AC Circuits **Marks: 30**

ANSWER KEY

Physics

Q.1 A	Q.2 B	Q.3 C	Q.4 C	Q.5 A	Q.6 A	Q.7 A	Q.8 D
Q.9 B	Q.10 D	Q.11 C	Q.12 D	Q.13 A	Q.14 B	Q.15 C	Q.16 D
Q.17 C	Q.18 C	Q.19 B	Q.20 A	Q.21 B	Q.22 D	Q.23 C	Q.24 B
Q.25 B	Q.26 C	Q.27 C	Q.28 D	Q.29 D	Q.30 A		

SOLUTION

Physics

Q.1 An a.c. source of frequency 50 Hz and e.m.f. 220 V is connected to the L-R circuit having L = $\frac{0.4}{\pi}$ henry and R = 30 Ω. The impedance of the circuit and a.c. current flowing in the circuit is

Correct option: (A)

Inductive reactance

X_L = 2πfL = 2π × 50 × $\frac{0.4}{\pi}$ = 40 Ω

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

= $\sqrt{(30)^2 + (20)^2}$= 50 Ω

∴ Current, i = $\frac{220}{50}$ = 4.4 A

Thinking Hatke

As the value of impedance is different in all the options, it is sufficient to calculate just the impedance to reach the final answer i.e., (A)

Q.2 The current in a series LCR circuit will be maximum, then ω is

Correct option: (B)

In a series LCR circuit, current will be maximum, when ω = natural frequency of LCR system = 1/$\sqrt{LC}$

Q.3 An inductor of 0.5 mH, capacitor of 20 μF and resistance of 20 Ω are connected in series with a 220 V a.c. source. If the current is in phase with e.m.f., the maximum current in the circuit is $\sqrt{x}$ A.

The value of x is

Correct option: (C)

When current is in phase with voltage, we have

Z = R = 20 Ω

$e_0 = \sqrt{2}e_{rms} = 220\sqrt{2}$ V

$i_0 = \frac{e_0}{Z} = \frac{220\sqrt{2}}{20} = 11\sqrt{2}A$

$i_0 = \sqrt{242}A$

∵ $i_0 = \sqrt{x}A$ …[Given]

∴ x = 242

Q.4 An a. c. source is connected to an inductor (L) and resistor (R) in series. The inductive reactance and resistance are both equal to 5 Ω. The phase difference between the applied voltage and the current in the circuit is (in radian) (tan 45º = 1)

Correct option: (C)

tan ϕ = $\frac{X_L}{R} = \frac{5}{5} = 1$

∴ ϕ = 45° = $\frac{\pi}{4}$

Q.5 With an alternating voltage source of frequency ‘f ’, inductor ‘L’, capacitor ‘C’ and resistance ‘R’ are connected in series. The voltage leads the current by 45°. The value of ‘L’ is (tan 45° = 1)

Correct option: (A)

The phase difference between the current and the voltage is given by tan ϕ = $\frac{\omega L - \frac{1}{\omega C}}{R}$

∴ $\omega L - \frac{1}{\omega C} = R$ ….(∵ tan ϕ = tan 45° = 1)

∴ ωL = R + $\frac{1}{\omega C}$

∴ L = $\frac{R}{\omega} + \frac{1}{\omega^2 C} = \frac{R\omega C + 1}{\omega^2 C}$

∴ L = $\frac{1 + 2\pi f CR}{4\pi^2 f^2 C}$ ….(∵ ω = 2πf)

Q.6 Same current is flowing in two AC circuits. First contains only inductance and second contains only capacitance. If frequency of AC is decreased for both, the current will

Correct option: (A)

Inductive reactance XL = ωL = 2πfL

∴ XL ∝ f

Capacitive reactance XC = $\frac{1}{\omega_C} = \frac{1}{2\pi fC}$

∴ XC ∝ $\frac{1}{f}$

As frequency decreases inductive reactance will decrease and current will increase. On the other hand capacitive reactance will increase and the current will decrease.

Q.7 A parallel LC circuit contains a 50 μF capacitor with an initial charge of 10 mC and coil of inductance 20 mH and of negligible resistance. At what time the energy stored becomes completely magnetic?

