ALTERNATING CURRENTS

SYNOPSIS

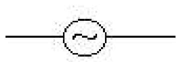
ALTERNATING CURRENT (A.C.)

i) Electric current, which keeps on changing in magnitude and direction with respect to time is defined as alternating current.

ii) It obeys Ohm's law and Joule's heating law.

iii) It is produced using the principle of electro-magnetic Induction.

iv) A.C. source is represented by the symbol.



ALTERNATING VOLTAGE (A.V)

i) The voltage, which changes in magnitude and direction with respect to time is defined as alternating voltage.

ii) The alternating voltage in general use is sinusoidal voltage. It is produced by rotating a coil in a uniform magnetic field with uniform angular velocity.

INSTANTANEOUS VALUE OF A.C. (I)

It is the electric current flowing at any instant of time t in an A.C. circuit.

$I = I_0 \sin \omega t$

AMPLITUDE OF A.C. (I_0)

It is the maximum value of A.C. The value of A.C. becomes maximum twice in one cycle.

AVERAGE VALUE OF A.C. < I >

For one complete cycle $\langle I \rangle = 0$

For half cycle $\langle I \rangle = \frac{2I_0}{\pi} = 0.636 I_0$

FREQUENCY OF A.C. (f)

It is the number of cycles completed by A.C. in one second.

TIME PERIOD OF A.C. (T)

It is the time taken by A.C. to complete one cycle.

$f = 1/T$

MEAN SQUARE VALUE OF A.C. < I² >

$\langle I^2 \rangle = \frac{I_0^2}{2}$

R.M.S. VALUE OF A.C. (I_{rms})

It is equal to that direct current which produces same heating in a resistance as is produced by the A.C. in same resistance during same time.

$I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707 I_0 = 70.7\%$ of I_0

RESISTANCE (R)

It is the opposition offered by a conductor to the flow of direct current.

IMPEDANCE (Z)

It is the opposition offered by a conductor to the flow of alternating current.

$$Z = \frac{|\text{alternating emf}|}{|\text{alternating current}|}$$

$$= \frac{\text{peak value of alternating voltage}}{\text{peak value of AC}}$$

$$= \frac{\text{RMS value of alternating voltage}}{\text{RMS value of AC}}$$

$Z = |R + jX|$; $Z = \sqrt{R^2 + X^2}$

Where X is reactance and phase angle,

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

REACTANCE (X)

It is that part of impedance, in which alternating voltage (A.V) and alternating current (A.C.) do not remain in same phase.

There are two types of reactance:-

i) Inductive reactance (X_L)

ii) Capacitive reactance (X_C)

INDUCTIVE REACTANCE (X_L)

i) It is the effective path of A.C. due to a pure inductance.

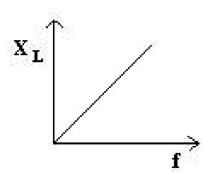
ii) It is the part of impedance in which A.V. leads the A.C. by a phase angle of $\frac{\pi}{2}$.

iii) Its value is $X_L = \omega L = 2\pi f L$.

iv) It bypasses D.C. but offers finite impedance to the flow of A.C.

v) It is produced due to pure inductance coil or induced current.

vi) X_L - f curve.



vii) Its value depends on L and f.

CAPACITIVE REACTANCE (X_C)

i) It is effective in the path of A.C. due to a pure capacitance.

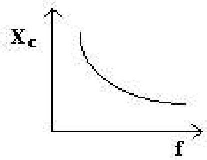
ii) It is that part of impedance in which A.C. leads the A.V. by a phase angle of $\frac{\pi}{2}$.

iii) Its value is $X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C}$.

iv) It bypasses A.C. but blocks D.C.

v) It is produced due to pure capacitor or induced charge.

vi) X_C - f curve



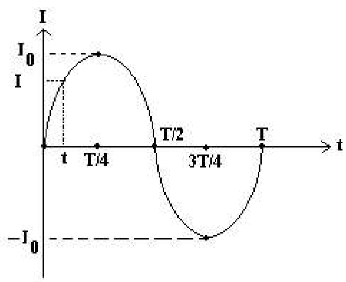
vii) Its value depends on C and f.

Resistance, Impedance, Reactance have the same units and D.F.

i.e. SI unit is ohm; DF is $(ML^2T^{-3}A^2)$

PHASE OF A.C :

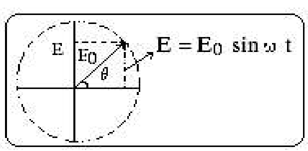
The term 'ωt' is phase of alternating current (emf) and is defined as the fraction of time period that has elapsed since the current (emf) last passed its zero value in positive direction.



PHASOR DIAGRAMS:

a) Alternating current and emf vary sinusoidally with time with same frequency. They will not be in phase. Depending on the circuit, current may lag or lead the emf. The study of such circuits become easy if alternating current and emf are represented by vectors in a plane

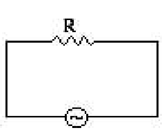
b) The graphical representation of alternating currents and emfs as vectors is called Phasor or Argand diagram



A.C THROUGH A RESISTOR:

a) A pure resistor of resistance R is connected across an alternating source of emf

i) The instantaneous value of alternating emf is $E = E_0 \sin\omega t$

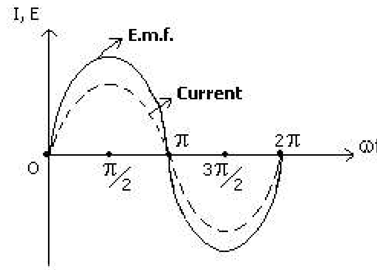


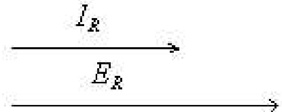
ii) The instantaneous value of alternating current is

$$I = I_0 \sin\omega t$$

Peak value of current, $I_0 = \frac{E_0}{R}$

b) Phasor diagrams:-



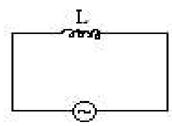


c). The value of impedance (Z) and reactance (X) are zero

A.C THROUGH AN INDUCTOR:

a) A pure inductor of inductance L is connected across an alternating source of emf

i) The instantaneous value of alternating emf is $E = E_0 \sin\omega t$

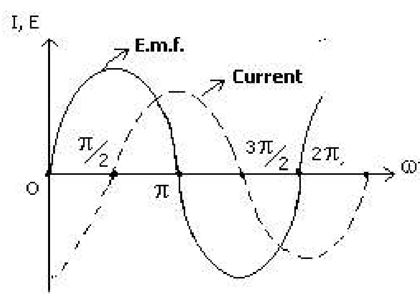


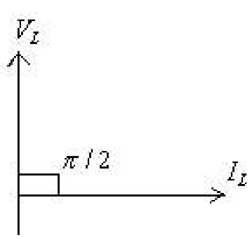
ii) The instantaneous value of alternating current is

$$\Rightarrow I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

$\therefore$ Peak value of current $I_0 = \frac{E_0}{\omega L}$

b) Phasor diagram





c) The alternating current lags behind the emf by a phase angle of $\frac{\pi}{2}$ or 90^0 or alternating emf leads the current by a phase angle of $\frac{\pi}{2}$ or 90^0.

The equations of instantaneous values of emf and curents are $E = E_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ and $I = I_0 \sin\omega t$ respectively

d) Inductive reactance : Inductance not only causes the current to lag behind emf but it also limits the magnitude of current in the circuit.

i) $I_0 = \frac{E_0}{\omega L} \Rightarrow X_L = \omega L = \frac{E_0}{I_0}$, $X_L = \omega L = 2\pi fL$

ii) Inductive reactance in terms of RMS value is $X_L = \omega L = \frac{E_{rms}}{I_{rms}}$

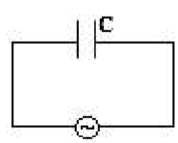
A.C THROUGH A CAPACITOR :

a) When an alternating emf is applied to a capacitor, then alternating current is constituted in the circuit. Due to this charge on the plates and electric field between the plates of capacitor varies sinusoidally with time. At any instant the potential difference between the plates of a capacitor is equal to applied emf at that time.

i.e., $E = \frac{Q}{C}$

b) A capacitor of capacity C is connected across an alternating source of emf

i) The instantaneous value of alternating emf is $E = E_0 \sin\omega t$

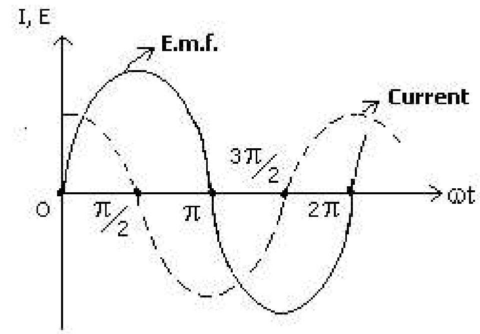


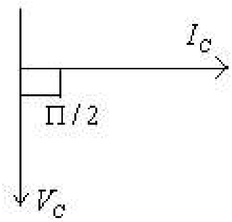
ii) The instantaneous value of alternating current is

