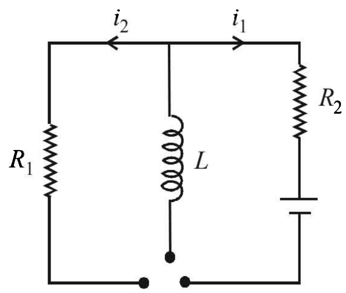
$$\therefore \quad \frac{L_1}{L_2} = \frac{R_3}{R_4} \quad ....(4)$$

At $t = \infty$, $\frac{di_2}{dt} = 0$, $i_2 = \left(\frac{E}{R_2 + R_4}\right)$ = constant

$$\Rightarrow R_2 - \frac{R_4R_1}{R_3} = 0 \therefore \frac{R_1}{R_2} = \frac{R_3}{R_4} \quad ....(5)$$

From equations (4) and (5), $\frac{L_1}{L_2} = \frac{R_1}{R_2} = \frac{R_3}{R_4}$

9. (a, b, c)



At time t, $i_1 = \frac{E}{R_2}\left(1 - E^{-\frac{t}{L}R_2}\right)$

So, $i_1 = i_2 = i_{2\,max}$; $i_2(t) = i_1e^{-\frac{(t')}{L}R_1}$

Now for power become half $i_2(t) = \frac{i_1}{\sqrt{2}}$

$$\Rightarrow \frac{i_1}{\sqrt{2}} = i_1\left[e^{-\frac{(t')}{L}R_1}\right] \quad \text{(don't depend on } t\text{)}$$

When $t = \infty$, $i_1 = \frac{E}{R_2}$

So power in R_2 generated

$$\frac{1}{2}L\,[i_1(t = \infty)]^2 = \frac{1}{2}L\left(\frac{E}{R_2}\right)^2 = \frac{L}{2}\frac{E^2}{R_2^2}$$

10. 7 For the maximum current,

$$X_C = X_L \quad \text{or} \quad \frac{1}{\omega C} = \omega L$$

$$\therefore \quad C = \frac{1}{\omega^2L} = \frac{1}{(2\pi f)^2L}$$

$$= \frac{1}{(2\pi\times2\times10^3)^2\times100\times10^{-3}} = 63\times10^{-9}F$$

11. 4 $\tan\frac{\pi}{6} = \frac{X_L}{R} = \frac{1}{\sqrt{3}}$

$R = 3\Omega$

$\tan\theta = \frac{X_C}{R} = 1\Omega$

$\phi = \frac{\pi}{4}$

12. 4 $X_L = \omega L = (2\pi\times500)\times8.1 = 25.4\,\Omega$

and $X_C = \frac{1}{\omega C} = \frac{1}{(2\pi\times500)\times(12.5\times10^{-6})} = 25.4\ \Omega$

As $X_L = X_C$, so resonance will occur and $V_R = 100V$.

13. 5 The impedance, $Z = \frac{Vrms}{i} = \frac{160}{2} = 80\Omega$

We know that, Power,

$$P = \frac{V_{rms}^2R}{Z^2} \text{ or } 200 = \frac{160^2\times R}{80^2}$$

$\therefore \quad R = 50\,\Omega$

We know that, $Z = \sqrt{R^2 + X_L^2}$

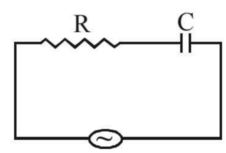
or $80 = \sqrt{50^2 + {X_L}^2}$ $\therefore X_L = 62.5\,\Omega$

The back emf, $V_L = iX_L = 2\times62.5 = 125$ V.

14. (a)

15. (b)

16. (b)



$E = E_0 \sin\omega t$

For a C-R series circuit

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

So, $I = \frac{E}{Z} = \frac{E}{\sqrt{R^2 + \frac{1}{\omega^2C^2}}}$, $\left(\text{here, } X_C = \frac{1}{\omega C}\right)$

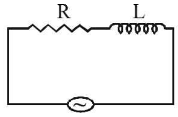
Voltage across capacitor $= I \times X_C$

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

$$= \frac{E}{\sqrt{R^2\omega^2C^2 + 1}} \quad \text{or} \quad V_C = \frac{E}{\sqrt{(XY\omega)^2 + 1}}$$

17. **(b)** For L-R series circuit,

$Z = \sqrt{R^2 + \omega^2 L^2}$



Phase difference $\phi = \tan^{-1}\dfrac{\omega L}{R}$

and voltage is leading.

18. **(c)**

19. **A → q; B → r, p; C → r, s; D → q, r**

Resonant frequency is $\omega_c^2 = \dfrac{1}{LC}$.

(i) if $\omega < \omega_c$, capacitor dominates

(ii) if $\omega > \omega_c$, inductor property dominates

20. **A → p; B → q; C → p; D → s**

A: $i_{rms} = \dfrac{V_R}{R} = \dfrac{40}{4} = 10A$; $i_0 = \sqrt{2} i_{rms} = 10\sqrt{2}\ A$

B: $\therefore\ V_{rms} = iZ = 10 \times 5 = 50V$; $V_0 = \sqrt{2}\, V_{rms} = 50\sqrt{2}\, V$

C: $i_{rms} = \dfrac{V_R}{R} = \dfrac{40}{4} = 10A$; $i_0 = \sqrt{2} i_{rms} = 10\sqrt{2}\ A$

D: Now $V^2 = V_R^2 + (V_L - V_C)^2$

or $50^2 = 40^2 + (40 - V_C)^2$

$\therefore\ V_C = 10V$,

and $X_C = \dfrac{V_C}{i} = \dfrac{10}{10} = 1\Omega$