Correct option: (A)

The natural frequency of the circuit is,

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2 \times 3.142 \times \sqrt{20 \times 10^{-3} \times 50 \times 10^{-6}}}$$

= 159.15 Hz

The initial charge, $Q_0 = 10 \times 10^{-3}$ C

The energy stored in the circuit is given by,

$$E = \frac{1}{2}QC^2 + \frac{1}{2}LI^2$$

But, $Q = Q_0 \cos \omega t$

Hence, the energy stored in the circuit will be completely magnetic, when energy stored in the capacitor is zero.

i.e., cos ωt = 0 ⇒ $\omega t = \frac{\pi}{2}$

∴ $\frac{2\pi}{T} t = \frac{\pi}{2}$ ⇒ $t = \frac{T}{4}$

∴ $t = \frac{1}{159.15 \times 4} = 1.57 \times 10^{-3}$ s = 1.57 ms

Q.8 A 16 μF capacitor is charged to 20 volts. The battery is then disconnected and a pure 40 mH coil is connected across the capacitor so that LC oscillations are set up. The maximum current in the coil is

Correct option: (D)

As the electric and magnetic fields share energy equally in an LC circuit,

$$\frac{1}{2}Li^2 = \frac{1}{2}CV^2$$

∴ $i = \left(\frac{CV^2}{L}\right)^{1/2} = \left(\frac{16 \times 10^{-6} \times 20^2}{40 \times 10^{-3}}\right)^{1/2}$

= 0.4 A

Q.9 The inductive reactance of a coil is 1000 Ω. If its inductance and the frequency of A.C. supply are both doubled, then the reactance will become

Correct option: (B)

$X_L = fL \Rightarrow \frac{X_{L_2}}{X_{L_1}} = \frac{f_2L_2}{f_1L_1} = \frac{2f_1 \times 2L_1}{f_1L_1} = 4$

∴ $X_{L_2} = 4 \times 1000 = 4000\ \Omega$

Q.10 With increase in frequency of a.c. supply, the impedance of an L-C-R series circuit

Correct option: (D)

We know

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

⇒ When the frequency increases, X_L increases and X_C decreases.

∴ The impedance of an LCR series circuit decreases at first, becomes minimum and then increases.

Q.11 A series resonant circuit has an inductor of inductance L and a resistor of resistance R connected to an alternating source of angular frequency ω. The quality factor Q of the circuit is

Correct option: (C)

Notes 12: The quality factor of series resonant circuit is also defined as the ratio of voltage drop across capacitor or inductor to the voltage drop across the resistor.

i.e., $Q = \frac{\omega_r L}{R}$ where, ω_r = resonant frequency.

Q.12 A condenser of 10 F and an inductor of 1.2 H are connected in series with an A.C. source of frequency 50 Hz. The impedance of the combination will be

Correct option: (D)

The impedance of combination,

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

$$= 2\pi \times 50 \times 1.2 - \frac{1}{2\pi \times 50 \times 10^{-5}}$$

$$= 376.8 - 318.5 = 58.3\ \Omega$$

Q.13 Out of the following graphs, the correct graphical relation for LC parallel resonant circuit at resonance is

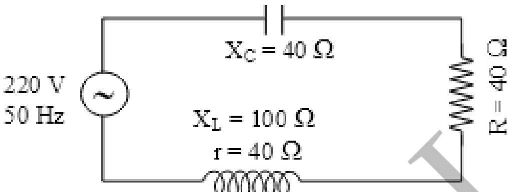
Correct option: (A)

According to condition of parallel resonance for LC circuit, at resonant frequency (f_r) impedance of circuit is maximum and current is minimum.

Q.14 When a capacitor is connected in series LR circuit, the alternating current flowing in the circuit

Correct option: (B)

Q.15 The power factor of the circuit shown in figure is



Correct option: (C) 0.8

R = 40 + 40 = 80 Ω

∴ $X_L - X_C = 100 - 40 = 60\ \Omega$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{80^2 + 60^2} =$$

100

∴ Power factor, $\cos\phi = \frac{R}{Z} = \frac{80}{100} = 0.8$

Q.16 A 220 V, 50 Hz A.C. source is connected to an inductance of 0.2 H and a resistance of 20 ohm in series. What is the current in the circuit?