$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

Peak value of current, $I_0 = \frac{E_0}{\left(\frac{1}{\omega C}\right)}$

c) Phasor diagram





d) The alternating current leads emf by a phase angle of $\frac{\pi}{2}$ or 90^0 or alternating emf lags behind the current by a phase angle $\frac{\pi}{2} or 90^0$. The equations for instantaneous values for emf and current are $E = E_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

$I = I_0 \sin\omega t$ respectively

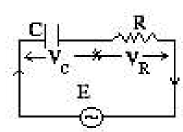
e) Capacitive Reactance : Capacitance not only causes the voltage to lag behind the current but it also limits the magnitude of current in the circuit

$$I_0 = \frac{E_0}{\left(\frac{1}{\omega C}\right)} \Rightarrow X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC} = \frac{E_0}{I_0} = \frac{E_{rms}}{I_{rms}}$$

A.C THROUGH CR SERIES CIRCUIT

a) CR circuit consists of a capacitor of capacity C and a resistor of resistance R in series with a source of alterning emf.

i. The instantaneous value of alternating emf is $E = E_0 \sin\omega t$



ii. The instantaneous value of alternating current is

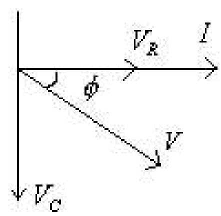
$I = I_0 \sin(\omega t + \phi)$

where $\phi = Tan^{-1}\left(\frac{X_C}{R}\right)$

and peak value of current, $I_0 = \frac{E_0}{\sqrt{R^2 + X_C^2}}$

where $X_C = \frac{1}{\omega C}$ is the capacitive reactance.

b) Phasor diagram



c) The alternating current in the circuit leads the emf by a phase angle (or) Alternating emf in the circuit lags the current by a phase angle

$$\phi = Tan^{-1}\left(\frac{X_C}{R}\right) = Tan^{-1}\left(\frac{1}{\omega CR}\right)$$

$$= Tan^{-1}\left(\frac{1}{2\pi fCR}\right)$$

d) Impedance : Total opposition to the flow of alternating current in CR circuit is impedance in the circuit

i) $I_0 = \frac{E_0}{\sqrt{R^2 + X_C^2}} \Rightarrow Z = \sqrt{R^2 + X_C^2} = \frac{E_0}{I_0}$

ii) Impedance, $Z = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}$

$$= \sqrt{R^2 + \frac{1}{4\pi^2 f^2 C^2}}$$

iii) Impedance in terms of RMS values

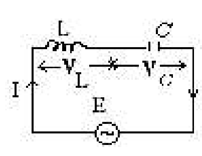
$$Z = \sqrt{R^2 + X_C^2} = \frac{E_{rms}}{I_{rms}}$$

A.C THROUGH LC SERIES CIRCUIT

a) LC circuit consists of inductor (L) and a capacitor (C) connected in series with a source of alternating emf.

i) The instantaneous value of emf is given by

$$E = E_0 \, Sin\, \omega t$$



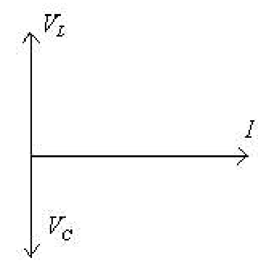
ii) The instantaneous value of alternating current is

$$I = I_0 \, Sin\left(\omega t - \frac{\pi}{2}\right)$$

$$Where \; I_0 = \frac{E_0}{(X_L - X_C)}$$

$$and \; X_L = \omega L, X_C = \frac{1}{\omega C}$$

b) Phasor diagram



c) When $X_L = X_C$ then I is maximum. The circuit is called resonant circuit

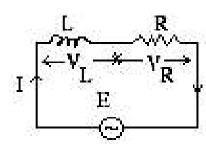
d) If $X_L = X_C$ then $\omega = \frac{1}{\sqrt{LC}}$ and the natural frequency of LC circuit for resonance is

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

A.C THROUGH LR SERIES CIRCUIT

a) LR circuit consists of a resistor of resistance R and an inductor of inductance L in series with a source of alternating emf

i) the instantaneous value of alternating emf is $E = E_0 \sin \omega t$



ii) the instantaneous value of alternating current is

$$I = I_0 \sin(\omega t - \phi)$$

where $\phi = Tan^{-1}\left(\frac{X_L}{R}\right)$

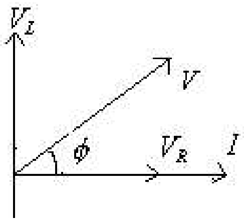
peak value of current ,

$$I_0 = \frac{E_0}{\sqrt{R^2 + X_L^2}} = \frac{E_0}{\sqrt{R^2 + \omega^2 L^2}}$$

$$= \frac{E_0}{\sqrt{R^2 + 4\pi^2 f^2 L^2}}$$

where $X_L = \omega L = 2\pi f$ is inductive reactance

b) Phasor Diagram



c) The alternating current in the circuit lags behind the emf by a phase angle (or) Alternating emf leads the current by a phase angle

$$\phi = Tan^{-1}\left(\frac{X_L}{R}\right) = Tan^{-1}\left(\frac{\omega L}{R}\right) = Tan^{-1}\left(\frac{2\pi f L}{R}\right)$$

d) Impedance : The total opposition to the flow of alternating current in the LR circuit is called impedance. It is also called inductive impedance

i) $I_0 = \dfrac{E_0}{\sqrt{R^2 + X_L^2}} \Rightarrow Z = \sqrt{R^2 + X_L^2} = \dfrac{E_0}{I_0}$

, this quantity $\sqrt{R^2 + X_L^2}$ is called impedance in LR circuit.

ii) Impedance

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + \omega^2 L^2}$$
$$= \sqrt{R^2 + 4\pi^2 f^2 L}$$

iii) Impedance in terms of RMS values ,

$$Z = \sqrt{R^2 + X_L^2} = \frac{E_{rms}}{I_{rms}}$$

A.C THROUGH LCR SERIES CIRCUIT

a) LCR circuit consists of a resistor of resistance R, an inductor of inductance L and a capacitor of capacitance C in series with a source of alternating emf

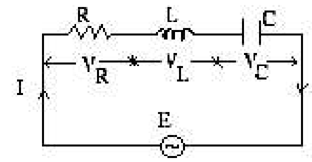
i) the instantaneous value of alternating emf is $E = E_0 \sin \omega t$

ii) the instantaneous value of alternating current is

$$I = I_0 \sin(\omega t - \phi)$$

where $\phi = Tan^{-1}\left(\dfrac{X_L - X_C}{R}\right)$

and The peak value of current, ,



$$I_0 = \frac{E_0}{\sqrt{R^2 + (X_L - X_C)^2}}$$

where $X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi f C}$ is capacitive reactance & $X_L = \omega L = 2\pi f L$ is inductive reactance.

b) The alternating current in the circuit may lead or lag or may be in phase with emf depending on the value of ϕ

case (i) : If $X_L > X_C$ then ϕ is +ve. In this case the A.C. lags behind the emf by a phase angle $\phi = Tan^{-1}\left(\dfrac{X_L - X_C}{R}\right)$

case (ii) : If $X_L < X_C$ then ϕ is -ve. In this case the A.C leads the emf by a phase angle $\phi = Tan^{-1}\left(\dfrac{X_L - X_C}{R}\right)$

case (iii) : If $X_L = X_C$ then ϕ is 0. In this case the A.C and emf are in phase.

c)

i) $I_0 = \dfrac{E_0}{\sqrt{R^2 + (X_L - X_C)^2}}$

$$\Rightarrow Z = \sqrt{R^2 + (X_L - X_C)^2} = \frac{E_0}{I_0}$$

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

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

iii) Impedance interms of RMS values

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

iv) If $X_L > X_C$, then the circuit will be inductive

v) If $X_L < X_C$, then the circuit will be capacitive

vi) If $X_L = X_C$, then the circuit will be purely resistive.

vii) The LCR circuit can be inductive or capacitive or purely resistive depending on the value of frequency of alternating source of emf.

viii) At some frequency of alternating source, $X_L > X_C$ and for some other frequency, $X_L < X_C$. There exists a particular value of frequency where $X_L = X_C$ (This situation is explained under resonance of LCR series circuit)

RESONANCE :

1) Resonance in series LCR circuit :

a) The LCR series circuit

The constant L and C values can be inductive $(X_L > X_C)$ or capacitive $(X_L < X_C)$ depending on the frequency of alternating source of emf.

b) At certain frequency called resonant frequency $f_r, X_L = X_C$ (inductive reactance exactly cancels capacitive reactance) and resonance will occur. This is called series Resonance.

c) When series resonance occurs, the LCR series circuit is purely resistive in nature

d) Expression for resonant frequency

At resonance $X_L = X_C$

$$2\pi f_r L = \frac{1}{2\pi f_r C} \Rightarrow f_r = \frac{1}{2\pi\sqrt{LC}}$$

This frequency is also called natural frequency of circuit

e) At resonance, impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$ becomes $Z = R$. i.e., impedance is minimum

f) At resonance, current in the circuit $I_{rms} = \frac{E_{rms}}{\sqrt{R^2 + (X_L - X_C)^2}}$ become $I_{rms} = \frac{E_{rms}}{R}$ i.e., current is maximum.

g) At resonance, phase angle $\phi = Tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ becomes $\phi = 0$ i.e., the alternating current and emf are in phase.

