JEE MAIN

PREVIOUS YEAR QUESTION

ALTERNATING CURRENT

PHYSICS

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Alternating Current

Q1: A series AC circuit containing an inductor (20 mH), a capacitor (120 F) and a resistor (60 Ω) is driven by an AC source of 24 V/50 Hz. The energy dissipated in the circuit in 60 s is

(a) 3.39×10^3 J

(b) 5.65×10^2 J

(c) 2.26×10^3 J

(d) 5.17×10^2 J

Solution

Impedance,

$Z = (R^2 + (X_C - X_L)^2)^{1/2}$

$X_L = \omega L = (2\pi v L)$

$X_L = 6.28 \times 50 \times 20 \times 10^{-3} = 6.28\ \Omega$

$X_C = (1/\omega C) = 1/(2\pi v C) = 1/(6.28 \times 120 \times 10^{-6} \times 50) = 26.54\ \Omega$

$X_C - X_L = 26.54 - 6.28 = 20.26$

$Z = ((60)^2 + (20.26)^2)^{1/2}$

$Z^2 = 4010\ \Omega^2$

Average power dissipated, $P_{av} = \varepsilon_{rms} I_{rms} \cos \Phi$

$P_{av} = \varepsilon_{rms} \times (\varepsilon_{rms}/Z) \times (R/Z)$

$P_{av} = (\varepsilon_{rms}^2/Z^2) \times R = [(24)^2/4010] \times 60\ W = 8.62\ W$

Energy dissipated in 60 S = $8.62 \times 60 = 5.17 \times 10^2$ J

Answer: (d) 5.17×10^2 J

Q2: In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is

(a) NAB

(b) NABR

(c) NABω

(d) NABRc

Answer: (c) In an a.c. generator, maximum emf = NABω

Q3: The phase difference between the alternating current and emf is π/2. Which of the following cannot be the constituent of the circuit?

(a) LC

(b) L alone

(c) C alone

(d) R, L

Solution

R and L cause phase difference to lie between 0 and π/2 but never 0 and π/2 at extremities

Answer: (d) R, L

Q4: Alternating current cannot be measured by D.C ammeter because

(a) A.C cannot pass through D.C ammeter

(b) A.C changes direction

(c) The average value of current for the complete cycle is zero

(d) D.C. ammeter will get damaged

Solution

The average value of A.C for the complete cycle is zero. Hence A.C cannot be measured by D.C ammeter

Answer: (c) The average value of current for the complete cycle is zero

Q5: A power transmission line feeds input power at 2300 V to a step-down transformer with its primary windings having 4000 turns. The output power is delivered at 230 V by the transformer. If the current in the primary of the transformer is 5 A and its efficiency is 90%, the output current would be

(a) 25 A

(b) 50 A

(c) 45 A

(d) 35 A

Solution

Given ϵ_p = 2300 V, N_p = 4000

ϵ_s = 230 V,

I_p = 5 A,

η = 90% = 0.9

$\eta = P_o/P_i = (\epsilon_s I_s)/(\epsilon_p I_p)$

$I_s = \eta \epsilon_p I_p/\epsilon_s$ = (0.9 x 2300 x 5)/230 = 45 A

Answer: (c) 45 A

Q6: A circuit connected to an ac source of emf e = e_0 sin(100 t) with t in seconds, gives a phase difference of π/4 between the emf e and current I. Which of the following circuits will exhibit this?

(a) RC circuit with R = 1 kΩ and C = 10μF

(b) RL circuit with R = 1 kΩ and L = 10mH

(c) RC circuit with R = 1 kΩ and C = 1μF

(d) RL circuit with R = 1 kΩ and L = 1mH

Solution

$X_C = R$

$1/\omega C = R$

$\omega = 100$ rad/s

Therefore, $1/100 = RC$

Substituting values from option (a)

$R = 1\ k\Omega = 10^3\ \Omega$

$C = 10\mu F = 10 \times 10^{-6}$ F

$RC = 10^3 \times 10 \times 10^{-6} = 1/100$

Therefore, option (a) is correct

Answer (a) RC circuit with R = 1 kΩ and C = 10μF

Q7: In an a.c. circuit, the instantaneous e.m.f. and current is given by

e = 100sin30t, i = 20sin(30t – π/4)

