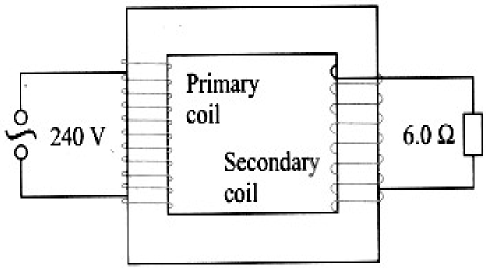
PHYSICS

ALTERNATING CURRENT

1. Figure shows an iron-cored transformer assumed to be 100% efficient. The ratio of the secondary turns to the primary turns is 1:20.



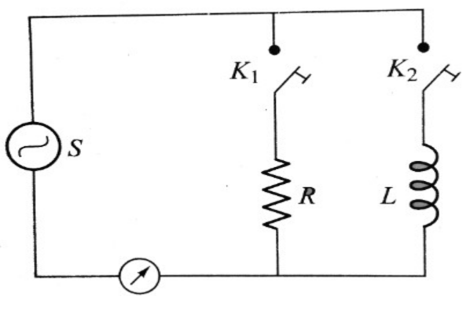
A 240V ac supply is connected to the primary coil and a 6Ω resistor is connected to the secondary coil. What is the current in the primary coil?

1) 0.10 A 2) 0.14 A 3) 2A 4) 40A

2. When $100V$ dc is applied across a solenoid, a current of 1.0 A flows in it. When $100V$ ac is applied across the same coil, the current drops to 0.5 A. if the frequency of the ac source is 50 Hz, the impedance and inductance of the solenoid are

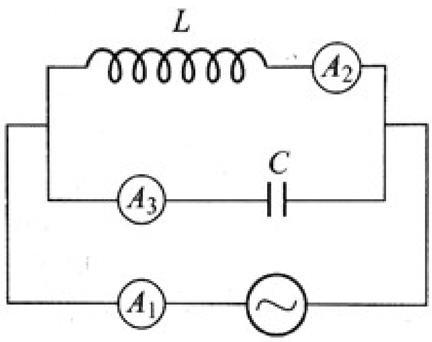
1) 200Ω and 0.55H 2) 100Ω and 0.86H 3) 200Ω and 1.0H 4) 100Ω and 0.93H

3. In the circuit shown in Figure, R is a pure resistor, L is an inductor of negligible resistance (as compared to R), S is a $100V, 50Hz$ ac source of negligible resistance. With either key K_1 alone or K_2 alone closed, the current is I_0 If the source is changed to 100 V, 100 Hz the current with K_1 alone closed and with K_2 alone closed will be, respectively,



1) $I_{0,} \frac{I_0}{2}$ 2) $I_{0,} 2I_0$ 3) $2I_{0,} I_0$ 4) $2I_{0,} \frac{I_0}{2}$

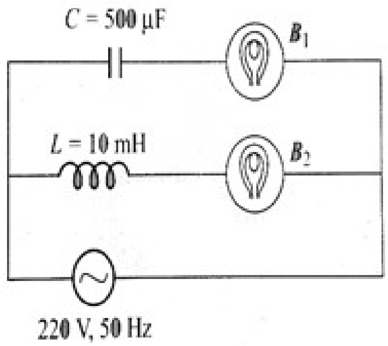
4. For the circuit shown in Figure , the ammeter A_2 reads 1.6 A and ammeter A_3 reads 0.4 A. Then



1) $\omega = \frac{4}{\sqrt{LC}}$ 2) $f = \frac{2\pi}{\sqrt{LC}}$

3) the ammeter A_1 reads 1.2A 4) the ammeter A_1 reads 2A

5. In the circuit shown in Figure, if both the bulbs, B_1 and B_2 are identical,



1) Their brightness will be the same

2) B_2 will be brighter than B_1

3) B_1 will be brighter than B_2

4) Only B2 will glow because the capacitor has infinite impedance

6. A resistor and an inductor are connected to an ac supply of 120 V and 50 Hz. The current in the circuit is 3A. If the power consumed in the circuit is 108 w, then the resistance in the circuit is