TRANSFORMER

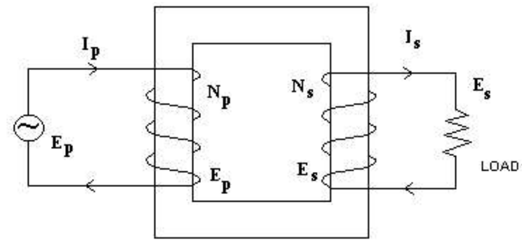
a) A transformer is a device used to change the voltage of an A.C supply by corresponding change of current.

b) It works on the principle of the mutual induction.

c) Construction :

i) It consists of two coils wounded on a laminated iron core which inturn is a combination of several identical iron strips.

ii) The coil to which the source of A.C is connected is called primary coil



iii) The coil in which alternating induced voltage is generated is called secondary coil

d) Step up transformer :

i) It converts a low voltage at high current into a high voltage at low current

ii) The number of turns in primary coil is lesser than that of secondary coil, i.e., $N_p < N_s$

e) Step down transformer :

i) It converts a high voltage at low current into a low voltage at high current.

ii) The number of turns in primary coil is greater than that of secondary coil. i.e., $N_p > N_s$

f) The ratio $\frac{N_s}{N_p}$ is called transformation ratio or turns ratio (K)

$$K = \frac{N_s}{N_p} = \frac{\phi_s}{\phi_p} = \frac{e_s}{e_p} = \frac{I_p}{I_s} = \sqrt{\frac{Z_s}{Z_p}} = \frac{E_s}{E_p}$$

where ϕ - flux linked

e - emf induced ; I- current

Z- impedance; E - voltage

g) For ideal transformer K = 1

for step up transformer K> 1

for step down transformer K < 1

h) i) Input power = $E_p I_p$

ii) Output power = $E_s I_s$

iii) Efficiency = $\frac{\text{Output power}}{\text{Input power}} \times 100$

$$\eta = \frac{E_s I_s}{E_p I_p} \times 100$$

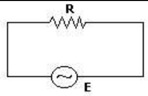
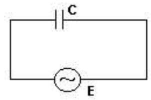
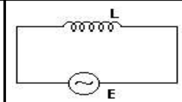
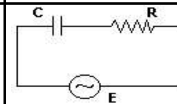
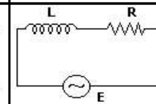
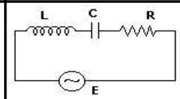
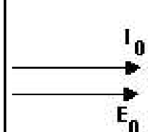
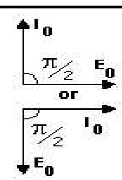
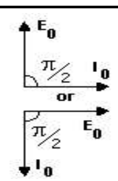
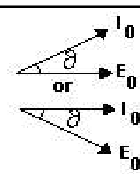
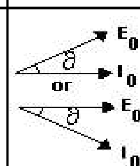
iv) The value of η range from 70% to 95% . The efficiency of an ideal transformer is 100%

Losses in transformer :

a) Copper Loss : Due to resistance of the windings of primary and secondary coils, some electric energy is converted into heat energy.This is minimised by using thin laminated core.

b) Magnetic or flux loss : The coupling of the coils is never be perfect. The whole of magnetic flux produced in primary coil is never linked with secondary.This loss is very small.

(L) Various combinations of components in A.C. circuits and parameters related to them

Circuit	Purely resistive circuit	Purely capacitive circuit	Purely inductive circuit	C-R circuit	L-R Circuit	LCR Circuit
Characteristics Circuit diagram						
Values of A.V. when A.C. is $I = I_0 Sin\,\omega t$	$E = E_0 Sin\ \omega t$	$E = E_0 Sin\left(\omega t - \frac{\pi}{2}\right)$	$E = E_0 Sin\left(\omega t + \frac{\pi}{2}\right)$	$E = E_0 Sin(\omega t + \theta)$	$E = E_0 Sin(\omega t - \theta)$	$E = E_0 Sin(\omega t \pm \theta)$ (i) If $X_L > X_C$ then $E = E_0 Sin(\omega t + \theta)$ (ii) If $X_C > X_L$ then $E = E_0 Sin(\omega t - \theta)$ (iii) If $X_L = X_C$ then $E = E_0 Sin\ \omega t$
Values of A. C. when A.V. is $E = E_0 Sin\ \omega t$	$I = I_0 Sin\,\omega t$	$I = I_0 Sin\left(\omega t + \frac{\pi}{2}\right)$	$I = I_0 Sin\left(\omega t - \frac{\pi}{2}\right)$	$I = I_0 Sin(\omega t + \theta)$	$I = I_0 Sin(\omega t - \theta)$	$I = I_0 Sin(\omega t \pm \theta)$
Impedance Z	Z = R	$Z = X_C = \frac{1}{\omega C}$	$Z = X_L = \omega L$	$Z = \sqrt{R^2 + X_C^2}$ $= \sqrt{R^2 + 1/\omega^2 C^2}$	$Z = \sqrt{R^2 + X_L^2}$ $= \sqrt{R^2 + \omega^2 L^2}$	$Z = \sqrt{R^2 + (X_L \sim X_C)^2}$
Reactance-X	Zero	$X_C = \frac{1}{\omega C}$	$X_L = \omega L$	$\frac{1}{\omega C}$	ωL	$X = (X_L \sim X_C)$ $= (\omega_L \sim 1/\omega C)$
Phase difference between E and I	0^0	$-\frac{\pi}{2}$	$+\frac{\pi}{2}$	$\theta = \tan^{-1}\frac{X_C}{R}$ $= \tan^{-1}\frac{1}{\omega CR}$	$\theta = \tan^{-1}\frac{X_L}{R}$ $= \tan^{-1}\frac{\omega L}{R}$	$\theta = \tan^{-1}\frac{X_L \sim X_C}{R}$
Value of E_0	$I_0 R$	$I_0 X_C$	$I_0 X_L$		$I_0\sqrt{R^2 + X_L^2}$	$I_0\sqrt{R^2 + (X_L - X_C)^2}$
Variation of A.V. and A.C. with time	$E = E_0 Sin\,\omega t$ $I = I_0 Sin\,\omega t$	$E = E_0 Sin\,\omega t$ $I = I_0 Sin(\omega t + \pi/2)$ $= I_0 Cos\,\omega t$	$E = E_0 Sin\,\omega t$ $I = I_0 Sin(\omega t - \pi/2)$ $= -I_0 Cos\,\omega t$	$E = E_0 Sin\,\omega t$ $I = I_0 Sin(\omega t + \theta)$	$E = E_0 Sin\,\omega t$ $I = I_0 Sin(\omega t - \theta)$	$E = E_0 Sin\,\omega t$ $I = I_0 Sin(\omega t \pm \theta)$
	Maximum and equal to $\frac{I_0^2 R}{2}$ or $\frac{E_0^2}{2R}$ or $E_{rms} I_{rms}$ or $\frac{E_0 I_0}{2}$	zero	zero	$E_{rms} I_{rms} \frac{R}{\sqrt{R^2 + X_C^2}}$	$E_{rms} I_{rms} \frac{R}{\sqrt{R^2 + X_L^2}}$	$\frac{E_{rms} I_{rms} \times R}{\sqrt{R^2 + (X_L \sim X_C)^2}}$
vector phase diagram						

CONCEPTUAL QUESTIONS

1. In an ac circuit the current
   1) is in phase with the voltage
   2) leads the voltage 3) lags the voltage
   4) any of the above depending on the circumstances
2. Alternating current is transmitted to distant places at
   1) high voltage and low current
   2) high voltage and high current
   3) low voltage and low current
   4) low voltage and high current
3. In an AC circuit containing only capacitance the current
   1) leads the voltage by 180º
   2) lags the voltage by 90º
   3) leads the voltage by 90º
   4) remains in phase with the voltage
4. An inductance and resistance are connected in series with an A.C circuit. In this circuit

