Alternating Currents

Question1

Primary side of a transformer is connected to 230 V, 50Hz supply. Turns ratio of primary to secondary winding is 10:1. Load resistance connected to secondary side is 46Ω. The power consumed in it is :

[27-Jan-2024 Shift 2]

Options:

A.

12.5W

B.

10.0W

C.

11.5W

D.

12.0W

Answer: C

Solution:

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{230}{V_2} = \frac{10}{1}$$

$$V_2 = 23\text{V}$$

$$\text{Power consumed} = \frac{V_2^2}{R}$$

$$= \frac{23 \times 23}{46} = 11.5\text{W}$$

Question2

A series LCR circuit with L = 100/π mH, C = 10^{-3}/π F and R = 10Ω, is connected across an ac source of 220V, 50Hz supply. The power factor of the circuit would be___

[27-Jan-2024 Shift 2]

Answer: 1

Solution:

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

$$X_L = \omega L = 2\pi \times 50 \times \frac{100}{\pi} \times 10^{-3}$$

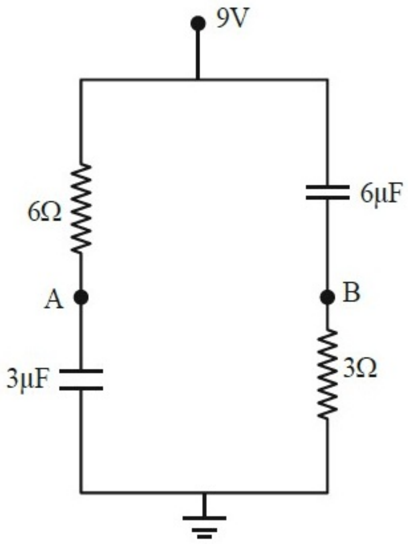
$$= 10\Omega$$

$\because X_C = X_L$, Hence, circuit is in resonance

$\therefore$ power factor $= \frac{R}{Z} = \frac{R}{R} = 1$

Question3

In the given figure, the charge stored in 6μF capacitor, when points A and B are joined by a connecting wire is ____ μC.



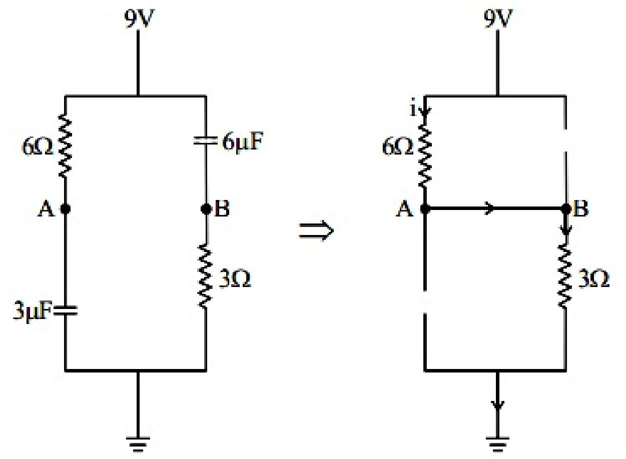
[29-Jan-2024 Shift 2]

Options:

Answer: 36

Solution:

At steady state, capacitor behaves as an open circuit and current flows in circuit as shown in the diagram.



$R_{eq} = 9\Omega$

$i = \frac{9V}{9\Omega} = 1A$

$\Delta V_{6\Omega} = 1 \times 6 = 6V$

$V_A = 3V$

So, potential difference across $6\mu F$ is $6V$.

Hence

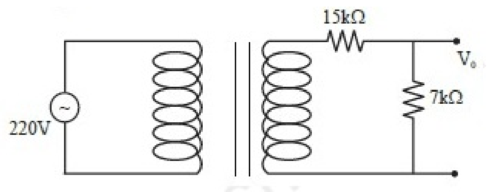
$Q = C \Delta V$

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

$= 36\mu C$

Question4

Primary coil of a transformer is connected to 220V ac. Primary and secondary turns of the transforms are 100 and 10 respectively. Secondary coil of transformer is connected to two series resistance shown in shown in figure. The output voltage (V_0) is :



[30-Jan-2024 Shift 1]

Options:

A.

7V

B.

15V

C.

44V

D.

22V

Answer: A

Solution:

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{N_1}{N_2} = \frac{100}{10} \Rightarrow \varepsilon_2 = 22\text{V}$$

$$I = \frac{22}{22 \times 10^3} = 1\text{ mA}, V_0 = 7\text{V}$$

Question5

A series L,R circuit connected with an ac source E = (25sin 1000t)V has a power factor of 1/√2. If the source of emf is changed to E=(20sin2000 t)V, the new power factor of the circuit will be :

[30-Jan-2024 Shift 1]

Options:

A.

1/√2

B.

1/√3

C.

1/√5

D.

1/√7

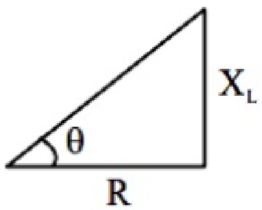
Answer: C

Solution:

$E = 25 sin\,(1000t)$

$\cos\theta = \frac{1}{\sqrt{2}}$

LR circuit



Initially $\frac{R}{\omega_1 L} = \frac{1}{\tan\theta} = \frac{1}{\tan 45^{\circ}} = 1$

$X_L = \omega_1 L$

$\omega_2 = 2\omega_1$, given

$\tan\theta' = \frac{\omega_2 L}{R} = \frac{2\omega_1 L}{R}$

$\tan\theta' = 2$

$\cos\theta' = \frac{1}{\sqrt{5}}$

Question6

An alternating voltage V(t) = 220sin 100πt volt is applied to a purely resistive load of 50Ω. The time taken for the current to rise from half of the peak value to the peak value is:

[30-Jan-2024 Shift 2]

Options:

A.

5 ms

B.

3.3 ms

C.

7.2 ms

D.

2.2 ms

Answer: B

Solution:

Rising half to peak

$t = T/6$

$t = \frac{2\pi}{6\omega} = \frac{\pi}{3\omega} = \frac{\pi}{300\pi} = \frac{1}{300} = 3.33 \text{ ms}$

Question7

A power transmission line feeds input power at 2.3 kV to a step down transformer with its primary winding having 3000 turns. The output power is delivered at 230V by the transformer. The current in the primary of the transformer is 5A and its efficiency is 90%. The winding of transformer is made of copper. The output current of transformer is_____A.

[30-Jan-2024 Shift 2]

Answer: 45

Solution:

$P_i = 2300 \times 5$ watt

$P_0 = 2300 \times 5 \times 0.9 = 230 \times I_2$

$I_2 = 45A$

Question8

An AC voltage V = 20sin 200πt is applied to a series LCR circuit which drives a current I = 10sin (200πt + π/3). The average power dissipated is:

[31-Jan-2024 Shift 2]

Options:

A.

21.6 W

B.

200W

C.

173.2 W

D.

50W

Solution:

$$<P> = IV\cos\phi$$

$$= \frac{20}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \cos 60^{\circ}$$

$$= 50W$$

Question9

A parallel plate capacitor has a capacitance C = 200pF. It is connected to 230V ac supply with an angular frequency 300rad/ s. The rms value of conduction current in the circuit and displacement current in the capacitor respectively are :

[1-Feb-2024 Shift 1]

Options:

A.

1.38μA and 1.38μA

B.

14.3μA and 143μA

C.

13.8μA and 138μA

D.

13.8μA and 13.8μA

Answer: D

Solution:

$$I = \frac{V}{X_C} = 230 \times 300 \times 200 \times 10^{-12} = 13.8\mu A$$

Question10

In series LCR circuit, the capacitance is changed from C to 4C. To keep the resonance frequency unchanged, the new inductance should be :

[1-Feb-2024 Shift 1]

Options:

A.

reduced by $\frac{1}{4}L$

B.

increased by 2L

C.

reduced by $\frac{3}{4}L$

D.

increased to 4L

Answer: C

Solution:

$\omega' = \omega$

$\frac{1}{\sqrt{L'C'}} = \frac{1}{\sqrt{LC}}$

$\therefore L'C' = LC$

$L'(4C) = LC$

$L' = \frac{L}{4}$

$\because$ Inductance must be decreased by $\frac{3L}{4}$

Question11

A transformer has an efficiency of 80% and works at 10V and 4kW. If the secondary voltage is 240V, then the current in the secondary coil is :

[1-Feb-2024 Shift 2]

Options:

A.

1.59A

B.

13.33A

C.

1.33A

D.

15.1A

Answer: B

Solution:

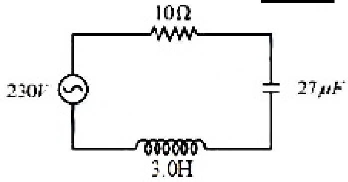
$$\text{Efficiency} = \frac{E_S I_S}{E_P I_P}$$

$$0.8 = \frac{240 I_S}{4000}$$

$$I_S = \frac{3200}{240} = 13.33\text{A}$$

Question12

In the circuit shown in the figure, the ratio of the quality factor and the band width is____s.



[24-Jan-2023 Shift 1]

Solution:

$$\Delta\omega = \frac{R}{L}$$

$$Q = \frac{\omega_0}{\Delta\omega} = \omega_0 \frac{L}{R}$$

$$\omega_0 = \frac{1}{\sqrt{3 \times 27 \times 10^{-6}}} = \frac{1}{9 \times 10^{-3}}$$

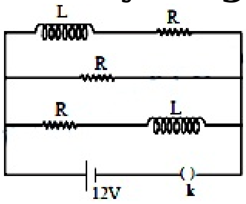
$$\frac{Q}{\Delta\omega} = \frac{\omega_0 \frac{L}{R}}{\frac{R}{L}} = \omega_0 \frac{L^2}{R^2} = \sqrt{\frac{1}{LC}} \frac{L^2}{R^2}$$

$$= \frac{1}{9 \times 10^{-3}} \times \frac{9}{100} = 10\text{ s}$$

Question13

Three identical resistors with resistance R = 12Ω and two identical inductors with sell inductance L = 5 mH are connected to an ideal

battery with emf of 12V as shown in figure. The current through the battery long after the switch has been closed will be___A.