1) 12Ω 2) 40Ω 3) $\sqrt{(52\times 28)}\,\Omega$ 4) 360Ω

7. An inductor and a resistor are connected in series with an ac source. In the circuit.

1) The current and PD across the resistance lead the PD across the inductance

2) The current and the PD across the resistance lag behind the PD across the inductance by an angle $\pi/2$

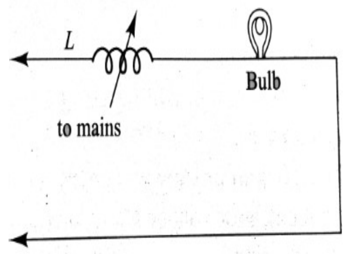
3) The current and the PD across the resistance lag behind the PD across the inductance by an angle π

4) The PD across the resistance lags behind the PD across the inductance by an angle $\pi/2$ but the current in resistance leads the PD across the inductance by $\pi/2$

8. A dc ammeter and a hot wire ammeter are connected to a circuit in series. When a direct current is passed through circuit, the dc ammeter shows 6A. When ac current flows through circuit, the ac ammeter shows 8 A. What will be reading of each ammeter if dc and ac currents flow simultaneously through the circuit?

1) dc = 6A, ac =10A 2) dc = 3A, ac =5A 3) dc = 5A, ac =8A 4) dc = 2A, ac =3A

9. A typical light dimmer used to dim the stage lights in a theatre consists of a variable induction for L (where inductance is adjustable between zero and L_{max}) is connected in series with a light bulb B as shown in Fig. The mains electrical supply is 220V at 50 Hz, the light bulb is rated at 220 V, 1100 W. What L_{max} is required if the rate of energy dissipated in the light bulb is to be varied by a factor of 5 from its upper limit of 1100 W?



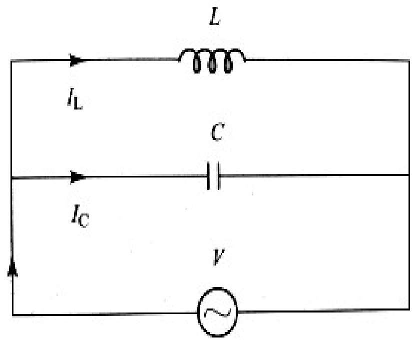
1) 0.69 H 2) 0.28 H 3) 0.38 H 4) 0.56 H

10. Two alternating voltage generators produce emfs of the same amplitude E_0 but with a phase difference of $\pi/3$. The resultant emf is

1) $E_0 \sin\left[\omega t + (\pi/3)\right]$ 2) $E_0 \sin\left[\omega t + (\pi/6)\right]$

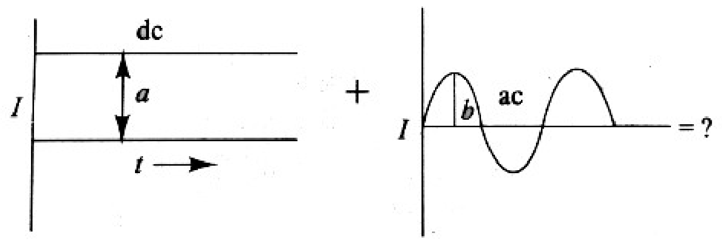
3) $\sqrt{3}E_0 \sin\left[\omega t + (\pi/6)\right]$ 4) $\sqrt{3}E_0 \sin\left[\omega t + (\pi/2)\right]$

11. For the circuit shown in Fig. current in inductance is 0.8 A while that in capacitance is 0.6A. What is the current drawn from the source?



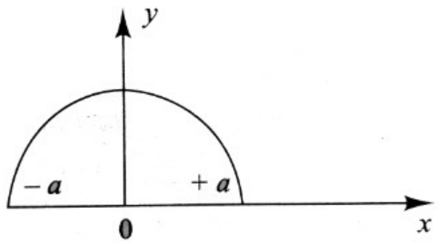
1) 0.1 A 2) 0.3 A 3) 0.6 A 4) 0.2 A

12. If a direct current of value a ampere is superimposed on an alternative current $I = b\sin\omega t$ flowing through a wire, what is the effective value of the resulting current in the circuit?