1) the current and P.d across the resistance lead P.d across the inductance by $\frac{\pi}{2}$

2) the current and P.d across the resistance lags behind the P.d across the inductance by angle $\frac{\pi}{2}$

3) The current across resistance leads and the P.d across resistance lags behind the P.d across the inductance by $\frac{\pi}{2}$

4) the current across resistance lags behind and the P.d across the resistance leads the P.d across the inductance by $\frac{\pi}{2}$

5. The value of induced e.m.f in an LR circuit at break, as compared to its value at make will be
1) less 2) more
3) some times less and some times more
4) nothing can be said

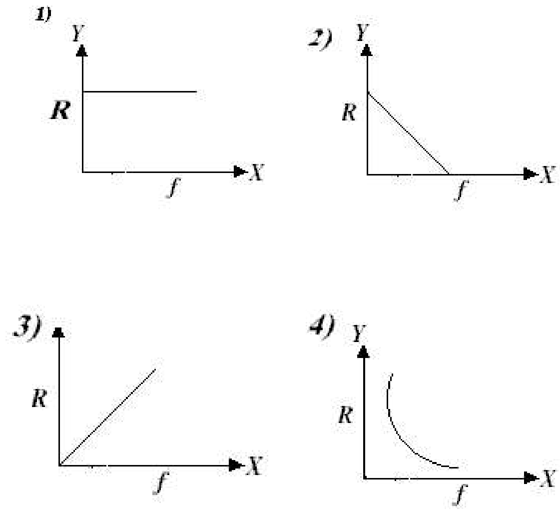
6. An LCR circuit is connected to a source of alternating current. At resonance, the applied voltage and the current flowing through the circuit will have a phase difference of
1) $\pi/4$ 2) zero 3) π 4) $\pi/2$

7. In series L - C - R resonant circuit, to increase the resonant frequency
1) *L* will have to be increased
2) *C* will have to be increased
3) *LC* will have to be decreased
4) *LC* will have to be increased

8. If in a series L - C - R ac circuit, the voltages across R, L, C are V_1, V_2, V_3 respectively. Then the voltage of applied AC source is always equal to
1) $V_1+V_2+V_3$ 2) $\sqrt{V_1^2+(V_2+V_3)^2}$
3) $V_1-V_2-V_3$ 4) $\sqrt{V_1^2+(V_2-V_3)^2}$

9. In non-resonant circuit, the nature of circuit for frequencies greater than the resonant frequency is
1) resistive 2) capacitive
3) inductive 4) none of the above

10. The correct graph between the resistance of a conductor with frequency is



11. The phase difference between voltage and current in an LCR series circuit is
1) zero always 2) $\pi/4$ always
3) π 4) between 0 and $\pi/2$

12. The phase angle between current and voltage in a purely inductive circuit is
1) zero 2) π
3) $\pi/4$ 4) $\pi/2$

13. In an LCR a.c circuit at resonance, the current
1) Is always in phase with the voltage
2) Always leads the voltage
3) Always lags behind the voltage
4) May lead or lag behind the voltage

14. The average e.m.f during the positive half cycle of an a.c. supply of peak value E_0 is
1) E_0/π 2) $E_0/\sqrt{2}$
3) $E_0/2\pi$ 4) $2E_0/\pi$

15. When an a.c source is connected across a resistor
1) The current leads the voltage in phase
2) The current lags behind the voltage in phase
3) The current and voltage are in same phase
4) The current and voltage are out of phase

16. Transformers are used in
1) d.c circuits only 2) a.c. circuits only
3) Both a.c and d.c circuits 4) Integrated circuits.

17. The magnitude of the e.m.f. across the secondary of a transformer does not depend on
1) The number of the turns in the primary
2) The number of the turns in the secondary
3) The magnitude of the e.m.f applied across the primary
4) The resistance of the primary and the secondary

18. In case of a.c circuit, Ohm's law holds good for
1) Peak values of voltage and current
2) Effective values of voltage and current
3) Instantaneous values of voltage and current
4) All the above

19. In an A.C circuit having resistance and capacitance
1) emf leads ahead of the current
2) current lags behind the emf
3) both the current and emf are in phase
4) current leads ahead of the emf.

20. An inductance L and capacitance C and resistance R are connected in series across an AC source of angular frequency ω. If $\omega^2 > \frac{1}{LC}$ then
1) emf leads the current
2) both the emf and the current are in phase
3) current leads the emf
4) emf lags behind the current

21. The emf and current in a circuit are such that $E = E_0 \sin \omega t$ and $I = I_0 \sin(\omega t - \theta)$
This AC circuit contains.
1) R and L 2) R and C
3) only R 4) only C

22. An inductor coil having some resistance is connected to an AC source. Which of the following have zero average value over a cycle ?
1) induced emf in the inductor 2) current
3) both 1 and 2 4) neither 1 nor 2

23. In case of AC circuits the relation V = i Z, where Z is impedance, can directly applied to
1) peak values of voltage and current only
2) rms values of voltage and current only
3) instantaneous values of voltage and current only
4) both 1 and 2 are true

24. The core of any transformer is laminated so as to
1) increase the secondary voltage
2) reduce the energy loss due to eddy currents
3) make it light weight
4) make it robust and strong

25. Consider the following two statements A and B and identify the correct answer.
A) In a transformer a large alternating current at low voltage can be transformed into a small alternating current at high voltage
B) Energy in current carrying coil is stored in the form of magnetic field.
1) A is true but B is false
2) Both A and B are true
3) A is false but B is true
4) Both A and B are false

26. Consider the following two statements A and B and identify the correct answer.
A) At resonance of L - C - R series circuit, the reactance of circuit is minimum.
B) The reactance of a capacitor in an A.C circuit is similar to the resistance of a capacitor in a D.C. circuit
1) A is true but B is false
2) Both A and B are true
3) A is false but B is true
4) Both A and B are false

27. Statement (A) : The reactance offered by an inductance in A.C. circuit decreases with increase of AC frequency.
Statement (B) : The reactance offered by a capacitor in AC circuit increases with increase of AC frequency.
1) A is true but B is false 2) Both A and B are true
3) A is false but B is true 4) Both A and B are false

28. Statement (A) : Flux leakage in a transformer can be minimized by winding the primary and secondary coils one over the other.
Statement (B) : Core of the transformer is made of soft iron
1) A is true but B is false 2) Both A and B are true
3) A is false but B is true 4) Both A and B are false

29. Statement (A) : In high current low voltage windings of a tranformer thick wire is used to minimize energy loss due to heat produced
Statement (B) : The core of any transformer is laminated so as to reduce the energy loss due to eddy currents
1) A is true but B is false
2) Both A and B are true
3) A is false but B is true
4) Both A and B are false

30. Statement (A) : Step up transformer converts low voltage, high current to high voltage, low current
Statement (B) : Transformor works on both ac and dc
1) A is true but B is false
2) Both A and B are true
3) A is false but B is true
4) Both A and B are false

31. Statement (A) : With increase in frequency of AC supply inductive reactance increases.
Statement (B) : With increase in frequency of AC supply capacitive reactance increase
1) A is true but B is false
2) Both A and B are true
3) A is false but B is true
4) Both A and B are false

32. Choose the wrong statement of the following.
1) The peak voltage across the inductor can be less than the peak voltage of the source in an LCR circuit
2) In a circuit containing and a capacitor and an ac source the current is zero at the instant source voltage is maximum
3) When an AC source is connected to a capacitor,then the rms current in the circuit gets increased if a dielectric slab is inserted into the capacitor.
4) In a pure inductive circuit emf will be in phase with the current.