In one cycle of A.C, the average power consumed by the circuit and the wattless current are, respectively

(a) 50, 10

(b) 1000/√2 ,10

(c) 50/√2, 0

(d) 50, 0

Solution

$P_{avg} = V_{rms} I_{rms} \cos\theta$

$P_{avg} = (V_0/\sqrt{2})\,(I_0/\sqrt{2})\cos\theta$

$= (100/\sqrt{2})\,(20/\sqrt{2})\cos 45^0$

$P_{avg} = 1000/\sqrt{2}$ watt

Wattless current = $I_{rms}\sin\theta$

Wattless current = $(I_0/\sqrt{2})\sin\theta$

$= (20/\sqrt{2})\sin 45^0$

= 10 amp

Answer: (b) 1000/√2 ,10

Q8: A coil having n turns and resistance R Ω is connected with a galvanometer of resistance 4RΩ. This combination is moved in time "t" seconds from a magnetic field W_1 weber to W_2 weber. The induced current in the circuit is

(a) $-(W_2 – W_1)/5Rnt$

(b) $-n(W_2 – W_1)/5Rt$

(c) $-(W_2 – W_1)/Rnt$

(d) $-(W_2 – W_1)/5Rnt$

Solution

The emf induced in the coil is $e = -n(d\Phi/dt)$

Induced current, $I = e/R' = – (n/R')(d\Phi/dt)$ ——(1)

Given, $R' = R + 4R = 5R$

$d\Phi = W_2 – W_1$

$dt = t$

(here, W_1 and W_2 are flux associated with one turn)

Substituting the given values in equa(1) we get

$I = (-n/5R)(W_2 – W_1/t)$

Answer: (b) $-n(W_2 – W_1)/5Rt$

Q9: An alternating voltage $V(t) = 220 \sin100\pi t$ volts is applied to a purely resistive load of 50 Ω. The time taken for the current to rise from half of the peak value is

(a) 5 ms

(b) 2.2 ms

(c) 7.2 ms

(d) 3.3 ms

Solution

As $v(t) = 220 \sin100\pi t$

So $I(t) = (220/50) \sin100\pi t$

I.e., $I = I_m = \sin100\pi t$

For $I = I_m$

$t_1 = (\pi/2) \times (1/100\pi) = (1/200)$ sec,

And for $I = I_m/2$

$\Rightarrow (I_m/2) = I_m\sin(100\pi t_2)$

$\Rightarrow (\pi/6) = 100\pi t_2$

$\Rightarrow t_2= (1/600)$ s

$\therefore t_{req} = (1/200) – (1/600) = (2/600) = (1/300)s =3.3$ ms

Answer: (d) 3.3 ms

Q10: An arc lamp requires a direct current of 10A at 80V to function. If it is connected to a 220V (RMS), 50 Hz AC supply, the series inductor needed for it to work is close to

(a) 0.065 H

(b) 80 H

(c) 0.08 H

(d) 0.044 H

Solution

I = 10A

V = 80 V

R = 8 Ω

$10 = 220/(8^2 + X_L^2)^{½}$

$64 + X_L^2 = 484$

$X_L = \sqrt{420}$

$2\pi \times 50L = \sqrt{420}$

$L = \sqrt{420}/100\pi$

L = 0.065 H

Answer: (a) 0.065 H

Q11: In a series, LCR circuit R = 200Ω and the voltage and the frequency of the main supply is 220 V and 50 Hz respectively. On taking out the capacitance from the circuit the current lags behind the voltage by 30^0. On taking out the inductor from the circuit the current leads the voltage by 30^0. The power dissipated in the LCR circuit is

(a) 242 W

(b) 305 W

(c) 210 W

(d) Zero

Solution

$\text{Tan } \Phi = (X_L - X_C)/R$

$\text{Tan } 30^0 = X_C/R = X_C = R/\sqrt{3}$

$\text{Tan } 30^0 = X_L/R = X_L = R/\sqrt{3}$

$X_L = X_C \Rightarrow$ Condition for resonance

So $\Phi = 0^0$

$P = VI\cos 0^0$

$P = V^2/R = (220)^2/200 = 242$ W

Answer: (a) 242 W

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