[24-Jan-2023 Shift 2]

Answer: 3

Solution:

Solution:
After long time an inductor behaves as a resistance-less path.
So current through cell

$I = \frac{12}{R/3} = 3A\{\because R = 12\Omega\}$

Question14

In an LC oscillator, if values of inductance and capacitance become twice and eight times, respectively, then the resonant frequency of oscillator becomes x times its initial resonant frequency ω_0. The value of x is:
[25-Jan-2023 Shift 1]

Options:

A. 1 / 4

B. 16

C. 1 / 16

D. 4

Answer: A

Solution:

Solution:
The resonance frequency of LC oscillations circuit is

$\omega_0 = \frac{1}{\sqrt{LC}}$
$L \rightarrow 2L$
$C \rightarrow 8C$
$\omega = \frac{1}{\sqrt{2L \times 8C}} = \frac{1}{4\sqrt{LC}}$
$\omega = \frac{\omega_0}{4}$

So $x = \frac{1}{4}$

Question15

An LCR series circuit of capacitance 62.5 nF and resistance of 50Ω. is connected to an A.C. source of frequency 2.0 kHz. For maximum value of amplitude of current in circuit, the value of inductance is ________ mH. (take $\pi^2 = 10$)
[25-Jan-2023 Shift 1]

Answer: 100

Solution:

Solution:
$f = 1 / 2\pi\sqrt{LC}$
$2000\,Hz = 1 / 2\pi\sqrt{L \times 62.5 \times 10^{-9}}$
$L = 1 / 4\pi^2 \times 2000^2 \times 62.5 \times 10^{-9} = 0.1H = 100\,mH$

Question16

A series LCR circuit is connected to an AC source of 220V, 50 Hz. The circuit contains a resistance R = 80Ω, an inductor of inductive reactance X_L = 70Ω, and a capacitor of capacitive reactance X_C = 130Ω. The power factor of circuit is $\frac{X}{10}$. The value of x is :
[25-Jan-2023 Shift 2]

Options:

A.

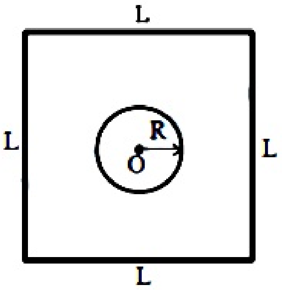
Answer: 8

Solution:

Solution:
$\cos\varphi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + (X_C - X_L)^2}}$
$\cos\varphi = \frac{80}{\sqrt{(80)^2 + (60)^2}}$
$\cos\varphi = \frac{80}{100} \Rightarrow \frac{8}{10}$
So, $x = 8$

Question17

Find the mutual inductance in the arrangement, when a small circular loop of wire of radius ' R ' is placed inside a large square loop of wire of side L (L ≫ R). The loops are coplanar and their centres coincide :



[29-Jan-2023 Shift 1]

Options:

A. $M = \frac{\sqrt{2}\mu_0 R^2}{L}$

B. $M = \frac{2\sqrt{2}\mu_0 R}{L^2}$

C. $M = \frac{2\sqrt{2}\mu_0 R^2}{L}$

D. $M = \frac{\sqrt{2}\mu_0 R}{L^2}$

Answer: C

Solution:

Solution:

$\varphi = Mi$

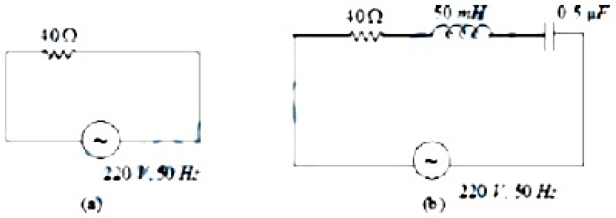
$\varphi = (BA)$

$$\varphi = \pi R^2\left(4\frac{\mu_0}{4\pi}\frac{i}{\left(\frac{L}{2}\right)}\sqrt{2}\right)$$

$$\Rightarrow M = \frac{2\sqrt{2}\mu_0 R^2}{L}$$

Question18

For the given figures, choose the correct options:



[29-Jan-2023 Shift 2]

Options:

A. The rms current in circuit (b) can never be larger than that in (a)

B. The rms current in figure (a) is always equal to that in figure (b)

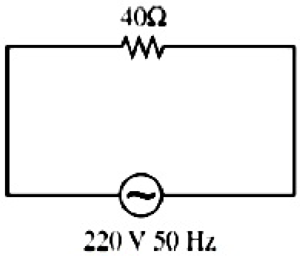
C. The rms current in circuit (b) can be larger than that in (a)

D. At resonance, current in (b) is less than that in (a)

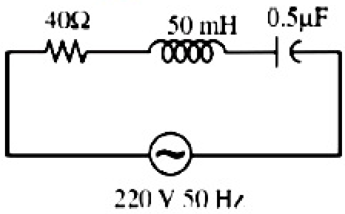
Answer: A

Solution:

Solution:



$$I_{rms} = \frac{220}{40} = 5.5A$$



X_L is not equal to X_C. So rms current in (b) can never be larger than (a).

Question19

An inductor of inductance 2μH is connected in series with a resistance, a variable capacitor and an AC source of frequency 7 kHz. The value of capacitance for which maximum current is drawn into the circuit is $\frac{1}{x}$F, where the value of x is _______.

(. Take $\pi = \frac{22}{7}$)

[29-Jan-2023 Shift 2]

Answer: 3872

Solution:

Solution:

$$\frac{1}{2\pi fC} = 2\pi fL$$

$$C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4 \times \pi^2 \times 49 \times 10^6 \times 2 \times 10^{-6}}$$

$C = \frac{1}{3872} F$
$x = 3872$ Ans.

Question20

A sinusoidal carrier voltage is amplitude modulated. The resultant amplitude modulated wave has maximum and minimum amplitude of 120V and 80V respectively. The amplitude of each sideband is :
[30-Jan-2023 Shift 1]

Options:

A. 15V

B. 10V

C. 20V

D. 5V

Answer: B

Solution:

Solution:
$A_c + A_m = 120$
$A_c - A_m = 80$
$\therefore A_c = 100$
$A_m = 20$
Modulation index $= \frac{20}{100} = \frac{1}{5}$
Amplitude of each sideband
$= A_c \frac{(\text{mod ulation index})}{2}$
$= 100 \times \frac{1}{10} = 10$ volt

Question21

In a series LR circuit with $X_L = R$. power factor is P_1. If a capacitor of capacitance C with $X_C = X_L$ is added to the circuit the power factor becomes P_2. The ratio of P_1 to P_2 will be :
[30-Jan-2023 Shift 1]

Options:

A. 1 : 3

B. $1 : \sqrt{2}$

C. 1 : 1

D. 1 : 2

Answer: B

Solution:

$$= \frac{R}{\sqrt{R^2 + X_L^2}} = \frac{R}{R\sqrt{2}} (\text{ as } X_L = R)$$

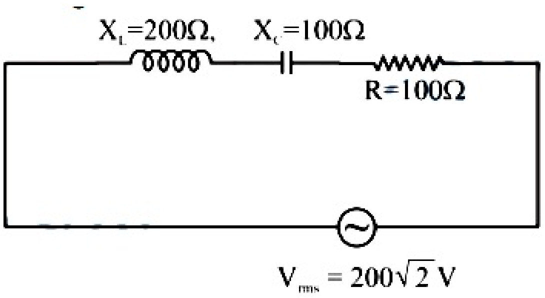
$$P_1 = \frac{1}{\sqrt{2}}$$

$$P_2 = \frac{R}{\sqrt{R^2 + (X_L - X_L)^2}} = P_2 = 1$$

$$\frac{P_1}{P_2} = \frac{1}{\sqrt{2}}$$

Question22

In the given circuit, rms value of current (I_{rms}) through the resistor R is :



[30-Jan-2023 Shift 2]

Options:

A. 2A

B. $\frac{1}{2}$A

C. 20A

D. $2\sqrt{2}$A

Answer: A

Solution:

Solution:

$$z = \sqrt{100^2 + (200 - 100)^2}$$

$$= 100\sqrt{2}\Omega$$

$$i_{rms} = \frac{V_{rms}}{z} = \frac{200\sqrt{2}}{100\sqrt{2}}$$

$$= 2A$$

Question23

In an ac generator, a rectangular coil of 100 turns each having area $14 \times 10^{-2} m^2$ is rotated at 360 rev / min about an axis perpendicular to a uniform magnetic field of magnitude 3.0T. The maximum value of the emf produced will be V _______.(. Take $\pi = \frac{22}{7}$)
[30-Jan-2023 Shift 2]

Answer: 1584

Solution:

Solution:

$\xi_{max} = NAB\omega$

$= 100 \times 14 \times 10^{-2} \times 3 \times \frac{360 \times 2\pi}{60}$

$= 1584V$

Question24

An alternating voltage source V = 260sin (628t) is connected across a pure inductor of 5 mH. Inductive reactance in the circuit is:
[31-Jan-2023 Shift 2]

Options:

A. 3.14Ω

B. 6.28Ω

C. 0.5Ω

D. 0.318Ω

Answer: A

Solution:

Solution:

$\omega = 628 \text{ rad / s}$

$X_L = L\omega$

$= 5 \text{ mH} \times 628$

$= 3.14\Omega$

Question25

A series LCR circuit consists of $R = 80\Omega X_L = 100\Omega$, and $X_C = 40\Omega$ The input voltage is $2500 \cos(100\pi t)$ V. The amplitude of current, in the circuit, is ________ A.