33. Match the following

a) step up transformer	d) turns ratio is 1
b) step down tranformer	e) Ns > Np
c) Ideal transformer	f) Np > Ns

1) $a \to f, b \to e, c \to d$ 2) $a \to e, b \to d, c \to f$
3) $a \to d, b \to e, c \to f$ 4) $a \to e, b \to f, c \to d$

34. Select the correct options among the follow ing: In an R-C circuit
a) instantaneous A.C is given by $I = I_0 \sin(wt + \phi)$
b) the alternating current in the circuit leads the emf by a phase angle.
c) Its impedance is $\sqrt{R^2 + (\omega c)^2}$
d) Its capacitive reactance is ω c
1) a, b are ture 2) b, c, d are true
3) c, d are true 4) a, c are true

35. **Assertion (A) :** A transformer can't work on dc
Reason (R) : dc changes neither in magnitude nor in direction
1) A,R are true and R is the correct reason for A
2) A,R are true and R is not the correct reason for A
3) A is true, R is false 4) A is false, R is true

36. **Assertion (A) :** In series LCR circuit, the resonance occurs at one frequency only.
Reason (R) : At resonance the inductive reactance is equal and opposite to the capacitive reactance.
1) A,R are true and R is the correct reason for A
2) A,R are true and R is not the correct reason for A
3) A is true, R is false 4) A is false, R is true

37. **Assertion (A):**More the turns more is the resistance
Reason(R): Impedance of primary and secondary in a tranformer is directly proportional to number of turns in the coils.
1) A,R are true and R is the correct reason for A
2) A,R are true and R is not the correct reason for A
3) A is true, R is false 4) A is false, R is true

KEY

01) 4	02) 1	03) 3	04) 2	05) 2
06) 2	07) 3	08) 4	09) 3	10) 1
11) 4	12) 4	13) 4	14) 4	15) 3
16) 2	17) 4	18) 4	19) 4	20) 1
21) 1	22) 3	23) 4	24) 2	25) 2
26) 1	27) 4	28) 2	29) 2	30) 1
31) 1	32) 4	33) 4	34) 1	35) 1
36) 1	37) 1			

LEVEL - 1

01. The input and output voltage in a step down transformer are 22KV and 550 V respectively. The ratio of turns in secondary and primary coils will be _______
1) 40:1 2) 1:40 3) 1:20 4) 20:1

02. The turns ratio in a step up transformer is 4:1. On passing a current of 4A in the primary, the current in the secondary will be
1) 8A 2) 2A 3) 1A 4) 0.25A

03. The correct relation between the impedance of secondary coil with that of primary coil is _________
1) $Z_s = Z_p$ 2) $Z_s = Z_p \frac{N_s}{N_p}$
3) $Z_s = Z_p \left(\frac{N_s}{N_p}\right)^2$ 4) $Z_s = Z_p \left(\frac{N_p}{N_s}\right)^2$

04. If the current in the primary coil and number of turns in it are I_p and N_p respectively and the number of turns and current in the secondary are N_s and I_s respectively then the value of $N_s:N_p$ will be ________
1) $I_s : I_p$ 2) $I_p : I_s$ 3) $I_s^2 : I_p^2$ 4) $I_p^2 : I_s^2$

05. The time taken by an AC of 50 Hz in reaching from zero to its maximum value will be ____
1) 0.5 s 2) 0.005 s 3) 0.05 s 4) 5s

06. At what frequency the inductive reactance of 2H inductance will be equal to the capacitive reactance of $2\mu F$ capacitance?
1) 80Hz 2) 40 Hz 3) 60Hz 4) 20Hz

07. The capacitive reactance of $50\mu F$ capacitance at a frequency of 2 x 10^3Hz will be ____ Ω
1) $\frac{2}{\pi}$ 2) $\frac{3}{\pi}$ 3) $\frac{4}{\pi}$ 4) $\frac{5}{\pi}$

08. A condenser of capacity 1pF is connected to an A.C source of 220V and 50Hz frequency. The current flowing in the circuit will be_____
1) 6.9 x 10^{-8}A 2) 6.9A
3) 6.9 x 10^{-6}A 4) zero

09. A bulb and a condenser are connected in series with an A.C. source. On increasing the frequency of the source it's brightness will _____
1) increase 2) decrease
3) some times increase and some times decrease
4) neither increase nor decrease

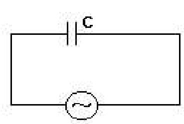
10. A condenser of $10\mu F$ and an inductor of 1H are connected in series with an A.C. source of frequency 50Hz. The impedance of the combination will be _____
1) zero 2) Infinity 3) 44.7Ω 4) 4.47Ω

11. A coil of self - inductance $\left(\frac{1}{\pi}\right)$H is connected in series with a 300Ω resistance. A voltage of 200V at frequency 200Hz is applied to this combination. The phase difference between the voltage and the current will be ____
1) $\tan^{-1}\left(\frac{4}{3}\right)$ 2) $\tan^{-1}\left(\frac{3}{4}\right)$
3) $\tan^{-1}\left(\frac{1}{4}\right)$ 4) $\tan^{-1}\left(\frac{5}{4}\right)$

12. A resistance of 3 x $10^3\Omega$ and an inductance of 1H are connected in series with an A.C. source of frequency $\left(\frac{3\times10^3}{2\pi}\right)$Hz. Phase difference between the voltage and the current will be ___
1) 45^0 2) 90^0 3) 180^0 4) 0^0

13. A coil is used in a circuit in which an A.C. of frequency 50Hz is flowing. The self-inductance of the coil, in order to produce an impedance of 100Ω, will be ___ H
1) π 2) $\frac{1}{\pi}$ 3) π^2 4) $\frac{1}{\pi^2}$

14. In the following circuit; if the frequency of A.C is increased then the value of current flowing in the circuit will become _______



1) decrease 2) increase
3) zero 4) Infinity

15. The capacitive reactance at 1600Hz is 81Ω. When the frequency is doubled then the capacitive reactance will be ____
1) 40.5Ω 2) 81Ω 3) 162Ω 4) zero

16. The inductive reactance of a coil is 2500Ω. On increasing it's self-inductance to three times, the new inductive reactance will be _____
1) 7500Ω 2) 2500Ω 3) 1225Ω 4) zero

17. An alternating voltage source of maximum value 170V is connected in a circuit. The value of potential at a phase angle of 45^0 will be nearly ______
1) 120 V 2) 110 V 3) 240V 4) zero

18. The phase difference between alternating emf and current in a purely capacitive circuit will be ___
1) zero 2) π 3) $-\frac{\pi}{2}$ 4) $\frac{\pi}{2}$

19. A voltmeter connected in an A.C circuit reads 220V. It represents,
1) peak voltage 2) RMS voltage
3) Average voltage 4) Mean square voltage

20. The peak value of A.C. is $2\sqrt{2}A$. It's apparent value will be _________
1) 1A 2) 2A 3) 4A 4) zero

21. What will be the equation of A.C. of frequency 75Hz, if it's RMS value is 20A?
1) $I = 20\text{Sin}(150\pi t)$ 2) $I = 20\sqrt{2}\,\text{Sin}(150\pi t)$
3) $I = \frac{20}{\sqrt{2}}\text{Sin}(150\pi t)$ 4) $I = 20\sqrt{2}\,\text{Sin}(75\pi t)$

22. The instantaneous value of emf and current in an A.C. circuit are;
$E = 1.414\,\text{Sin}\left(100\pi t - \frac{\pi}{4}\right)$, $I = 0.707\,\text{Sin}(100\pi t)$.
The RMS value of emf will be ______ V.
1) $2\sqrt{2}$ 2) 1 3) $\frac{1}{2}$ 4) $\frac{1}{2\sqrt{2}}$

23. In above question RMS value of current will be _______A
1) 1 2) $\frac{1}{\sqrt{2}}$ 3) $\sqrt{2}$ 4) $\frac{1}{2}$

24. In question 22, the impedance of the circuit will be _________ Ω
1) 1 2) 2 3) $\sqrt{2}$ 4) $\frac{1}{2}$

25. In question 22, the admittance of the circuit will be _______ mho
1) $\frac{1}{\sqrt{2}}$ 2) $\sqrt{2}$ 3) $\frac{1}{2}$ 4) 2

26. In question 22, the current,
1) leads the voltage by 45^0
2) lags behind the voltage by 45^0
3) leads the voltage by 90^0
4) lags behind the voltage by 90^0

27. In question 22, the resistance of the circuit is ________ Ω
1) 2 2) $\sqrt{2}$ 3) $\frac{1}{\sqrt{2}}$ 4) $\frac{1}{2}$

28. In question 22, the reactance of the circuit will be _______ Ω
1) $\sqrt{2}$ 2) 2 3) $\frac{1}{\sqrt{2}}$ 4) $\frac{1}{2}$

29. When the frequency of applied emf in an LCR series circuit is less than the resonant frequency, then the nature of the circuit will be ________
1) Capacitive 2) resistive
3) inductive 4) all the above

30. An alternating emf given by $V = V_0\,Sin\,\omega t$ has peak value 10 volt and frequency 50 Hz. The instantaneous emf at $t = \frac{1}{600}s$ is
1) 10 V 2) $5\sqrt{3}V$ 3) 5 V 4) 1V

31. If the instantaneous current in a circuit is given by $I = 2\cos(\omega t + \phi)$ ampere, the rms value of the current is