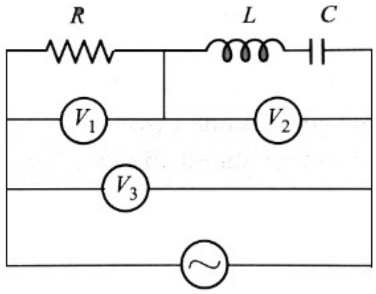
1) $\left[a^2-\frac{1}{2}b^2\right]^{1/2}$ 2) $\left[a^2+b^2\right]^{1/2}$ 3) $\left[\frac{a^2}{2}+b^2\right]^{1/2}$ 4) $\left[a^2+\frac{1}{2}b^2\right]^{1/2}$

13. Determine the rms value of a semi-circular current wave which has a maximum value of a.



1) $\left(1/\sqrt{2}\right)a$ 2) $\sqrt{(3/2)a}$ 3) $\sqrt{(2/3)a}$ 4) $\left(1/\sqrt{3}\right)a$

14. Which voltmeter will give zero reading at resonance?

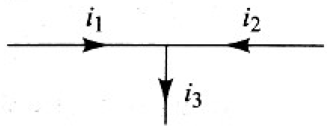


1) V_1 2) V_2 3) V_3 4) none

15. A capacitor of $10\mu F$ and an inductor of 1H are joined in series. An ac of 50 Hz is applied to this combination. What is the impedance of the combination?

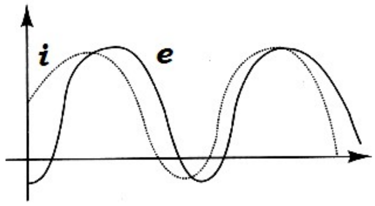
1) $\frac{5\left(\pi^2-5\right)}{\pi}\Omega$ 2) $\frac{10^2\left(10-\pi^2\right)}{\pi}\Omega$ 3) $\frac{10\left(\pi^2-5\right)}{\pi}\Omega$ 4) $\frac{5\left(10-\pi^2\right)}{\pi}\Omega$

16. If $i_1=3\sin\omega t$ and $i_2=4\cos\omega t$, then i_3 is



1) $5\sin\left(\omega t+53^0\right)$ 2) $5\sin\left(\omega t+37^0\right)$ 3) $5\sin\left(\omega t+45^0\right)$ 4) $5\sin\left(\omega t+53^0\right)$

17. When an ac source of emf $e=E_0\sin(100t)$ is connected across a circuit, the phase difference between emf e and current i in the circuit is observed to be $\pi/4$ as shown in Fig. If the circuit consists possibly only of $R-C$ or $L-R$ series, find the relationship between the two elements.



1) $R=1k\Omega, C=10\mu F$ 2) $R=1k\Omega, C=1\mu F$

3) $R=1k\Omega, L=10H$ 4) $R=1k\Omega, L=1H$

18. For an LCR series circuit with an ac source of angular frequency ω,

1) Circuit will the capacitive if $\omega > \frac{1}{\sqrt{LC}}$

2) Circuit will be inductive if $\omega = \frac{1}{\sqrt{LC}}$

3) Power factor of circuit will be unity if capacitive reactance equals inductive reactance

4) Current will be leading voltage if $\omega > \frac{1}{\sqrt{LC}}$

19. The value of current in two series LCR circuits at resonance is same. Then

1) Both circuits must be having same value of capacitance and inductance

2) In both circuits ratio of L and C will be same

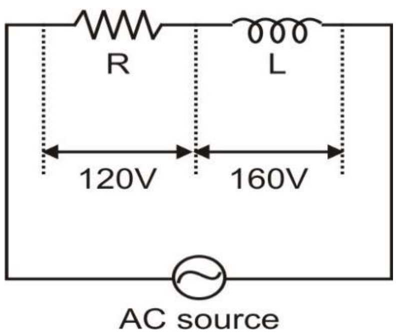
3) For both the circuits X_L / X_C must be same at that frequency

4) Both circuits must have same impedance at all frequencies

20. What reading would you expect of a square -wave current, switching rapidly between +0.5 A and – 0.5 A, when passed through an ac ammeter?