[31-Jan-2023 Shift 2]

Solution:

Solution:
$\omega = 100\pi$

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

$= \sqrt{80^2 + (100 - 40)^2}$

$= 100\Omega$

$i_0 = \frac{V_0}{Z} = \frac{2500}{100} A = 25A$

Question26

Match the List I with List II

List I	List II
A. AC generator	I. Presence of both L and C
B. Transformer	II. ElectromagneticInduction
C. Resonancephenomenonto occur	III. Quality factor
D. Sharpness of resonance	IV. Mutual Inductance

Choose the correct answer from the options given below: [1-Feb-2023 Shift 1]

Options:

A. A-IV, B-II, C-I, D-III

B. A-II, B-I, C-III, D-IV

C. A-II, B-IV, C-I, D-III

D. A-IV, B-III, C-I, D-II

Answer: C

Solution:

Solution:
Based on theory.

Question27

A series LCR circuit is connected to an ac source of 220V, 50 Hz. The circuit contain a resistance R = 100Ω and an inductor of inductive reactance X_L = 79.6Ω. The capacitance of the capacitor needed to maximize the average rate at which energy is supplied will be _______ μF.
[1-Feb-2023 Shift 1]

Solution:

Solution:
To maximize the average rate at which energy supplied i.e. power will be maximum.
So in LCR circuit power will be maximum at the condition of resonance and in resonance condition

$X_L = X_C$

$79.6 = \frac{1}{\omega C}$

$\therefore C = \frac{1}{2\pi \times 50 \times 79.6}$

$\therefore C = 40\mu F$

Question28

An ideal transformer with purely resistive load operates at 12 kV on the primary side. It supplies electrical energy to a number of nearby houses at 120V. The average rate of energy consumption in the houses served by the transformer is 60 kW. The value of resistive load (Rs) required in the secondary circuit will be mΩ.
[6-Apr-2023 shift 1]

Answer: 240

Solution:

$\Rightarrow \frac{120}{12000} = \frac{N_s}{N_p}$

$\Rightarrow \frac{N_s}{N_p} = \frac{1}{100} - - - (i)$

ansformer, input power = Output power
iven by $P = iV$

$i_p V_p = i_s V_s = 60000W$

$i_p = \frac{60000}{12000} = 5$

Now, $R_p = \frac{V_p}{i_p} = \frac{12000}{5} = 2400\Omega$

$R_s = \frac{V_s}{i_s} = \frac{120}{60000/120} = 120 \times \frac{120}{60000} = \frac{120}{500} = 0.240\Omega = 240m\Omega$

Question29

A capacitor of capacitance 150.0μF is connected to an alternating source of emf given by E = 36sin (120πt)V. The maximum value of current in the circuit is approximatively equal to :
[6-Apr-2023 shift 2]

Options:

A. $\sqrt{2}A$

B. $2\sqrt{2}A$

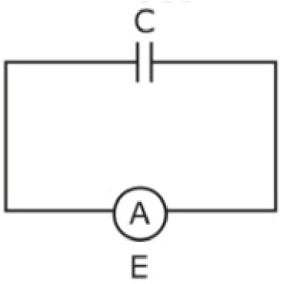
C. $\frac{1}{\sqrt{2}}A$

D. 2A

Answer: D

Solution:

Solution:
Given alternating AC source $E = 36\sin(120\pi t)$v& capacitor $C = 150\mu F$ using $Q = CV$
we can write $Q = (CE_0 \sin\omega t)$
Current $i = \frac{dQ}{dt} = (CE_0\omega\cos\omega t)$
max. value of current $i_0 = CE_0\omega$
or $i_0 = 150 \times 10^{-6} \times 36 \times 120\pi$
$= 2.03A$



Question30

An oscillating LC circuit consists of a 75 mH inductor and a 1.2μF capacitor. If the maximum charge to the capacitor is 2.7μC. The maximum current in the circuit will be ________ mA.
[8-Apr-2023 shift 1]

Answer: 9

Solution:

Solution:

LC oscillation $L = 75\,mH$

$C = 1.2\mu F$

$U_{max\,L} = U_{max\,C}$

$\frac{1}{2}LI_{max}^{2} = \frac{1}{2}\frac{q_{max}^{2}}{C}$

$I_{max} = \frac{q_{max}}{\sqrt{LC}} \Rightarrow I_{max} = \frac{2.7 \times 10^{-6}}{\sqrt{75 \times 10^{-3} \times 1.2 \times 10^{-6}}}$

$I_{max} = 9 \times 10^{-3} A$

$I_{max} = 9\,mA$

Question31

A series combination of resistor of resistance 100Ω, inductor of inductance 1H and capacitor of capacitance 6.25μF is connected to an ac source. The quality factor of the circuit will be _______.
[8-Apr-2023 shift 2]

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$= \frac{1}{100}\sqrt{\frac{1}{6.25 \times 10^{-6}}}$$

$$= 4$$

Question32

Given below are two statements:
Statement I : Maximum power is dissipated in a circuit containing an inductor, a capacitor and a resistor connected in series with an AC source, when resonance occurs
Statement II : Maximum power is dissipated in a circuit containing pure resistor due to zero phase difference between current and voltage.
In the light of the above statements, choose the correct answer from the

options given below :
[10-Apr-2023 shift 1]

Options:

A. Statement I is true but Statement II is false

B. Both Statement I and Statement II are false

C. Statement I is false but Statement II is true

D. Both Statement I and Statement II are true

Answer: D

Solution:

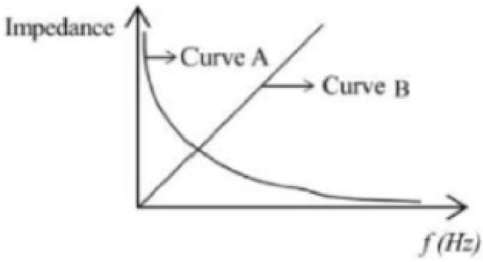
Power is more when total impendence of ckt in minimum

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

$\because X_L = X_C$ (conductor of resonance)

$\therefore Z_{min} = R \quad \therefore$ V&I in same phase

Question33



As per the given graph, choose the correct representation for curve A and curve B.
{ . Where X_C = reactance of pure capacitive circuit connected with A.C. source
X_L = reactance of pure inductive circuit connected with A.C. source
R = impedance of pure resistive circuit connected with A.C. source.
Z = impedance of the LCR series circuit
[11-Apr-2023 shift 1]

Options:

A. $A = X_L$, $B = R$

B. $A = X_L$, $B = Z$

C. $A = X_C$, $B = R$

D. $A = X_C$, $B = X_L$

Answer: D

Solution:

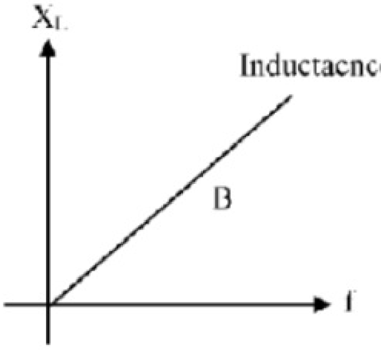
$X_L = W_L = 2\pi fL$

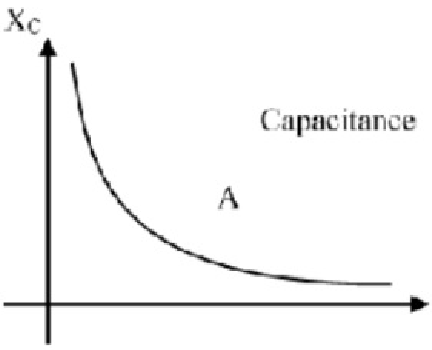
$X_C = \frac{1}{Wc} = \frac{1}{2\pi fc}$

R = const.

$A \rightarrow X_C$

$B \rightarrow X_L$





Question34

Given below are two statements:
Statements I : When the frequency of an a.c source in a series LCR circuit increases, the current in the circuit first increases, attains a maximum value and then decreases
Statements II : In a series LCR circuit, the value of power factor at resonance is one.
In the light of given statements, choose the most appropriate answer from the options given below.
[12-Apr-2023 shift 1]

Options:

A. Statement I is correct but Statement II is false.

B. Both Statement I and Statement II are true.

C. Statement I is incorrect but Statement II is true.

D. Both Statement I and Statement II are false.

Answer: B

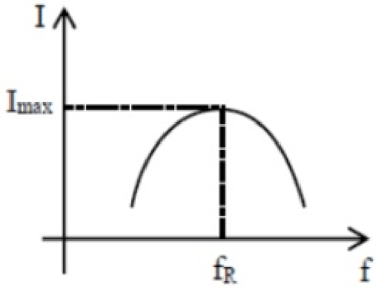
Solution:

Solution:
(i) At resonance frequency power factor of RLC circuit is one
(ii) Graph of RLC circuit is:

At $\omega = \omega_R$

$Z = R$

$\cos\varphi = \frac{R}{Z} = 1$



Question35

Given below are two statements :
Statements I : An AC circuit undergoes electrical resonance if it contains either a capacitor or an inductor.
Statement II : An AC circuit containing a pure capacitor or a pure inductor consumes high power due to its non-zero power factor.
In the light of above statements, choose the correct answer form the options given below :
[13-Apr-2023 shift 2]

Options:

A. Statement I is false but Statement II is true

B. Statement I is true but Statement II is false

C. Both Statement I and Statement II are false

D. Both Statement I and Statement II are true

Answer: C

Solution:

Solution:
Statement-I: An AC circuit for resonance inductor and capacitor both should required.
Statement-II: An AC circuit containing a pure capacitor and pure inductor have no power loss
For resonance, $\varphi = 0$
means both capacitor and inductor must be present.