1) $2\,A$ 2) $\sqrt{2}\,A$ 3) $2\sqrt{2}\,A$ 4) zero

32. The average emf during the positive half cycle of an AC supply of peak value E_0 is

1) $\frac{E_0}{\pi}$ 2) $\frac{E_0}{\sqrt{2}\pi}$ 3) $\frac{E_0}{2\pi}$ 4) $\frac{2E_0}{\pi}$

33. An inductor of 1 henry is connected across a 220 v, 50 Hz supply. The peak value of the current is approximately

1) 0.5 A 2) 0.7 A 3) 1 A 4) 1.4 A

34. An LCR series circuit contains L = 8 H, C=0.5 μF and $R = 100\Omega$. The resonant frequency of the circuit is

1) $\frac{100}{\pi}Hz$ 2) $\frac{500}{\pi}Hz$ 3) $\frac{250}{\pi}Hz$ 4) $\frac{125}{\pi}Hz$

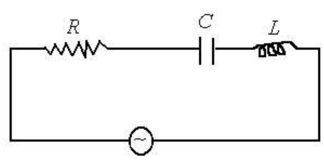
35. In an *LCR* series circuit, the capacitor is changed from *C* to *4C*. For the same resonant frequency, the inductance should be changed from *L* to

1) 2 *L* 2) *L/2* 3) *L/4* 4) *4L*

36. In an *LCR* series circuit the rms voltages across *R, L* and *C* are found to be 10 V, 10 V and 20 V respectively. The rms voltage across the entire combination is

1) 30 V 2) $1\,\mu F$ 3) $20V$ 4) $10\sqrt{2}\,V$

37. In the given circuit, the phase difference between voltages across *R* and *C* is



1) zero 2) $\pi/2$ 3) π 4) $3\pi/2$

38. In an A.C. circuit, the current lags behind the voltage by $\pi/3$. The components in the circuit are

1) *R* and *L* 2) *R* and *C*
3) *L* and *C* 4) only *R*

KEY

01) 1	02) 3	03) 3	04) 2	05) 2
06) 1	07) 4	08) 1	09) 1	10) 1
11) 1	12) 1	13) 2	14) 2	15) 1
16) 1	17) 1	18) 3	19) 2	20) 2
21) 2	22) 2	23) 4	24) 2	25) 3
26) 2	27) 3	28) 1	29) 4	30) 3
31) 2	32) 2	33) 3	34) 3	35) 3
36) 4	37) 2	38) 1		

HINTS

01. $\frac{N_s}{N_p} = \frac{e_s}{e_p}$

02. $\frac{N_s}{N_p} = \frac{I_p}{I_s}$

05. $t = \frac{T}{4} = \frac{1}{4f}$

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

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

08. $I_{rms} = \frac{E_{rms}}{X_C} = E_{rms}\,2\pi fC$

09. $X_C = \frac{1}{2\pi fC}$. on increasing f, X_C decreases, current flow increases.

10. $Z = \left(2\pi fL - \frac{1}{2\pi fC}\right)$

11. $\tan\theta = \frac{2\pi fL}{R}$

12. $\tan\theta = \frac{2\pi fL}{R}$

13. $X_L = 2\pi fL$

14. $X_C = \frac{1}{2\pi fC}$. On increasing f, X_C decreases, $\therefore$ current flow increases.

15. $X_C \,\alpha\, \frac{1}{f}$

17. $E = E_0 \sin\omega t = 170\sin 45^0$

23. $I_{rms} = \frac{I_0}{\sqrt{2}}$

25. $A = \frac{1}{Z}$

26. $I_{rms} = \frac{I_0}{\sqrt{2}}$

30. $V = 10\sin(100\pi t)$

$t = \frac{1}{600}s$

31. $I_{rms} = \frac{I_0}{\sqrt{2}}$

32. $E_{av} = \frac{2E_0}{T}\int_0^{\pi/2}\sin(\omega t)\,dt = \frac{2E_0}{\pi}$

33. $X_L = \omega L = 2\times 3.14\times 40 = 314$

$$I_0 = \frac{220\sqrt{3}}{314} = 1A$$

34. $R = \left(\omega L - \frac{1}{\omega C}\right)$

35. $f \alpha \frac{1}{\sqrt{LC}}$

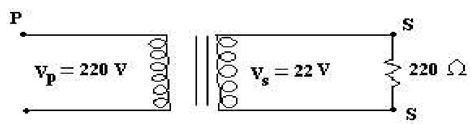
f is constant

$\therefore L_1C_1 = L_2C_2$

36. $V = \sqrt{V_R^2 + \left(V_L - V_C\right)^2}$

LEVEL - II

01. The current in the primary coil of a transformer as shown in the following figure will be ___



1) 0.01A 2) 1A 3) 0.1A 4) 10^{-6}A

02. A current of 5A is flowing at 220V in the primary coil of a transformer. If the voltage produced in the secondary coil is 2200V and 50% of power is lost, then the current in the secondary coil will be _______

1) 2.5A 2) 5A 3) 0.25A 4) 0.025A

03. A transformer converts 220V to 11V. If the current in the primary coil is 5A and that in the secondary coil is 90A, then the efficiency of transformer will be ____

1) 20% 2) 100% 3) 90% 4) 150%

04. A condenser and a 30Ω resistance are connected in series. When they are connected to 120V A.C. source then the current flowing in the circuit is 1A The p.d. across the ends of the condenser will be nearly______

1) 1 V 2) 116 V 3) zero 4) 220 V

05. An inductance of 0.2 H and a resistance of 100Ω are connected in series to an A.C. 180 V, 50 Hz supply. The apparent current flowing in the circuit will be _____

1) 0.525 A 2) 5.25 A 3) 1.525 A 4) 15.25 A

06. If the A.C. main supply is of 220 V then the average e.m.f. during positive half cycle will be ____

1) 198.2 V 2) 98.2 V 3) 9.82 V 4) zero

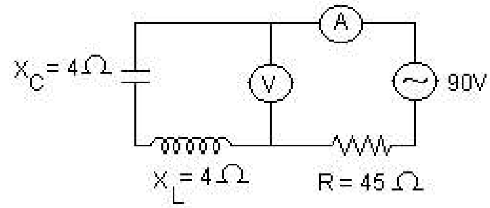
07. Waves of wave length 300m are being transmitted from a transmitting station. If the condenser available for resonating circuit is of 2.4 μF capacity then the self inductance of coil necessary for the circuit will be ______

1) 10^{-6} H 2) 1.056×10^{-8} H
3) 10.56×10^{-8} H 4) 105.6×10^{-8} H

08. An alternating voltage of $E = 200\sqrt{2}\sin(100t)V$ is connected to a condenser of 1 μF through an A.C. ammeter. The reading of the ammeter will be _____

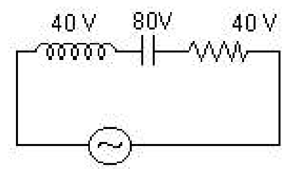
1) 10 mA 2) 40 mA 3) 80 mA 4) 20 mA

09. The reading of voltmeter and ammeter in the following figure will respectively be ____



1) 0 and 2A 2) 2A and 0V
3) 2V and 2A 4) 0V and 0A

10. In the following diagram, the value of emf of A.C. source will be ____

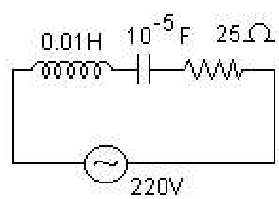


1) 40 V 2) $40\sqrt{2}$V 3) $\frac{40}{\sqrt{2}}$V 4) 160 V

11. The values of X_L, X_C and R in series with an A.C. circuit are 8Ω, 6Ω and 10Ω respectively. The total impedance of the circuit will be ________Ω

1) 10.2 2) 12.2 3) 10 4) 24.4

12. In the following circuit, the values of current flowing in the circuit at f = 0 and f = ∞ will respectively be _______



1) 8A and 0A 2) 0A and 0A
3) 8A and 8A 4) 0A and 8A

13. In an LR circuit, R = 10Ω and L = 2H. If an alternating voltage of 120V and 60Hz is connected in this circuit, then the value of current flowing in it will be _______ A

1) 0.32 2) 0.16 3) 0.48 4) 0.8

14. If the phase difference between A.V. and A.C. is $\frac{\pi}{6}$ and the resistance in the circuit is $\sqrt{300}\Omega$, then the impedance of the circuit will be ______ Ω

1) 25 2) 50 3) 20 4) 100

15. An LCR series circuit with 100 Ω resistance is connected to an ac source of 200V and of frequency of 300 rad/s. When only the capacitance is removed, the current lags behind the voltage by 60^0. When only the inductance is removed, the current leads the voltage by 60^0 the current through the circuit is
1) 1A 2) 2A 3) 3A 4) 4A