1) 0 2) 0.5 A 3) 0.25 A 4) 1.0 A

21. The circuit given in Figure has a resistance less choke coil L and a resistance R. The voltages across R and L are also given in figure. The virtual value of the applied voltage is



22. A coil has an inductance of 0.7 H and is joined in series with a resistance of 200Ω. When an alternating emf of $220V$ at 50 cps is applied to it, then the wattless component of the current in the circuit is $\frac{x}{10}$ then value of x is $(\text{take } 0.7\pi = 2.2)$

23. In LCR circuit current resonant frequency is 600 Hz and half power points are at 650 and 550 Hz . The quality factor is________

24. An ac voltage is represented by $\text{E} = 220\sqrt{2}\cos(50\pi)\text{t}$. How many times will the current become zero in 1s?___________

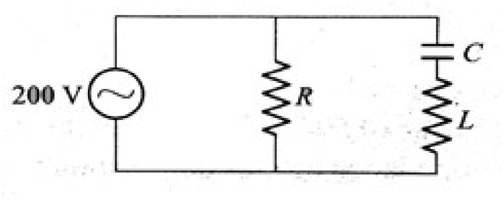
25. A capacitor of capacitance 1 μF is charged to a potential of 1V. It is connected in parallel to an inductor of inductance $10^{-3}H$. The maximum current that will flow in the circuit has the value $\left(10\sqrt{x}\right)mA$ then x = ______

26. A direct current of 5A is superimposed on an alternating current $I = 10\sin\omega t$ flowing through a wire. The effective value of the resulting current will be $5\sqrt{x}$ then x =______

27. An alternating voltage $E = 50\sqrt{2}\sin(100t)V$ is connected to a $1\mu F$ capacitor through an ac ammeter. What will be the reading of the ammeter (in mA)

28. A 50 W, 100V lamp is to be connected to an ac mains of 200 V, 50 Hz. Capacitor is essential to be put in series with the lamp is $\frac{x}{10}$ then x = ______ (in μF)

29. In the circuit shown in Fig. $X_C = 100\Omega, X_L = 200\Omega$ and $R = 100\Omega$..The effective current through the source is $2\sqrt{a}$ then value of a = ________



30. In an ideal transformer, the voltage and the current in the primary coil are $200V$ and $2A$, respectively. If the voltage in the secondary coil is $2000V$, then the value of current in the secondary coil will be $\frac{x}{10}$ then x =_____

KEY

1)1	2)1	3)1	4)3	5)2	6)1	7)2	8)1	9)2	10)3
11)4	12)4	13)3	14)2	15)2	16)1	17)1	18)3	19)3	20)2
21)200	22) 5	23)6	24)50	25) 10	26) 3	27)5	28) 92	29) 2	30) 2

Solutions

1. Power $(P) = \frac{V^2}{R} = \frac{e^2}{R} = \frac{\left(N\frac{d\phi}{dt}\right)^2}{R} = \text{constant}$

$\Rightarrow R \propto N^2$

The equivalent primary load is

$$R_1 = \left(\frac{N_1}{N_2}\right)^2 R_2 = \left(\frac{20}{1}\right)^2 (6.0) = 2400\Omega$$

current in the primary coil

$$= \frac{240}{R_1} = \frac{240}{2400} = 0.1A$$

2. $R = \frac{E}{I} = \frac{100}{1} = 100\Omega$

for ac: $Z = \left[R^2 + (2\pi fL)^2\right]^{1/2}$

$$= \frac{E_V}{I_V} = \frac{100}{0.5} = 200\Omega$$

or $200 = \left[(100)^2 + (100\pi L)^2\right]^{1/2}$

Solving, we get $L = 0.55H$

3. Current remains unchanged in R. However, it becomes half in L. because reactance is doubled on doubling the frequency.

4. The current of 1.6 A lags emf in phase by $\pi/2$. The current of 0.4A leads emf in phase by $\pi/2$. So, these two currents are 180^0 out of phase with each other.

5. $X_C = \frac{1}{2\pi fc} = \frac{10^6}{2\pi 50 \times 500} = \frac{20}{\pi}\Omega$

$X_L = 2\pi fL = 2\pi \times 50 \times 10 \times 10^{-3} = \pi\Omega$

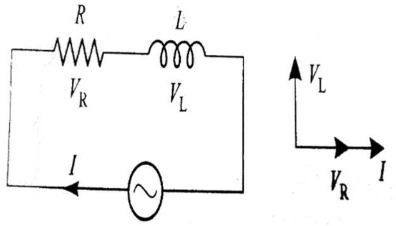
Since $X_L < X_C$, so inductive branch has less impedance, and so more current. Hence B_2 will be brighter.