Question36

A resistance of 40Ω is connected to a source of alternating current rated 220V, 50 Hz. Find the time taken by the current to change from its maximum value to the rms value :
[24-Jun-2022-Shift-1]

Options:

A. 2.5 ms

B. 1.25 ms

C. 2.5s

D. 0.25s

Answer: A

Solution:

Solution:

$I = I_0 \cos(\omega t)$ say

$\Rightarrow$ At maximum $\omega t_1 = 0$ or $t_1 = 0$

Then at rms value $I = I_0 / \sqrt{2}$

$\Rightarrow \omega t_2 = \pi / 4$

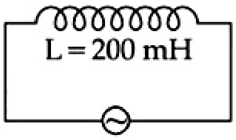
$\Rightarrow \omega(t_2 - t_1) = \pi / 4$

$\Delta t = \frac{\pi}{4\omega} = \frac{\pi T}{4 \times 2\pi}$

$= \frac{1}{400} s$ or $2.5\,ms$

Question37

As shown in the figure an inductor of inductance 200 mH is connected to an AC source of emf 220V and frequency 50 Hz. The instantaneous voltage of the source is 0V when the peak value of current is $\frac{\sqrt{a}}{\pi}$A. The value of a is _____



[24-Jun-2022-Shift-1]

Options:

A. Your Answer :

Answer: 242

Solution:

Solution:

$I_{rms} = \frac{V_{rms}}{z}$

$z = X_2 = \omega_2$

$= 2\pi \times 50 \times \frac{200}{1000}$

$= 20\pi$

$\therefore I_{rms} = \frac{220}{20\pi} = \frac{11}{\pi}$

$\therefore I_{peak} = \sqrt{2} \times \frac{11}{\pi}$

$= \frac{\sqrt{2 \times 121}}{\pi}$

$= \frac{\sqrt{242}}{\pi}$

Question38

Given below are two statements:
Statement I: The reactance of an ac circuit is zero. It is possible that the circuit contains a capacitor and an inductor.
Statement II : In ac circuit, the average power delivered by the source never becomes zero.
In the light of the above statements, choose the correct answer from the options given below.
[24-Jun-2022-Shift-2]

Options:

A. Both Statement I and Statement II are true.

B. Both Statement I and Statement II are false.

C. Statement I is true but Statement II is false.

D. Statement I is false but Statement II is true.

Answer: C

Solution:

Solution:
$X = |X_C - X_L|$
So, it can be zero if $X_C = X_L$
And, average power in ac circuit can be zero.

Question39

Choose the correct answer from the options given below :

	List - I		List -II
(A)	AC generator	(I)	Detects the presence of current in the circuit
(B)	Galvanometer	(II)	Converts mechanical energy into electrical energy
(C)	Transformer	(III)	Works on the principle of resonance in AC circuit
(D)	Metal detector	(IV)	Changes an alternating voltage for smaller or greater value

[25-Jun-2022-Shift-1]

Options:

A. (A) – (II), (B) – (I), (C) – (IV), (D) – (III)

B. (A) – (II), (B) – (I), (C) – (III), (D) – (IV)

C. (A) – (III), (B) – (IV), (C) – (II), (D) – (I)

D. (A) − (I I I), (B) − (I), (C) − (I I), (D) − (I V)

Answer: A

Solution:

Solution:

AC generator	→	Converts mechanical energy into electrical energy
Galvanometer	→	Detects the presence of current in the circuit
Transformer	→	Change AC voltage for smaller or greater value
Metal detector	→	Works on the principle of resonance in AC circuit

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Question40

If wattless current flows in the AC circuit, then the circuit is : [25-Jun-2022-Shift-1]

Options:

A. Purely Resistive circuit

B. Purely Inductive circuit

C. LCR series circuit

D. RC series circuit only

Answer: B

Solution:

Solution:
For wattless current to flow in AC circuit the circuit will be Purely Inductive circuit.

Question41

A sinusoidal voltage $V(t) = 210 \sin 3000t$ volt is applied to a series LCR circuit in which $L = 10$ mH, $C = 25\mu F$ and $R = 100\Omega$. The phase difference (Φ) between the applied voltage and resultant current will be : [25-Jun-2022-Shift-2]

Options:

A. $\tan^{-1}(0.17)$

B. $\tan^{-1}(9.46)$

C. $\tan^{-1}(0.30)$

D. $\tan^{-1}(13.33)$

Answer: A

Solution:

$X_L = 3000 \times 10 \times 10^{-3} = 30\Omega$

$X_C = \frac{1}{3000 \times 25} \times 10^6 = \frac{40}{3}\Omega$

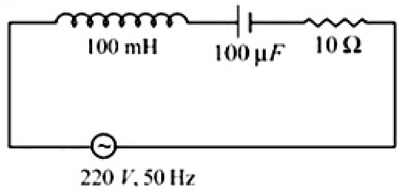
So $X_L - X_C = 30 - \frac{40}{3} = \frac{50}{3}\Omega$

$\tan\theta = \frac{X_L - X_C}{R} = \frac{50/3}{100} = \frac{1}{6}$

So $\theta = \tan^{-1}(0.17)$

Question42

In a series LCR circuit, the inductance, capacitance and resistance are L = 100 mH, C = 100μF and R = 10Ω respectively. They are connected to an AC source of voltage 200V and frequency of 50 Hz. The approximate value of current in the circuit will be A.



[25-Jun-2022-Shift-2]

Answer: 22

Solution:

Solution:

$Z = \sqrt{R^2 + (x_L + x_C)^2}$

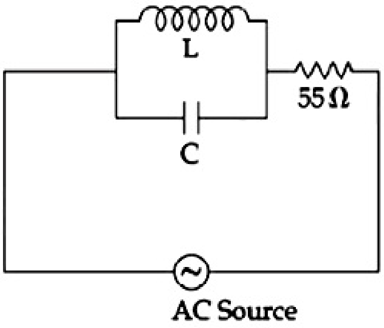
$= \sqrt{10^2 + \left[10\pi - \frac{100}{\pi}\right]^2}\Omega$

$\simeq 10\Omega$

$\Rightarrow$ Current $= \frac{220}{10}A = 22A$

Question43

A 110V, 50 Hz, AC source is connected in the circuit (as shown in figure). The current through the resistance 55Ω, at resonance in the circuit, will be _____A.



[26-Jun-2022-Shift-1]

Solution:

Solution:

$\frac{1}{Z} = \sqrt{\left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$

At resonance, $X_L = X_C$ & $Z \rightarrow \infty$

$\therefore Z_{\text{total circuit}} \rightarrow \infty$

i.e, $I = 0$

Question44

The current flowing through an ac circuit is given by
$I = 5\sin(120\pi t)$ A
How long will the current take to reach the peak value starting from zero?
[27-Jun-2022-Shift-1]

Options:

A. $\frac{1}{60}$S

B. 60s

C. $\frac{1}{120}$S

D. $\frac{1}{240}$S

Answer: D

Solution:

$\omega = 120\pi$

$\Rightarrow T = \frac{1}{60}$ sec

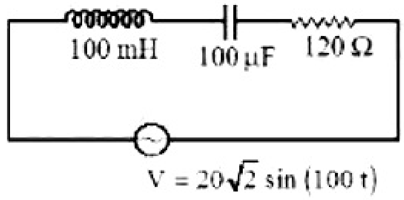
will take its peak value in $\frac{T}{4}$ time

So $t = \frac{T}{4}$

$= \frac{1}{240} s$

Question45

An AC source is connected to an inductance of 100 mH, a capacitance of 100μF and a resistance of 120Ω as shown in figure. The time in which the resistance having a thermal capacity 2J / °C will get heated by 16°C is______ s.



[28-Jun-2022-Shift-1]

Solution:

$L = 100 \times 10^{-3} H$

$C = 100 \times 10^{-6} F$

$R = 120\Omega$

$\omega L = 10\Omega$

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

$\Rightarrow X_C - X_L = 90\Omega$

$\Rightarrow Z = \sqrt{90^2 + 120^2} = 150\Omega$

$\Rightarrow I_{rms} = \frac{20}{150} = \frac{2}{15} A$

For heat resistance by 16°C heat required $= 32J$

$\Rightarrow \left(\frac{2}{15} \right)^2 \times (120) \times t = 32$

$t = \frac{32 \times 15 \times 15}{4 \times 120} = 15$

Question46

A telegraph line of length 100 km has a capacity of 0.01μF / km and it carries an alternating current at 0.5 kilo cycle per second. If minimum impedance is required, then the value of the inductance that needs to be introduced in series is ____mH(if $\pi = \sqrt{10}$)

[28-Jun-2022-Shift-1]

Answer: 100

Solution:

Solution:

Total capacitance $= 0.01 \times 100 = 1\mu F$

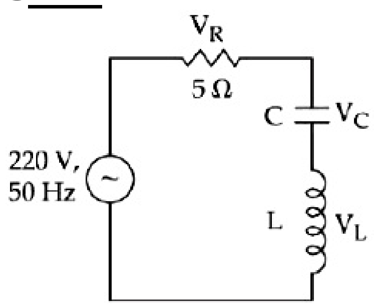
$\omega = 500 \times 2\pi = 1000\pi \, rad/s$

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

$\Rightarrow L = \frac{1}{\omega^2 C} = \frac{1}{1^6\pi^2 \times 10^{-6}} = \frac{1}{10}H = 100\,mH$

Question47

In the given circuit, the magnitude of V_L and V_C are twice that of V_R. Given that f $= 50\,Hz$, the inductance of the coil is $\frac{1}{K\pi}$ mH. The value of K is____



[28-Jun-2022-Shift-2]

Answer: 0

Solution:

Solution:

$V_L = 2V_R$

So $\omega Li = 2Ri$

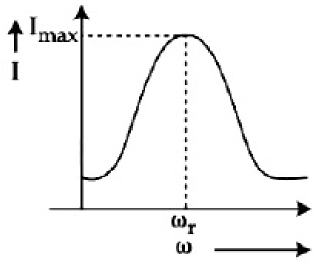
$\Rightarrow L = \frac{2R}{\omega} = \frac{2 \times 5}{2\pi \times 50} = \frac{1}{10\pi}H = \frac{100}{\pi}H$

So $k = \frac{1}{100} \simeq 0$

Question48

Choose the most appropriate answer from the options given below :
For a series LCR circuit, I vs ω curve is shown :
(a) To the left of ω_r, the circuit is mainly capacitive.
(b) To the left of ω_r, the circuit is mainly inductive.