Correct option: (D)

$$i = \frac{e}{\sqrt{R^2 + X_L^2}}$$

$$i = \frac{220}{\sqrt{(20)^2 + (2 \times \pi \times 50 \times 0.2)^2}} = \frac{220}{66} =$$

3.33 A

Q.17 The coil of an a.c. generator has 100 turns, each of cross-sectional area 2 m^2. It is rotating at constant angular speed 30 rad/s, in a uniform magnetic field of 2 × 10^{-2} T. If the total resistance of the circuit is 600 Ω then maximum power dissipated in the circuit is

Correct option: (C)

N = 100, A = 2 m^2, ω = 30 rad/s,

B = 2 × 10^{-2} T, R = 600 Ω

Maximum power dissipated in the circuit

$$P_{max} = E_{rms} \times I_{rms} = \frac{E_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}}$$

$$= \frac{E_0 I_0}{2} \quad ....(i)$$

But $I_0 = \frac{E_0}{R}$ ....(ii)

Putting (ii) into (i) we get,

$$P_{max} = \frac{E_0^2}{2R}$$

But $E_0 = NAB\omega$

$E_0 = 100 \times 2 \times 2 \times 10^{-2} \times 30$

= 120 V

∴ $P_{max} = \frac{120 \times 120}{2 \times 600} = 12$ W

Q.18 An inductance of $\frac{300}{\pi}$ mH, a capacitance of $\frac{1}{\pi}$ mF and a resistance of $20\ \Omega$ are connected in series with an a.c. source of 240 V, 50 Hz. The phase angle of the circuit is

Correct option: (C)

$$\tan\phi = \frac{X_L - X_C}{R} = \left(\frac{\omega L - \frac{1}{\omega C}}{R}\right)$$

$$= \frac{(2 \times \pi \times 50) \times \left(\frac{300}{\pi} \times 10^{-3}\right) - \frac{1}{(2\times\pi\times 50)\times\left(\frac{1}{\pi}\times 10^{-3}\right)}}{20}$$

i.e. $\tan\phi = 1$

$\phi = \tan^{-1}(1)$

Q.19 A 1 μF condenser is charged to 50 V. The charging battery is then disconnected

and a 10 mH coil is connected across the capacitor so that LC oscillations occur. The maximum current in the coil is (Assume that circuit contains no resistance)

Correct option: (B)

When capacitor is connected,

$$I_{\max} = \omega C \times V = \frac{1}{\sqrt{LC}} \times CV$$

$$\therefore \ I_{\max} = \sqrt{\frac{C}{L}} \times V = \sqrt{\frac{10^{-6}}{10 \times 10^{-3}}} \times 50$$

$$\therefore \ I_{\max} = 0.5 \ A$$

Q.20 The energy of the magnetic field in an inductor reduces from its peak value to zero in 2 ms when connected to an AC source. The frequency of the source is

Correct option: (A)

Magnetic field energy $\left(\frac{1}{2}LI^2\right)$ changes from max. to zero, when current changes from I_0 to zero i.e. T/4 sec.

$\frac{T}{4}$ = 2 ms, T = 8 ms = 8 × 10^{-3} s

f = $\frac{1}{T} = \frac{1}{8 \times 10^{-3}} = \frac{10^3}{8}$ = 125 Hz

Q.21 The resistance offered by the inductor (X_L) in an ac circuit is

Correct option: (B)

$X_L = 2\pi$fL

$\therefore \ X_L \propto$ fL

Q.22 The inductive reactance of a coil is 'R' Ω. If inductance of a coil is tripled and frequency of a.c supply is also tripled, then new inductive reactance will be

Correct option: (D)

Inductive reactance = X_L = R = 2πfL

If L and f both are tripled, the inductive reactance will become 9R.

Q.23 The peak value of an alternating current is 6 ampere, then r.m.s. value of current will be

Correct option: (C)

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{6}{\sqrt{2}} = 3\sqrt{2}$ A

Q.24 An e.m.f $E = E_0$ cosωt is applied to a circuit containing 'L' and 'R' in series. If $X_L = R$ then the power dissipated in the circuit is

Correct option: (B)