6. In an ac circuit, a pure inductor does not consume any power. Therefore, power is consumed by the resistor only.

$\therefore P = {I_V}^2 R$

or $108 = (3)^2 R$ or $R = 12\Omega$

7. Here inductance and resistance are connected in series. We know that in case of resistance, both current and potential difference are in the same phase. In inductor, voltage leads current by $\pi/2$.



8. Resultant current is superposition of two currents, i.e,

I(instantaneous total current) $= 6 + I_0 \sin \omega t$

dc ammeter will read average value

$= \overline{6 + I_0 \sin \omega t} = 6 \qquad \left(\because \overline{I_0 \sin \omega t = 0}\right)$

Ac ammeter will read $= \sqrt{\overline{\left(6 + I_0 \sin \omega t\right)^2}}$

$= \sqrt{\overline{\left(36 + 12 I_0 \sin \omega t + I_0^2 \sin^2 \omega t\right)}} \quad \left(\because \overline{I_0 \sin \omega t = 0}\right)$

Since $\overline{\sin^2 \omega t} = \dfrac{1}{2}$ and $I_{rms} = 8 = \dfrac{I_0}{\sqrt{2}} \Rightarrow I_0 = 8\sqrt{2} A$

Therefore, ac reading $= \sqrt{36 + \dfrac{I_0^2}{2}} = \sqrt{36 + 64} = 10A$

9. Resistance of bulb : $R = \dfrac{V_0^2}{P_0} = \dfrac{(220)^2}{1100} = 44\Omega$

When L is maximum, power consumed will be minimum

Which is $P = \dfrac{1100}{5} = 220W$

Now $P = I_v^2 R \Rightarrow 220 = I_v^2 \times 44 \Rightarrow I_v = \sqrt{5} A$

$I_v = \dfrac{E_v}{Z} \Rightarrow \sqrt{5} = \dfrac{220}{\sqrt{44^2 + X_L^2}} \Rightarrow X_L = 88\Omega$

$\Rightarrow 2\pi f L_{\max} = 88 \Rightarrow 2 \times \dfrac{22}{7} \times 50 L_{\max} = 88$

$\Rightarrow L_{\max} = 0.28H$

10. $E_1 = E_0 \sin \omega t;\ E_2 = E_0 \sin\left[\omega t + (\pi/3)\right]$

$E = E_2 + E_1$

$= E_0 \sin\left[\omega t + (\pi/3)\right] + E_0 \sin \omega t$

$= E_0 \left[2 \sin\left\{\omega t + (\pi/6)\right\} \cos(\pi/6)\right]$

$= \sqrt{3} E_0 \sin\left[\omega t + (\pi/6)\right]$

11. If an ac source $E = E_0 \sin \omega t$ is applied across an inductance and capacitance in parallel, the current in inductance will lag the applied voltage while that across the capacitor will lead, and so,

$I_L = \dfrac{E_0}{X_L} \sin\left(\omega t - \dfrac{\pi}{2}\right) = -0.8\sqrt{2} \cos \omega t$

$$I_C = \frac{V}{X_C}\sin\left(\omega t + \frac{\pi}{2}\right) = 0.6\sqrt{2}\cos\omega t$$

So the current drawn from the source

$$I = I_L + I_C = -0.2\sqrt{2}\ \cos\omega t$$

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{0.2\sqrt{2}}{\sqrt{2}} = 0.2A$$

12. As current at any instant in the circuit will be

$$I = I_{dc} + I_{ac} = a + b\sin\omega t$$

$$I_{eff} = \left[\frac{\int_0^T I^2 dt}{\int_0^T dt}\right]^{1/2} = \left[\frac{1}{T}\int_0^T \left(a + b\sin\omega t\right)^2 dt\right]^{1/2}$$

$$I_{eff} = \left[\frac{1}{T}\int_0^T \left(a^2 + 2ab\sin\omega t + b^2\sin^2\omega t\right)dt\right]^{1/2}$$

But as $\frac{1}{T}\int_0^T \sin\omega t dt = 0$ and $\frac{1}{T}\int_0^T \sin^2\omega t dt = \frac{1}{2}$