(c) At ω_r, impedance of the circuit is equal to the resistance of the circuit.
(d) At ω_r, impedance of the circuit is 0 .



[29-Jun-2022-Shift-1]

Options:

A. (a) and (b) only.

B. (b) and (d) only.

C. (a) and (c) only.

D. (b) and (c) only.

Answer: C

Solution:

Solution:

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

Also, at $\omega = \omega_r : X_L = X_C$

$\Rightarrow$ For $\omega < \omega_r$: capacitive

and $\omega = \omega_r : z = \sqrt{R^2 + (X_L - X_C)^2} = R$

Question49

An inductor of 0.5 mH, a capacitor of 200μF and a resistor of 2Ω are connected in series with a 220V ac source. If the current is in phase with the emf, the frequency of ac source will be _____ $\times 10^2$ Hz
[29-Jun-2022-Shift-2]

Solution:

Current will be in phase with emf when

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

$\Rightarrow \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5 \times 10^{-4} \times 2 \times 10^{-4}}}$

$\Rightarrow \omega = \frac{10^4}{\sqrt{10}} rad / s$

$\Rightarrow f = \frac{1}{2\pi} \times \frac{10^4}{\sqrt{10}} Hz$

$\Rightarrow f \simeq 500 Hz$

Question50

To increase the resonant frequency in series LCR circuit, [25-Jul-2022-Shift-1]

Options:

A. source frequency should be increased.

B. another resistance should be added in series with the first resistance.

C. another capacitor should be added in series with the first capacitor.

D. the source frequency should be decreased.

Answer: C

Solution:

Solution:

Resonant frequency $= \frac{1}{\sqrt{LC}} = \omega_0$

$\Rightarrow$ If we decrease C, ω_0 would increase

$\Rightarrow$ Another capacitor should be added in series.

Question51

The rms value of conduction current in a parallel plate capacitor is 6.9μA. The capacity of this capacitor, if it is connected to 230V ac supply with an angular frequency of 600rad / s, will be: [25-Jul-2022-Shift-1]

Options:

A. 5pF

B. 50pF

C. 100pF

D. 200pF

Answer: B

Solution:

$Z_C = \frac{V}{I}$

$\Rightarrow \frac{1}{\omega C} = \frac{230}{6.9} M\Omega$

$\Rightarrow C = \frac{6.9}{230\omega} \mu F$

$= \frac{6.9}{230 \times 600} \mu F$

$C = 50 pF$

Question52

When you walk through a metal detector carrying a metal object in your pocket, it raises an alarm. This phenomenon works on :
[25-Jul-2022-Shift-2]

Options:

A. Electromagnetic induction

B. Resonance in ac circuits

C. Mutual induction in ac circuits

D. Interference of electromagnetic waves

Answer: B

Solution:

Solution:
Metal detector works on the principle of resonance in ac circuits.

Question53

In a series LR circuit $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ is put in series, the power factor becomes P_2. The ratio $\frac{P_1}{P_2}$ is:
[26-Jul-2022-Shift-1]

Options:

A. $\frac{1}{2}$

B. $\frac{1}{\sqrt{2}}$

C. $\frac{\sqrt{3}}{\sqrt{2}}$

D. 2 : 1

Answer: B

Solution:

Solution:

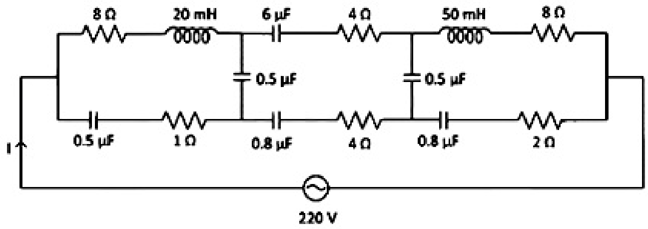
$P_1 = \cos\varphi = \frac{1}{\sqrt{2}} (X_L = R)$

$P_2 = \cos\varphi' = 1$ (will become resonance circuit)

So, $\frac{P_1}{P_2} = \frac{1}{\sqrt{2}}$

Question54

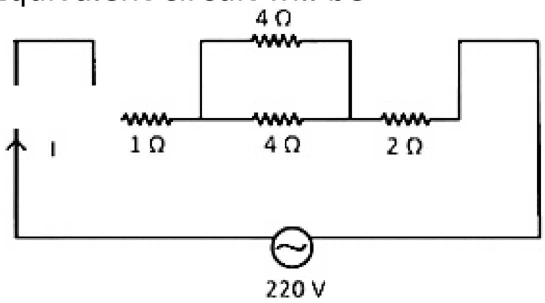
The effective current I in the given circuit at very high frequencies will be A.



[26-Jul-2022-Shift-1]

Solution:

Equivalent circuit will be



$I = \frac{220}{5} = 44A$

Question55

To light, a 50W, 100V lamp is connected, in series with a capacitor of capacitance $\frac{50}{\pi\sqrt{x}}\mu F$, with 200V, 50 Hz AC source. The value of x will be ________.

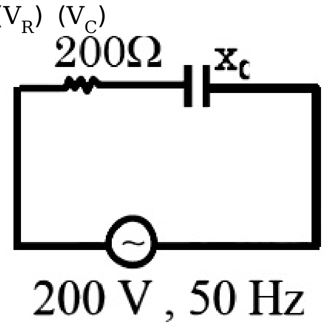
[27-Jul-2022-Shift-1]

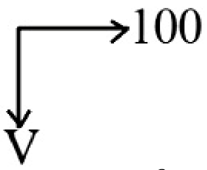
Answer: 3

Solution:

$P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P}$

(V_R) (V_C)





$R = \frac{100 \times 10^2}{50} = R = 200\Omega$

${V_R}^2 + {V_C}^2 = V^2$

$(100)^2 + {V_C}^2 = (200)^2$

$i = \frac{100}{200} = \frac{1}{2}; \quad V^2 = 40000$

$V = I \times X_C; \quad {V_C}^2 = 30000$

$V_C = 100\sqrt{3}$

$X_C = 200\sqrt{3}$

$200\sqrt{3} = \frac{1}{\omega C}$

$C = \frac{1}{20 \times 50 \times 20\sqrt{3}} = \frac{50 \times 10^{-6}}{\sqrt{x}}$

$\sqrt{x} = 50 \times 10^{-6} \times 100 \times 200\sqrt{3}$

$X = 3$

Question56

A series LCR circuit has L = 0.01H, R = 10Ω and C = 1μF and it is connected to ac voltage of amplitude (V_m)50V. At frequency 60% lower than resonant frequency, the amplitude of current will be approximately :

[27-Jul-2022-Shift-2]

Options:

A. 466 mA

B. 312 mA

C. 238 mA

D. 196 mA

Answer: C

Solution:

$$\text{ency, } \omega_0 = \frac{1}{\sqrt{LC}} = 10^4 \text{ rad / sec } \omega' = .4 \times 10^4 = 4000 \text{ rad / sec}$$

$$i_0 = \frac{V_0}{\sqrt{R^2 + (X_C' - X_L')^2}} = 238 \text{ mA}$$

Question57

The equation of current in a purely inductive circuit is $5\sin(49\pi t - 30^\circ)$. If the inductance is $30\,\text{mH}$ then the equation for the voltage across the inductor, will be :

$\{.\text{ Let } .\pi = \frac{22}{7}\}$

[28-Jul-2022-Shift-1]

Options:

A. $1.47\sin(49\pi t - 30^\circ)$

B. $1.47\sin(49\pi t + 60^\circ)$

C. $23.1\sin(49\pi t - 30^\circ)$

D. $23.1\sin(49\pi t + 60^\circ)$

Answer: D

Solution:

$$V(t) = I\,\omega L\,\sin(49\pi t - 30^\circ + 90^\circ)$$

$$9\pi \times \frac{30}{1000}\sin(49\pi t + 60^\circ)$$

$$= 23.1\,\sin(49\pi t + 60^\circ)$$

Question58

The frequencies at which the current amplitude in an LCR series circuit becomes $\frac{1}{\sqrt{2}}$ times its maximum value, are $212\,\text{rad s}^{-1}$ and $232\,\text{rad s}^{-1}$. The value of resistance in the circuit is $R = 5\Omega$. The self inductance in the circuit is _______ mH.