P = $E_{rms}I_{rms}$ cos ϕ

cos ϕ = $\frac{R}{Z}$

Also, $I_{rms} = \frac{E_{rms}}{Z} = \frac{E_0}{Z\sqrt{2}}$

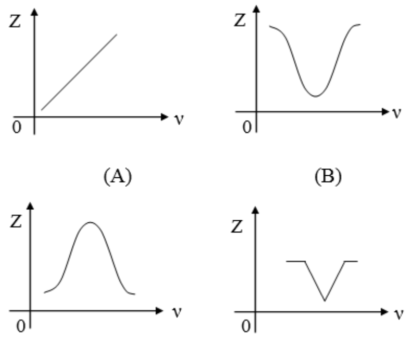
$\therefore$ P = $\frac{E_0}{\sqrt{2}} \times \frac{E_0}{Z\sqrt{2}} \times \frac{R}{Z} = \frac{E_0^2 R}{2Z^2}$

Given X_L = R

$\therefore$ Z = $\sqrt{R^2 + R^2} = \sqrt{2}R$

$\therefore$ P = $\frac{E_0^2 R}{2(2R^2)} = \frac{E_0^2}{4R}$

Q.25 Which one of the following graph represent correctly the variation of impedance (Z) of a series LCR circuit with the frequency (ν) of applied a.c.?



Correct option: (B)

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

From above equation at ν = 0 ⇒ Z = ∞

When ν = $\frac{1}{2\pi\sqrt{LC}}$ (resonant frequency)

$\Rightarrow Z = R$

For ν $> \frac{1}{2\pi\sqrt{LC}}$ ⇒Z starts increasing.

i.e., for frequency 0 – ν_r, Z decreases and for ν_r to ∞, Z increases. This is justified by graph (B).

Q.26 An a.c. source of variable frequency 'f' is connected to an LCR series circuit. Which one of the graphs represent the variation of current 'I' in the circuit with frequency 'f'?

Correct option: (C)

The graph showing the variation of current 'I' with frequency 'f' in an LCR series circuit is a resonance curve. At resonance, the inductive reactance (X_L) and capacitive reactance (X_C) are equal and cancel each other out. This results in a maximum current in the circuit. As the frequency deviates from the resonant frequency, the current decreases. Hence, the graph showing a peak at a particular frequency and decreasing current on either side of the peak represents the correct variation of current with frequency in an LCR series circuit.

Q.27 A capacitor 50 μF is connected to a.c. source e = 220 sin 50 t (e in volt , t in second). The value of peak current is

Correct option: (C)

Given: $e = 220 \sin 50t$

Comparing with $e = e_0 \sin\omega t$

$\therefore \ e_0 = 220\text{ V}, \omega = 50 \ \text{rad/s},$

$$X_C = \frac{1}{\omega C} = \frac{1}{50 \times 50 \times 10^{-6}} = \frac{1}{25 \times 10^{-4}} = 400\Omega$$

$$i_0 = \frac{e_0}{X_C} = \frac{220}{400} = 0.55\ A$$

Q.28 The natural frequency of an LC circuit is 2.5 × 10^4 Hz. The capacitor is replaced by another capacitor with a dielectric medium of dielectric constant K. The frequency decreases by 24 KHz. The value of K is

Correct option: (D)

Frequency of oscillation, $f = \frac{1}{2\pi\sqrt{LC}}$

$\therefore \ f \propto \frac{1}{\sqrt{C}}$

$$\therefore \ \frac{f_{air}}{f_{dielectric}} = \sqrt{\frac{C_{dielectric}}{C_{air}}}$$

But $\frac{C_{dielectric}}{C_{air}} = k$ ….(k = dielectric constant)

$$\therefore \ \frac{f_{air}}{f_{dielectric}} = \sqrt{k}$$

$$\frac{25 \times 10^3}{1 \times 10^3} = \sqrt{k}$$

$\therefore \ k = (25)^2$

$\therefore \ k = 625$

Q.29 The angular frequency of A.C. at which 1 mH inductor has a resistance of 1 Ω is

Correct option: (D)

$X_L = \omega L$

$$\therefore \omega = \frac{X_L}{L} = \frac{1}{10^{-3}} = 1000$$

Q.30 An LCR circuit contains R = 50 Ω, L = 1 mH and C = 0.1 μF. The impedance of the circuit will be minimum for a frequency of

Correct option: (A) $\frac{10^5}{2\pi}$ s^{-1}

Impedance of LCR circuit will be minimum at resonant frequency

$$\therefore \quad f_0 = \frac{1}{2\pi\sqrt{LC}} =$$

$$\frac{1}{2\pi\sqrt{1 \times 10^{-3} \times 0.1 \times 10^{-6}}} = \frac{10^5}{2\pi} s^{-1}$$