16. A 100Ω resistance is connected in series with a 4H inductor. The voltage across the resistor is $V_R = 2\sin(1000t)V$. The voltage across the inductor is
1) $80\sin\left(1000t+\frac{\pi}{2}\right)$ 2) $40\sin\left(1000t+\frac{\pi}{2}\right)$
3) $80\sin\left(1000t-\frac{\pi}{2}\right)$ 4) $40\sin\left(1000t-\frac{\pi}{2}\right)$

17. A circuit operating at $\frac{360}{2\pi}Hz$ contains a $1\mu F$ capacitor and a 20Ω resistor. The inductor must be added in series to make the phase angle for the circuit zero is
1) 7.7 H 2) 10 H
3) 3.5 H 4) 15 H

18. A 220 V, 50 Hz AC supply is connected across a resistor of 50 $k\Omega$. The current at time t seconds, assuming that it is zero at $t = 0$, is
1) $4.4\sin(314t)mA$ 2) $6.2\sin(314t)mA$
3) $4.4\sin(157t)mA$ 4) $6.2\sin(157t)mA$

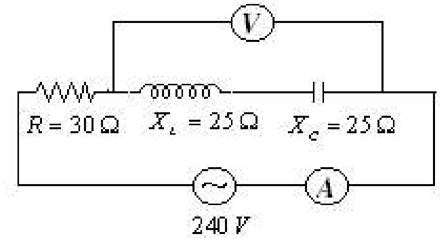
19. A 40 Ω electric heater is connected to 200 V, 50 Hz main supply. The peak value of the electric current flowing in the circuit is approximately
1) 2.5 A 2) 5.0 A 3) 7 A 4) 10 A

20. An inductive coil has a resistance of $100\,\Omega$. When an AC signal of frequency 1000 Hz is applied to the coil the voltage leads the current by 45°. The inductance of the coil is
1) $\frac{1}{100\pi}$ H 2) $\frac{1}{20\pi}$ H
3) $\frac{1}{40\pi}$ H 4)) $\frac{1}{60\pi}$ H

21. A resistor R and capacitor C are connected in series across an AC source of rms voltage 5 V. If the rms voltage across C is 3 V then that across R is
1) 1V 2) 2 V 3) 3 V 4) 4 V

22. The tuning circuit of a radio receiver has a resistance of 50Ω, an inductor of 10 mH and a variable capacitor. A 1 MHz radio wave produces a potential difference of 0.1 mV. The value of the capacitor to produce resonance is (take $\pi^2 = 10$)
1) 2.5 pF 2) 5.0 pF
3) 25 pF 4) 50 pF

23. In the circuit shown in the figure, neglecting source, resistance, the voltameter and ammeter readings will respectively be



1) 0 V, 8 A 2) 150 V, 8 A
3) 150 V, 3 A 4) 0 V, 3 A

24. An LCR series circuit containing a resistance of $120\,\Omega$ has angular resonance frequency 4×10^5 rad S^{-1}. At resonance the voltage across resistance and inductance are 60 V and 40 V respectively. Then the values of L and C are respectively.
1) $0.2\,mH, 1/32\,\mu F$ 2) $0.4\,mH, 1/16\,\mu F$
3) $0.2\,mH, 1/16\,\mu F$ 4) $0.4\,mH, 1/32\,\mu F$

KEY

01) 1	02) 3	03) 3	04) 2	05) 3
06) 1	07) 2	08) 4	09) 2	10) 2
11) 1	12) b	13) 2	14) 3	15) 2
16) 1	17) 1	18) 2	19) 3	20) 2
21) 2	22) 1	23) 1	24) 1	

HINTS

01. $V_S = I_S Z_S; \frac{V_S}{V_P} = \frac{I_P}{I_S}$

02. $P_S = \frac{P_P}{2}; V_S I_S = \frac{V_P I_P}{2}$

03. $\eta = \frac{V_s I_s}{V_p I_p} \times 100\%$

04. $E_{rms}{}^2 = E_C{}^2 + E_R{}^2; (120)^2 = E_C{}^2 + (1.5 \times 30)^2$

05. $I_{rms} = \frac{E_{rms}}{\sqrt{R^2 + 4\pi^2 f^2 L^2}}$

06. $E_{av} = \frac{2E_0}{\pi} = \frac{2\sqrt{2}E_{rms}}{\pi}$

07. $f = \frac{1}{2\pi\sqrt{LC}}$ and $f = \frac{C}{\lambda}$

08. $I_{rms} = \frac{E_{rms}}{X_C} = \frac{E_0 \omega C}{\sqrt{2}}$

09. $Z = \sqrt{R^2 + (X_L - X_C)^2} = 45\Omega$; $I_{rms} = \frac{E_{rms}}{Z} = 2A$;

$V_{rms} = I_{rms}(X_L - X_C) = 0$

10. $E_{rms} = \sqrt{V_R{}^2 + (V_C - V_L)^2}$

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

12. $I = \frac{E}{Z} = \frac{E}{\sqrt{R^2 + \left[2\pi f L - \frac{1}{2\pi f C}\right]^2}}$

13. $I = \frac{E}{Z} = \frac{E}{R^2 + 4\pi^2 f^2 L^2}$

14. $\text{Cos}\theta = \frac{R}{Z}$

15. $X_L = X_C$, $i = \frac{E}{Z} = \frac{E}{R}$

16. $i = \frac{V}{R}; V_L = V_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

17. $\omega L = \frac{1}{\omega C}$

18. $i = i_0 \sin \omega t$

$\omega = 2\pi f;\ i_0 = \frac{\in_0}{R} = \frac{\sqrt{2} \times E_{rms}}{R}$

19. $i_{\max} = \frac{\sqrt{2} \times E_{rms}}{R}$

20. $\tan\theta = \frac{X_L}{R} = \frac{\omega L}{R}$

21. $E_{rms} = V_C + V_R$

22. At resonance,

$\omega = \frac{1}{\sqrt{LC}}$ $\qquad C = \frac{1}{4\pi^2 f^2 L}$

23. $i = \frac{240}{\sqrt{R^2 + \left(X_L - X_C\right)L}} = 8\,A$

$V = i\left(X_L - X_C\right) = 0$

24. At resonance

$i = \frac{V}{R} = \frac{V_L}{X_L}$

$X_L = \omega L,\ \omega = \frac{1}{\sqrt{LC}}$

LEVEL - 3

1. A 100 volt A.C. source of frequency 500 hertz is connected to a L-C-R circuit with L = 8.1 millihenry, C = 12.5 microfarad and R = 10 ohm, all connected in series. The potential difference across the resistance will be
1) 10V 2) 100V 3) 50V 4) 500V

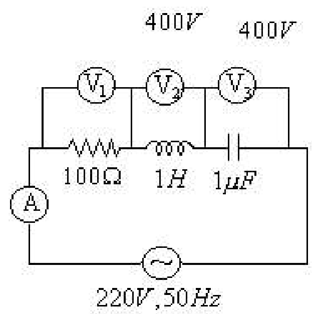
2. A series LCR circuit containing a resistance of 120Ω has angular frequency $4 \times 10^5\ rad/s$. At resonance the voltages across resistance and inductance are 60 V and 40 V respectively. The angular frequency at which the current in the circuit lags the voltage by $\frac{\pi}{4}$ is
1) $2 \times 10^5\ rad/s$ 2) $6 \times 10^5\ rad/s$
3) $8 \times 10^5\ rad/s$ 4) $10 \times 10^5\ rad/s$

3. An alternating voltage $V = 200\sqrt{2}\ \sin 100t$, Where V is in volt and t seconds, is connected to a series combination of $1\,\mu F$ capacitor and 10 $k\,\Omega$ resistor through an AC ammeter. The reading of the ammeter will be
1) $\sqrt{2}\,mA$ 2) $10\sqrt{2}\,mA$ 3) $2\,mA$ 4) $20\,mA$

4. The emf of an A.C. source is given by $E = 8\sin\omega t + 6\sin 2\omega t$ volt. The rms value of emf is
1) $5\sqrt{2}V$ 2) $7\sqrt{2}V$ 3) 10 V 4) $10\sqrt{2}V$

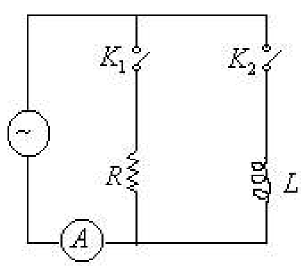
5. An ideal inductor takes a current of 10 A when connected to a 125 V, 50 Hz AC supply. A pure resistor across the same source takes 12.5 A. if the two are connected in series across a $100\sqrt{2}\,V$, 40 Hz supply, the current through the circuit will be
1) 10 A 2) 12.5 A 3) 20 A 4) 25 A

6. In the given circuit the readings of the voltmeter V_1 and the ammeter A are



1) 220 V, 2.2 A 2) 110 V; 1.1A
3) 220 V, 1.1 A 4) 110 V; 2.2 A

7. In the given circuit, R is a pure resistor, L is a pure inductor, S is a 100V, 50 Hz AC source, and A is an AC ammeter. With either K_1 or K_2 alone closed, the ammeter reading is I. If the source is changed to 100 V, 100 Hz, the ammeter reading with K_1 alone closed and with K_2 alone closed will be respectively.