[28-Jul-2022-Shift-1]

Answer: 250

Solution:

Band width $= 232 - 212 = \frac{R}{L}$

$\therefore L = \frac{5}{20} = 250\,mH$

Question59

An alternating emf $E = 440 \sin 100\pi t$ is applied to a circuit containing an inductance of $\frac{\sqrt{2}}{\pi}$H. If an a.c. ammeter is connected in the circuit, its reading will be :
[29-Jul-2022-Shift-1]

Options:

A. 4.4A

B. 1.55A

C. 2.2A

D. 3.11A

Answer: C

Solution:

Solution:

$E = 440 \sin 100\pi t,\ L = \frac{\sqrt{2}}{\pi}H$

$X_L = \omega L = 100\pi \frac{\sqrt{2}}{\pi} = 100\sqrt{2}\Omega$

Peak current $I_0 = \frac{E_0}{X_L} = \frac{440}{100\sqrt{2}} = 2.2\sqrt{2}A$

AC ammeter reads RMS value therefore reading will be I_{rms}

$I_{rms} = \frac{I_0}{\sqrt{2}} = 2.2A$

Question60

A coil of inductance 1H and resistance 100Ω is connected to a battery of 6V. Determine approximately :
(a) The time elapsed before the current acquires half of its steady - state value.
(b) The energy stored in the magnetic field associated with the coil at an instant 15 ms after the circuit is switched on. (Given $\ln 2 = 0.693$, $e^{-3/2} = 0.25$)
[29-Jul-2022-Shift-1]

Options:

A. t = 10 ms; U = 2 mJ

B. t = 10 ms; U = 1 mJ

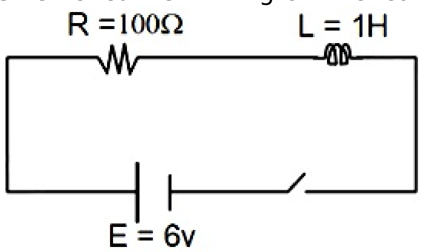
C. t = 7 ms; U = 1 mJ

D. t = 7 ms; U = 2 mJ

Answer: C

Solution:

Solution:
Given circuit is R − L growth circuit



$i = \frac{E}{R}(1 - e^{-t/\tau})$

$i = \frac{E}{2R} = \frac{E}{R}(1 - e^{-t/\tau)})$

Solving $t = \tau \ln 2$

$t = \frac{1}{R}\ln 2 = \frac{1}{100}0.693 = 0.00693$

$= 7\,ms$

$i(15\,ms) = \frac{E}{R}\left(1 - e^{-\frac{15}{10}}\right)$

$i = \frac{6}{100}(1 - 1/4) = \frac{3}{4} \times \frac{6}{100}$

$U = \frac{1}{2}LI^2$

by solving we get $U = 1\,mJ$.

Question61

A circuit element X when connected to an a.c. supply of peak voltage 100V gives a peak current of 5A which is in phase with the voltage. A second element Y when connected to the same a.c. supply also gives the same value of peak current which lags behind the voltage by $\frac{\pi}{2}$. If X and Y are connected in series to the same supply, what will be the rms value of the current in ampere?
[29-Jul-2022-Shift-2]

Options:

A. $\frac{10}{\sqrt{2}}$

B. $\frac{5}{\sqrt{2}}$

C. $5\sqrt{2}$

D. $\frac{5}{2}$

Answer: D

Solution:

Solution:

Element X should be resistive with, $R = \frac{100}{5} = 20\Omega$

Element Y should be inductive with, $X_L = \frac{100}{5} = 20\Omega$

When X and Y are connector in series,

$Z = \sqrt{20^2 + 20^2} = 20\sqrt{2}\Omega$

$I = \frac{100}{Z} = \frac{100}{20\sqrt{2}} = \frac{5}{\sqrt{2}}$

$i_{rms} = \frac{1}{\sqrt{2}} I$

$= \frac{5}{2}$

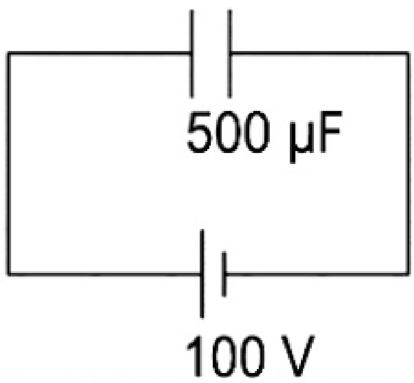
Question62

A capacitor of capacitance 500μF is charged completely using a dc supply of 100V. It is now connected to an inductor of inductance 50 mH to form an LC circuit. The maximum current in LC circuit will be ________ A.

[29-Jul-2022-Shift-2]

Solution:

At steady state charge stored on the capacitor,

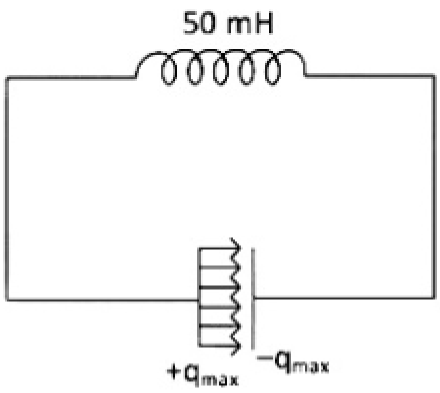


At steady state charge stored on the capacitor,

$q_{max} = CV$

$= 500 \times 10^{-6} \times 100$

$= 5 \times 10^{-2} C$



Energy stored in the capacitor,

$$U_{max} = \frac{q_{max}^2}{2C}$$

Now, when electrostatic energy of capacitor converted to magnetic field energy then all energy of capacitor is transferred to the inductor.

∴ Maximum energy stored in the inductor

$$U_{L max} = \frac{1}{2}LI_{max}^2$$

$$\therefore \frac{1}{2}LI_{max}^2 = \frac{q_{max}^2}{2C}$$

$$\Rightarrow I_{max} = \frac{q_{max}}{\sqrt{LC}}$$

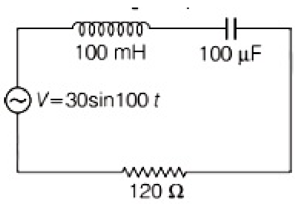
$$= \frac{5 \times 10^{-2}}{\sqrt{50 \times 10^{-3} \times 500 \times 10^{-6}}}$$

$$= \frac{5 \times 10^{-2}}{5 \times 10^{-3}}$$

$$= 10A$$

Question63

Find the peak current and resonant frequency of the following circuit (as shown in figure).



[26 Feb 2021 Shift 2]

Options:

A. 0.2A and 50Hz

B. 0.2A and 100Hz

C. 2A and 100Hz

D. 2A and 50Hz

Answer: A

Solution:

Solution:
Given, inductance, $L = 100mH$
$= 100 \times 10^{-3} H$
Capacitance, $C = 100\mu F$
$= 100 \times 10^{-6} F$
Resistance, $R = 120\Omega$
Maximum voltage, $V_0 = 30V$
Angular frequency, $\omega = 100 rad\, s^{-1}$
Impedance, $Z = \sqrt{(X_L - X_C)^2 + R^2}$
Here, $X_L = \omega L = 100 \times 100 \times 10^{-3} = 10\Omega$

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

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

$$= \sqrt{(100 - 10)^2 + (120)^2} = \sqrt{(90^2 + 120^2} = 153.3\Omega$$

As we know that, peak current,

$$I_0 = \frac{V_0}{Z} = \frac{30}{153.3} = 0.195A \sim eq0.2A$$

Resonance frequency,

$$\therefore f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{100 \times 10^{-3} \times 100 \times 10^{-6}}}$$

$$\Rightarrow f = \frac{1}{2\pi\sqrt{10^{-5}}} = \frac{1}{2\pi \times 10^{-2}\sqrt{10^{-1}}} = \frac{100\pi}{2\pi} = 50Hz$$

Question64

An alternating current is given by the equation $i = i_1 \sin\omega t + i_2 \cos\omega t$. The rms current will be [26 Feb 2021 Shift 1]

Options:

A. $\frac{1}{\sqrt{2}}(i_1^2 + i_2^2)^{1/2}$

B. $\frac{1}{\sqrt{2}}(i_1 + i_2)^2$

C. $\frac{1}{2}(i_1^2 + i_2^2)^{1/2}$

D. $\frac{1}{\sqrt{2}}(i_1 + i_2)$

Answer: A

Solution:

Solution:
Given, $i = i_1 \sin\omega t + i_2 \cos\omega t$

Let I_{rms} be the rms current.

$$\therefore I_{rms} = \left(\frac{i_1^2 + i_2^2}{2}\right)^{1/2}$$

$$\Rightarrow I_{rms} = \frac{1}{\sqrt{2}}(i_1^2 + i_2^2)^{1/2}$$

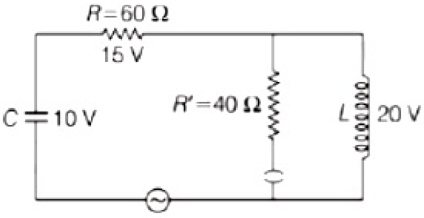
Question65

In a series L − C − R resonant circuit, the quality factor is measured as 100 . If the inductance is increased by two fold and resistance is decreased by two fold, then the quality factor after this change will be ……… .
[26 Feb 2021 Shift 1]

Solution:
Given, initial quality factor $(Q_i) = 100$
Let initial inductance $(x_{Li}) = x$
Final inductance $(x_{Lf}) = 2x$
and initial resistance $(R_i) = R$
Final resistance $(R_f) = \frac{R}{2}$
Final quality factor $= Q_f$
Since, $Q_i = \frac{X_L}{R}$
and $Q_f = \frac{2X_L}{R/2}$
$\Rightarrow Q_f = \frac{4X_L}{R} = 4Q_i = 4 \times 100$
Hence, final quality factor will be 400 .

Question66

The angular frequency of alternating current in an L-C-R circuit is 100rad / s. The components connected are shown in the figure. Find the value of inductance of the coil and capacity of condenser.