So, $I_{eff} = \left[a^2 + \frac{1}{2}b^2\right]^{1/2}$

13. The equation of a semi-circular wave is $x^2 + y^2 = a^2$ or $y^2 = a^2 - x^2$

$$I_{rms} = \sqrt{\frac{1}{2a}\int_{-a}^{+a} y^2 dx}$$

$$I_{rms}^2 = \frac{1}{2a}\int_{-a}^{+a}\left(a^2 - x^2\right)dx$$

$$= \frac{1}{2a}\int_{-a}^{+a}\left(a^2 - x^2\right)dx = \frac{1}{2a}\left|a^2 x - \frac{x^3}{3}\right|_{-a}^{+a}$$

$$= \frac{1}{2a}\left(a^3 - \frac{a^3}{3} + a^3 - \frac{a^3}{3}\right) = \frac{2a^2}{3}$$

$$I_{rms} = \sqrt{\frac{2a^2}{3}} = \sqrt{\frac{2}{3}}\,a$$

14. At resonance, the series combination of L and C gives zero impedance.

At resonance, the voltage across L and C are equal but opposite in phase.

15. Here, $X_L = \omega L = 2\pi f L = 2\pi \times 50 \times 1 = 100\pi\Omega$

$$X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 10 \times 10^{-6}} = \frac{10^3}{\pi}\Omega$$

So, $X = |X_L - X_C| = \left|100\pi - \frac{10^3}{\pi}\right| = \left|10^2\left[\frac{\pi^2 - 10}{\pi}\right]\right|\Omega$

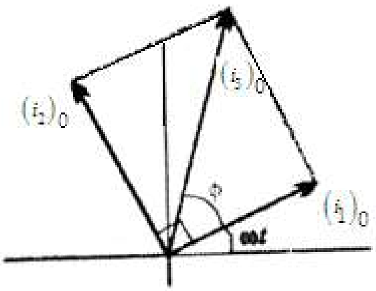
16. $i_3 = i_1 + i_2 = 3\sin\omega t + 4\cos\omega t$

$= 3\sin\omega t + 4\sin\left(\omega t + 90^0\right)$

$(i_3)_0 = \sqrt{(i_1)_0^2 + (i_2)_0^2} = \sqrt{3^2 + 4^2} = 5$

$\tan\phi = \frac{4}{3} \Rightarrow \phi = 53^0$

So $i_3 = (i_3)_0 \sin(\omega t + \phi) = 5\sin\left(\omega t + 53^0\right)$



17. Current leads emf so the circuit is R-C.

$\tan\phi = X_C / R, \phi = 45^0, R = 1000\Omega, \omega = 100$

C = ?

Since $\tan 45^0 = \frac{1}{\omega CR}, So\, C = 10\mu F$

18. The circuit will have inductive nature if

$\omega > \frac{1}{\sqrt{LC}}\left(\omega L > \frac{1}{\omega C}\right)$

Hence (1) is false. Also, if circuit has inductive nature, the current will lag behind voltage. Hence, (4) is also false.

If $\omega = \frac{1}{\sqrt{LC}}\left(\omega L = \frac{1}{\omega C}\right)$, the circuit will have resistance nature. Hence (2) is false.

Power factor, $\cos\phi = \frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} = 1$

If $\omega L = \frac{1}{\omega C}$. Hence, (3) is true.

19. $X_L = X_C$ at resonance

$\frac{X_L}{X_C} = 1$ for both circuits.

Impedance may be different if applied voltage is different.

20. $(0.5)^2 R\left(\frac{T}{2}\right) + (0.5)^2 R\left(\frac{T}{2}\right) = I_{rms}^2 RT$

Or $I_{rms} = \frac{1}{2} A = 0.5A$

21. $E_V = \sqrt{120^2 + 160^2} = 200V$

22. Wattless component of ac

$= I_V \sin\phi = \frac{E_V}{Z}\frac{X_L}{Z} = \frac{E_V X_L}{Z^2} = \frac{220 \times \omega L}{(R^2 + \omega^2 L^2)}$

As $\omega L = 0.7 \times 2\pi \times 50 = 220\Omega$

Hence, wattless component of ac

$= \frac{220 \times (220)}{(220^2 + 220^2)} = 0.5A$

23. Quality factor $= \frac{f_0}{f_{2-}f_1} = \frac{600}{650 - 550} = \frac{600}{100} = 6$

24. $E = E_0 \cos\omega t$

$\therefore \omega = 50\pi$

$2\pi f = 50\pi \Rightarrow f = 25Hz$

In one cycle ac current becomes zero twice. Therefore, 50 times the current becomes zero in 1 s.