1) $I, I/2$ 2) $I, 2I$ 3) $2I, I$ 4) $2I, I/2$

8. An LCR circuit has L = 10 mH, R = 3Ω, and C = 1 μF connected in series to a source of $15\cos\omega t$ volt. The current amplitude at a frequency that is 10% lower than the resonant frequency is

1) 0.5 A 2) 0.7 A 3) 0.9 A 4) 1.1 A

9. 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 $\omega/3$ (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

1) $\sqrt{\frac{3}{5}}$ 2) $\sqrt{\frac{5}{3}}$ 3) $\frac{3}{5}$ 4) $\frac{5}{3}$

KEY

1) 2 2) 3 3) 2 4) 1 5) 1 6) 1 7) 1
8) 2 9) 1

HINTS

1. $X_L = \omega L;\ X_C = \frac{1}{\omega C}\ ;\ Z = \sqrt{R^2 + (X_L - X_C)^2}$

2. $X_L - X_C = 0; \tan\theta = \frac{\omega L - \frac{1}{\omega C}}{R}$

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

4. $E^2 = 64\sin^2\omega t + 36\sin^2 2\omega t +$
$2\times 8\times 6\sin\omega t\sin 2\omega t$

$E_{rms}^2 = 64\times\frac{1}{2} + 36\times\frac{1}{2} + 0$

$E_{rms} = \sqrt{50} = 5\sqrt{2}$ V

5. For 50 Hz and 125 V supply

$X_L = \omega L = \frac{V}{i_L} \Rightarrow L = \frac{1}{8\pi}$

$R = \frac{V}{i_R} = 10\Omega$

For 40 Hz, $100\sqrt{2}V$ supply

$i = \frac{V}{\sqrt{R^2 + X_L^2}} = \frac{V}{\sqrt{R^2 + 4\pi^2 f^2 L^2}}$

6. $i = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = 2.2\ A$

$V_1 = i\Omega = 220V$

8. at resonance, $\omega_0 = \frac{1}{\sqrt{LC}}$

$\omega' = \omega_0 - \omega_0 \times \frac{10}{100}$

$I = \frac{V_0}{\sqrt{R^2 + (X_L - X_C)^2}}$

$X_L = \omega L;\ X_C = \frac{1}{\omega C}$

9. at frequency $\omega,\ X_C = 1/\omega C$

at frequency $\omega/3,\ X_C^{'} = \frac{3}{\omega C} = 3X_C$

$I = \frac{V}{\sqrt{R^2 + X_C^2}};\ \frac{I}{2} = \frac{V}{\sqrt{R^2 + 9X_C^2}}$

$\frac{X_C}{R} = \sqrt{\frac{3}{5}}$

OTHER COMPETITIVE EXAMS.

1. In an A.C. circuit the potential difference across an inductance and a resistance joined in series are respectively 16 V and 20 V. The total potential difference across the circuit is **[AFMC98]**
1) 20.0V 2) 25.6 V
3) 31.4 V 4) 53.5 V

2. In an A.C circuit, a resistance R is connected in series with an inductance L. If the phase angle between voltage and current be 45^0, the value of inductive reactance will be **[MP CET 98]**
1) $\frac{R}{4}$ 2) $\frac{R}{2}$ 3) R
4) cannot be found with the given data.

3. The voltage of an A.C.source varies with time according to the equation $V = 100\sin 100\pi t \cos 100\pi t$, where t is in seconds an V is in volts Then : **[MP PMT 02]**
1) the peak voltage of the source is 100 volts
2) the peak voltage of the source is 50 volts.
3) the peak voltage of the source is $100/\sqrt{2}$ volts
4) the frequency of the source is 50 hertz.

4. Voltage and current in an A.C circuit are given by
$V = 5\sin\left(100\pi t - \frac{\pi}{6}\right) and$
$I = 4\sin\left(100\pi t + \frac{\pi}{6}\right)$ **[Kerela Engg. 2001]**
1) Voltage leads the current by 30^0.
2) Current leads the voltage by 30^0.
3) Voltage leads the current by 60^0.
4) Current and voltage are in phase.

5. A 120 V AC source is connected across a pure inductor of inductance 0.70 H. If the frequency of the source is 60 Hz, the current passing through the inductor is **[MP PET 94]**
1) 4.55 A 2) 0.355 A
3) 0.455 A 4) 3.55 A

6. An inductance, a capacitance and a resistance are connected in series across a source of alternating voltages. At resonance, the applied voltage and the current flowing through the circuit will have a phase difference of
1) $\pi/4$ 2) zero
3) π 4) $\pi/2$

7. In an AC circuit, the rms value of the current, I_{rms}, is related to the peak current I_0 as
1) $I_{rms} = \frac{1}{\pi}I_0$ 2) $I_{rms} = \frac{1}{\sqrt{2}}I_0$
3) $I_{rms} = \sqrt{2}I_0$ 4) $I_{rms} = \pi I_0$

8. The source frequency for which a $5\mu F$ capacitor has a reactance of 1000Ω is **[MP PMT 93]**
1) $\frac{100}{\pi}$ Hz 2) $\frac{1000}{\pi}$ Hz
3) 200 Hz 4) 5000 Hz

9. The same alternating current is flowing in two circuits. The first circuit contains only inductance and the other contains only capacitance. If the frequency of the source is increased in both, the current **[MP PET 93]**
1) increases in the first circuit and decreases in the other
2) increases in both the circuits
3) decreases in both the circuits
4) decreases in the first circuit and increase in the other

10. In an A.C. circuit containing only capacitance, the current
1) leads the voltage by 180^o
2) remains in phase with the voltage
3) leads the voltage by 90^o
4) lags the voltage by 90^o

11. A capacitor of $2\mu F$ is connected in a radio circuit. The source frequency is 1000 Hz. If the current through the capacitor branch is 2 mA then the voltage across the capacitor is
1) 0.16 V 2) 0.32 V
3) 159 V 4) 79.5 V

12. An LCR series circuit is in resonance. The capacitance is now made one-fourth. For the circuit to remain in resonance, the inductance should be made
1) one-fourth 2) four times
3) eight times 4) two times

13. In L-C-R series A.C. circuit, the phase angle between current and voltage is
1) any angle between 0 and $\pm\frac{\pi}{2}$
2) $\frac{\pi}{2}$ 3) π
4) any angle between 0 and $\frac{\pi}{2}$

14. In a series LCR circuit $R = 10\Omega$ and the impedance $Z = 20\Omega$. Then the phase difference between the current and the voltage is
[Karnataka CET 99]
1) 60^o 2) 30^o
3) 45^o 4) 90^o

KEY

1) 2 2) 3 3) 2 4) 3 5) 3 6) 2 7) 2
8) 1 9) 4 10) 3 11) 1 12) 2 13) 1 14) 1

LEVEL - 4

I. A circuit having a resistor, an inductor and a capacitor in series connected to a 150 V AC mains For the circuit R = 9 Ohm, X_L = 28 Ohm, X_C = 16 ohm.

1) Impedance of the circuit is
1) 15 Ohm 2) 1.5 Ohm
3) 0.15 Ohm 4) 150 Ohm

2) Reactance of the circuit is
1) 12 Ohm 2) 44 Ohm
3) 37 Ohm 4) 30 Ohm

3) P.d. across the capacitor is
1) 1.6 V 2) 160 V 3) 16 V 4) 0.16 V

4) P.d. across the inductor is
1) 2.8 V 2) 28 V 3) 280 V 4) 0.28 V

II. In series with an alternating source of peak emf 300 volt and frequency 50 cycles/sec an inductance of 1 H and resistance $200\,\Omega$ are connected.

1. The reactance of the circuit is
1) 3140 Ohm 2) 31.4 Ohm
3) 314 Ohm 4) 3.14 Ohm

2. Impedance of the circuit is
1) 37.2 Ohm 2) 372 Ohm
3) 3720 Ohm 4) 3.72 Ohm

3. Its peak current is
1) 0.5 A 2) 0.6 A 3) 0.7 A 4) 0.8 A

4. If ϕ is the phase difference between current and voltage then $\tan\phi$ is
1) 1.57 2) 15.7 3) 3.14 4) 31.4

KEY

1) 1, 1, 2, 3 2) 3, 2, 4, 1