[25 Feb 2021 Shift 1]

Options:

A. 0.8H and 150μF

B. 0.8H and 250μF

C. 1.33H and 250μF

D. 1.33H and 150μF

Answer: B

Solution:

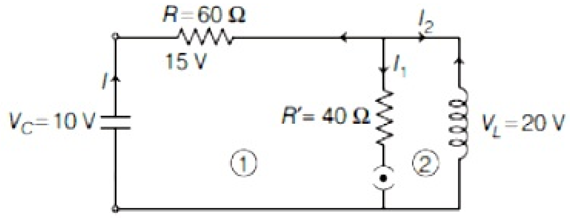
Solution:

Given, angular frequency, $\omega = 100 \text{rad s}^{-1}$

$R = 60\Omega, V_R = 15V$,

$R' = 40\Omega, V_{R'} = V_L = 20V$

$V_C = 10V \quad V_{R'} = V_L = 20V$



By using Ohm's law,

$V = IR \Rightarrow I = V / R$

$I = 15 / 60 = 1 / 4A \ldots$ (i)

$\text{and} \quad I_1 = \frac{V_{R'}}{R'} = 20 / 40 = 1 / 2A \ldots$ (ii)

$\text{As,} \quad X_C = \frac{V_C}{I} = \frac{10}{1 / 4} = 40\Omega$

$\text{and} \quad X_C = \frac{1}{\omega C}$

$\Rightarrow C = \frac{1}{X_C(1)} = \frac{1}{40 \times 100}$

$= 0.25 \times 10^{-3} F = 0.25 mF$

$= 250 \mu F$

By using KCL in loop2, (ii)

$I_2 = I - I_1$

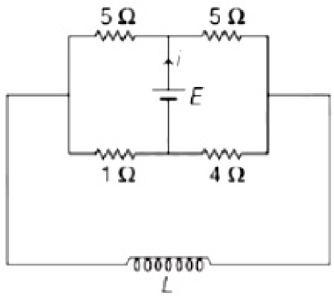
$= 1 / 4 - 1 / 2 = -1 / 4A$

$X_L = \frac{V_L}{|I_2|} = \frac{20}{1 / 4} = 80\Omega \Rightarrow \omega L = 80$

$L = \frac{80}{\omega} = \frac{80}{100} = 0.8H$

Question67

The current (i) at time t = 0 and t = ∞ respectively for the given circuit is



[25 Feb 2021 Shift 1]

Options:

A. $\frac{18E}{55}, \frac{5E}{18}$

B. $\frac{10E}{33}, \frac{5E}{18}$

C. $\frac{5E}{18}, \frac{18E}{55}$

D. $\frac{5E}{18}, \frac{10E}{33}$

Answer: D

Solution:

Solution:
As we know that at time $t = 0$, inductor acts as open circuit.

Then, the circuit becomes

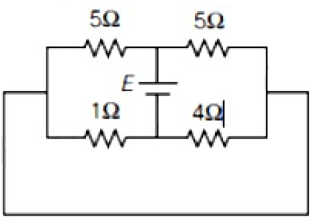
Therefore, $R_{eq} = \frac{(5+1)(5+4)}{(5+1)+(5+4)} = \frac{6 \times 9}{6+9} = \frac{54}{15} = \frac{18}{5}$

By using Ohm's law,

$V = IR_{eq}$

$I = \frac{E \times 5}{18} = \frac{5E}{18} \quad [\because V = E]$

At $t = \infty$, inductor will act as short circuit. It is shown below



Therefore,

$R_{eq} = \frac{5 \times 5}{5+5} + \frac{1 \times 4}{1+4} = \frac{25}{10} + \frac{4}{5} = \frac{5}{2} + \frac{4}{5} = \frac{33}{10}\Omega$

and $I = \frac{E}{\frac{33}{10}} = \frac{10E}{33}$

Question68

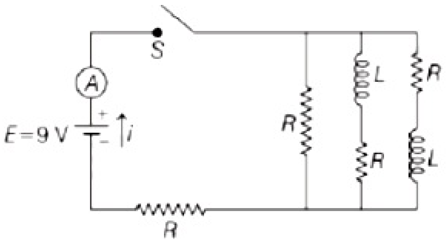
A transmitting station releases waves of wavelength 960m. A capacitor of 2.56μF is used in the resonant circuit. The self-inductance of coil necessary for resonance is .... $\times 10^{-8}$H.
[25 Feb 2021 Shift 1]

Solution:

Given, wavelength of transmission signal,
$\lambda = 960\text{m}$
Capacitance, $C = 2.56\mu\text{F} = 2.56 \times 10^{-6}\text{F}$
As we know resonance frequency,
$$f = \frac{1}{2\pi\sqrt{LC}}$$
Also, frequency $(f) = \frac{\text{speed } (v)}{\text{wavelength } (\lambda)}$
$$\therefore \frac{v}{\lambda} = \frac{1}{2\pi\sqrt{LC}}$$
$$\Rightarrow \sqrt{LC} = \frac{\lambda}{v \times 2\pi}$$
On squaring both sides, we get
$$\Rightarrow LC = \frac{\lambda^2}{v^2 \times 4\pi^2} \Rightarrow L = \frac{\lambda^2}{v^2 \times 4\pi^2 \times C}$$
$$\Rightarrow L = \frac{(960)^2}{(3 \times 10^8)^2 \times 4\pi^2 \times 2.56 \times 10^{-6}}$$
$$\therefore L = 10 \times 10^{-8}\text{H}$$

Question69

Figure shows a circuit that contains four identical resistors with resistance R = 2.0Ω, two identical inductors with inductance L = 2.0mH and an ideal battery with electromotive force E = 9V. The current i just after the switch S is closed will be



[24 Feb 2021 Shift 2]

Options:

A. 2.25A

B. 3.0A

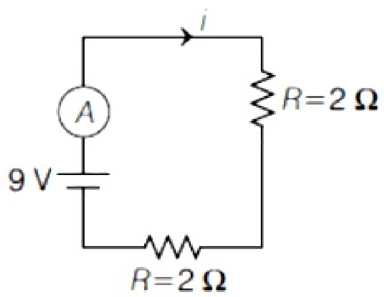
C. 3.37A

D. 9A

Answer: A

Solution:

Solution:
Given, resistance, $R = 2\Omega$,
Inductance, $L = 2\text{mH}$,
emf, $E = 9\text{V}$
and i be the current.
∵ At $t = 0$ when switch is closed, inductors behave as open circuit.
∴ Effective circuit will be



By using Ohm's law, $V = iR_{eq}$

$\Rightarrow i = V / R_{eq}$

where, R_{eq} is equivalent resistance of series resistors,

i.e., $R_{eq} = R + R = 2R = 2 \times 2 = 4\Omega$

$i = \frac{9}{4} = 2.25A$

Question70

A resonance circuit having inductance and resistance $2 \times 10^{-4}H$ and 6.28Ω respectively oscillates at $10MHz$ frequency. The value of quality factor of this resonator is[$\pi = 3.14$]
[24feb2021shift1]

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Solution:

Solution:
Given : $L = 2 \times 10^{-4}H$

$R = 6.28\Omega$

$v = 10MHz = 10^{7}Hz$

Since, quality factor,

$Q = \omega_0 \frac{L}{R} = 2\pi v \frac{L}{R}$

$\therefore Q = 2\pi \times 10^{7} \times \frac{2 \times 10^{-4}}{6.28}$

$Q = 2 \times 10^{3} = 2000$

Question71

A common transistor radio set requires 12 V (D.C.) for its operation. The D.C. source is constructed by using a transformer and a rectifier circuit, which are operated at 220V (A.C.) on standard domestic A.C. supply. The number of turns of secondary coil are 24 , then the number of turns of primary are
[24feb2021shift1]

Answer: 440

Solution:

Solution:
As we know,
$$\frac{N_P}{N_S} = \frac{V_P}{V_S}$$
Since, $N_S = 24$, $V_P = 220V$ and $V_S = 12V$
$$\frac{N_P}{24} = \frac{220}{12}$$
$$N_P = \frac{220 \times 24}{12} = 440$$

Question72

In a series $L - C - R$ resonance circuit, if we change the resistance only, from a lower to higher value, [18 Mar 2021 Shift 1]

Options:

A. the bandwidth of resonance circuit will increase

B. the resonance frequency will increase

C. the quality factor will increase

D. the quality factor and the resonance frequency will remain constant

Answer: A

Solution:

Solution:
Bandwidth of $L - C - R$ series resonance circuit, $\beta = \frac{R}{L}$
As we increase the value of the resistance from lower to the higher of the circuit, the bandwidth of resonance circuit will also increase.
So, the option (a) is correct.
Resonance frequency, $\omega = \frac{1}{\sqrt{LC}}$
Since, the resonance frequency is independent of the resistance.
So, the option (b) is incorrect.
We know that,
Quality factor, $Q = \frac{\omega L}{R}$
The quality factor is inversely proportional to the resistance of the circuit. So, increasing the value of resistance, the quality factor is decreased. So, the option (c) and (d) are incorrect.

Question73

An AC source rated $220V$, $50Hz$ is connected to a resistor. The time taken by the current to change from its maximum to the rms value is [18 Mar 2021 Shift 1]

Options:

A. 2.5ms

B. 25ms

C. 2.5s

D. 0.25ms

Answer: A

Solution:

Solution:
Given, the frequency of the AC source, $f = 50Hz$
Angular frequency of the circuit,
$\omega = 2\pi f$
$\Rightarrow \omega = 2\pi(50) \Rightarrow \omega = 100\pi$
As we know the general expression of the current in AC circuit,
$I = I_0 \sin \omega t$
$\Rightarrow \frac{I_0}{\sqrt{2}} = I_0 \sin(100\pi t)$
$\Rightarrow \sin(100\pi t) = \frac{1}{\sqrt{2}} \Rightarrow 100\pi t = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$
$\Rightarrow 100\pi t = \frac{\pi}{4} \Rightarrow t = \frac{1}{400}\sec$
$\Rightarrow t = 2.5 \times 10^{-3}s = 2.5ms$

Question74

What happens to the inductive reactance and the current in a purely inductive circuit, if the frequency is halved ?
[17 Mar 2021 Shift 2]

Options:

A. Both inductive reactance and current will be halved.

B. Inductive reactance will be halved and current will be doubled.

C. Inductive reactance will be doubled and current will be halved.

D. Both inductive reactance and current will be doubled.

Answer: B

Solution:

Solution:
As we know, the inductive reactance is directly proportional to the frequency of the AC circuit
i.e., $X_L = \omega L$
$\Rightarrow X_L = 2\pi f L \quad (\because \omega = 2\pi f)$
Here, f is the frequency of the AC circuit,
L is the inductive resistance
and X_L is the inductive reactance.
When the frequency of an AC circuit is halved, then the inductive reactance of the circuit is also halved.
i.e. $X_L' = \frac{X_L}{2}$

Using Ohm's law, $I = \frac{V}{X_L}$

When the frequency is halved, then the current

$I' = \frac{V}{X_L'} \Rightarrow I' = \frac{V}{X_L / 2}$

$I' = 2I$

The current becomes doubled.