25. Change on the capacitor,

$q_0 = CV = 1 \times 10^{-6} \times 1 = 10^{-6} C$

or $I_0 = \omega q_0 =$ maximum current

Now $\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-9}}} = (10^9)^{1/2}$

$\therefore I_0 = (10^9)^{1/2} \times (1 \times 10^{-6}) = \sqrt{10^{-3}} A = \sqrt{1000} mA$

26. Given $l = 5 + 10 \sin \omega t$

$$I_{eff}=\left[\frac{\int_0^T I^2 dt}{\int_0^T dt}\right]^{1/2}=\left[\frac{1}{T}\int_0^T (5+10\sin\omega t)^2\,dt\right]^{1/2}$$

$$=\left[\frac{1}{T}\int_0^T \left(25+10\sin\omega t+100\sin^2\omega t\right)\right]^{1/2}$$

But as $\frac{1}{T}\int_0^T \sin\omega t dt=0$

and $\frac{1}{T}\int_0^T \sin^2\omega t dt=\frac{1}{2}$

so $I_{eff}=\left[25+\frac{1}{2}\times 100\right]^{1/2}=5\sqrt{3}A$

27. $X_C=\frac{1}{\omega C}=\frac{1}{100\times 10^{-6}}=10^4\Omega$

So, $I_{rms}=\frac{E_{rms}}{Z}=\frac{50\sqrt{2}}{\sqrt{2}\times 10^4}=5mA$

28. As resistance of the lamp $R=\frac{V_S^2}{P_0}=\frac{100^2}{50}=200\Omega$

The rms current $I=\frac{V}{R}=\frac{100}{200}=\frac{1}{2}A$

So when the lamp is put in series with a capacitance and run at 200 V ac, from V = IZ, we have

$$Z=\frac{V}{I}=\frac{200}{(1/2)}=400\Omega$$

Now as in case of C-R circuit,

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

i.e., $R^2+\left(\frac{1}{\omega C}\right)^2=160000$

or, $\left(\frac{1}{\omega C}\right)^2=16\times 10^4-(200)^2=12\times 10^4$

$$\frac{1}{\omega C}=\sqrt{12}\times 10^2$$

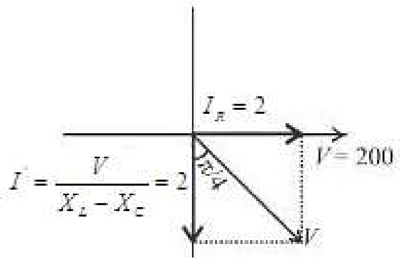
$$C=\frac{1}{100\pi\times\sqrt{12}\times 10^2}F$$

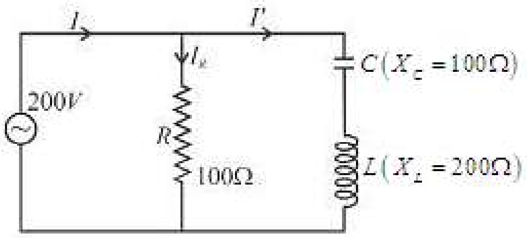
$$= \frac{100}{\pi\sqrt{12}} \mu F = \frac{50}{\pi\sqrt{3}} = 9.2\mu F$$

29. $$I_R = \frac{V}{R} = \frac{200}{100} = 2A$$

$$I' = \frac{V}{X_L - X_C} = \frac{200}{100} = 2A$$

$$I = \sqrt{I_R^2 + I'^2} = 2\sqrt{2}A$$





30. Given:

Voltage in primary coil, $V_P = 200V$

Current in primary coil, $i_p = 2A$

Voltage in secondary coil, $V_s = 2000V$

The relation for the current in the secondary coil is

$$\frac{V_p}{V_s} = \frac{i_p}{i_s} \Rightarrow \frac{2000}{200} = \frac{2}{i_s} = \frac{2 \times 200}{2000} = 0.2A$$