Question75

Match List-I with List-II

List-I	List-II
A. Phase difference between current and voltage in a purely resistive AC circuit	1. $\frac{\pi}{2}$; current leads voltage
B. Phase difference between current and voltage in a pure inductive AC circuit	2. Zero
C. Phase difference between current and voltage in a pure capacitive AC circuit	3. $\frac{\pi}{2}$; current lags voltage
D. Phase difference between current and voltage in an $L-C-R$ series circuit	4. $\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

Choose the most appropriate answer from the options given below. [17 Mar 2021 Shift 2]

Options:

A. A-1, B-3, C-4, D-2

B. A-2, B-4, C-3, D-1

C. A-2, B-3, C-4, D-1

D. A-2, B-3, C-1, D-4

Answer: D

Solution:

Solution:

A. In a purely resistive AC circuit, the phase difference between the current and voltage is zero.

B. In a purely inductive AC circuit, the current lags the voltage, so the phase difference between the current and voltage is $\pi / 2$.

C. In a purely capacitive AC circuit the current leads the voltage, so the phase difference between the current and voltage is $\pi / 2$.

D. The phase difference between current \& voltage in an $L - C - R$ series circuit is

$\varphi = \tan^{-1} \frac{(X_C - X_L)}{R}$

∴ The correct match is A-(2), B-(3), C-(1), D-(4).

Question76

An AC current is given by $I = I_1 \sin \omega t + I_2 \cos \omega t$. A hot wire ammeter

will give a reading
[17 Mar 2021 Shift 1]

Options:

A. $\sqrt{\frac{I_1^2 - I_2^2}{2}}$

B. $\sqrt{\frac{I_1^2 + I_2^2}{2}}$

C. $\frac{I_1 + I_2}{\sqrt{2}}$

D. $\frac{I_1 + I_2}{2\sqrt{2}}$

Answer: B

Solution:

Solution:
Given, $I = I_1 \sin \omega t + I_2 \cos \omega t$..(i)
We know that rms value of current is given by
$I_{rms} = \sqrt{\frac{\int I^2 dt}{T}}$
$\Rightarrow I_{rms} = \sqrt{\frac{\int_0^T (I_1 \sin \omega t + I_2 \cos \omega t)^2 dt}{T}}$ using Eq. (i)]
Squaring on both sides of the above equation, we get
$\Rightarrow (I_{rms})^2 = \int_0^T \frac{(I_1 \sin \omega t + I_2 \cos \omega t)^2}{T} dt$
$\Rightarrow (I_{rms})^2 = \int_0^T \frac{I_1^2(\sin^2\omega t + I_2 \cos^2\omega t + 2I_1 I_2 \sin \omega t \cos \omega t) dt}{T}$
$\Rightarrow I_{rms} = \sqrt{\frac{I_1^2}{2} + \frac{I_2^2}{2} + 0}$
$\Rightarrow I_{rms} = \sqrt{\frac{I_1^2 + I_2^2}{2}}$

Question77

A sinusoidal voltage of peak value 250V is applied to a series $L - C - R$ circuit, in which $R = 8\Omega$, $L = 24mH$ and $C = 60\mu F$. The value of power dissipated at resonant condition is xkW. The value of x to the nearest integer is
[16 Mar 2021 Shift 1]

Solution:

Given, $V_0 = 250V$, $R = 8\Omega$, $L = 24mH$ and $C = 60\mu F$

We know that, at resonance power, $P = \frac{V_{rms}^{2}}{R}$

$\Rightarrow P = \frac{(250/\sqrt{2})^2}{8} \left[\because V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{250}{\sqrt{2}}V\right]$

$= (250)^2 / 16$

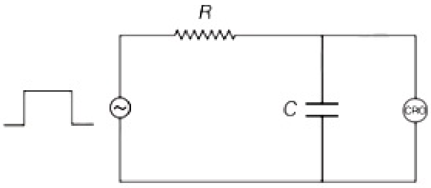
$= \frac{62500}{16} = 3906.25W \approx 4kW$

$x = 4$.

Comparing with the given value in the question i.e., xkW, the value of $x = 4$.

Question78

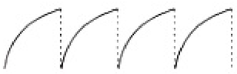
An R − C circuit as shown in the figure is driven by an AC source generating a square wav The output wave pattern monitored by CRO would look close to



[16 Mar 2021 Shift 1]

Options:

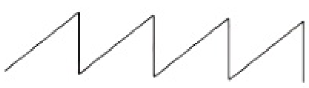
A.



B.

C.

D.



Answer: C

Solution:

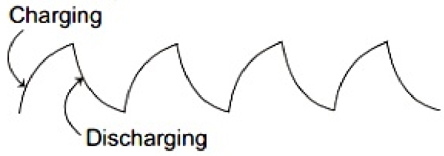
Solution:

When square wave is applied at the input, then

For charging, the capacitor $Q_1 = Q\left(1 - e^{\frac{-t}{RC}}\right)$

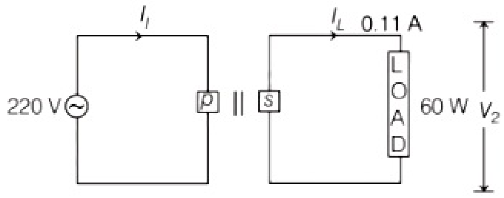
Similarly, for discharging the capacitor, $Q_2 = Q_{max}\left(e^{\frac{-t}{RC}}\right)$

In this manner, charging and discharging exponentially with time will keep on happening alternatively. Therefore, the output wave pattern monitored by CRO would look close to



Question79

For the given circuit, comment on the type of transformer used.



[16 Mar 2021 Shift 2]

Options:

A. Auxilliary transformer

B. Auto transformer

C. Step-up transformer

D. Step down transformer

Answer: C

Solution:

Solution:
Voltage across secondary coil,
$= \frac{\text{Power across load}}{\text{Current passing through load}}$
$\Rightarrow V_2 = \frac{P}{I_L} = \frac{60}{0.11} \Rightarrow V_2 = 545.45V$
Voltage across primary coil, $V_1 = 220V$
$\Rightarrow V_2 > V_1$
It means that step-up transformer is used.

Question80

A 100 Ω resistance, a 0.1 μF capacitor and an inductor are connected in series across a 250 V supply at variable frequency. Calculate the value of inductance of inductor at which resonance will occur. Given that the resonant frequency is 60 Hz.
[27 Jul 2021 Shift 2]

Options:

A. 0.70 H

B. 70.3 mH

C. 7.03×10^{-5} H

D. 70.3 H

Answer: D

Solution:

Solution:
$C = 0.1\mu F = 10^{-7}F$
Resonant frequency $= 60Hz$
$\omega_o = \frac{1}{\sqrt{LC}}$
$2\pi f_0 = \frac{1}{\sqrt{LC}} \Rightarrow L = \frac{1}{4\pi^2 f_o^2 C}$
by putting values $L \simeq 70.3Hz$

Question81

A 0.07H inductor and a 12Ω resistor are connected in series to a 220V, 50Hz ac source. The approximate current in the circuit and the phase angle between current and source voltage are respectively. [Take π as $\frac{22}{7}$]
[27 Jul 2021 Shift 1]

Options:

A. 8.8A and $\tan^{-1}\left(\frac{11}{6}\right)$

B. 88A and $\tan^{-1}\left(\frac{11}{6}\right)$

C. 0.88A and $\tan^{-1}\left(\frac{11}{6}\right)$

D. 8.8A and $\tan^{-1}\left(\frac{6}{11}\right)$

Answer: A

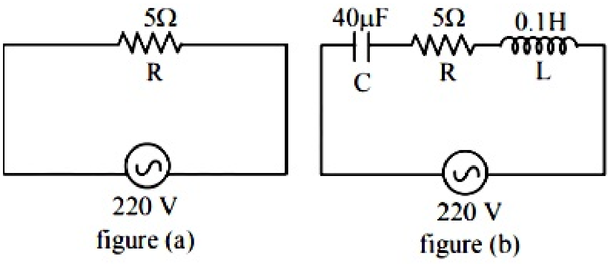
Solution:

Solution:
$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$
$X_L = \omega L$
$X_L = 2 \times \frac{22}{7} \times 50 \times 0.07 = 22\Omega$
$\phi = \tan^{-1}\left(\frac{22}{12}\right) \quad R = 12\Omega$
$\phi = \tan^{-1}\left(\frac{11}{6}\right)$
$Z = \sqrt{X_L^2 + R^2} = 25.059$

$I = \frac{V}{Z} = \frac{220}{25.059} = 8.77A$

Question82

Two circuits are shown in the figure (a) & (b). At a frequency of ______ rad/s the average power dissipated in one cycle will be same in both the circuits.



[25 Jul 2021 Shift 2]

Solution:

For figure (a)

$P_{avg} = v_{rms}{}^2 R$

$\frac{v_{rms}{}^2}{Z^2} \times R = v_{rms}{}^2 R \times 1$

$R^2 = Z^2$

$25 = \left(\sqrt{(x_C - x_L)^2 + 5^2}\right)^2$

$25 = (x_c - x_L)^2 + 25$

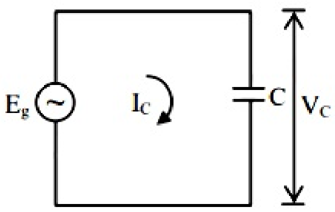
$x_c = x_L \Rightarrow \frac{1}{\omega C} = \omega L$

$\omega^2 = \frac{1}{LC} = \frac{10^6}{0.1 \times 40}$

$\omega = 500$

Question83

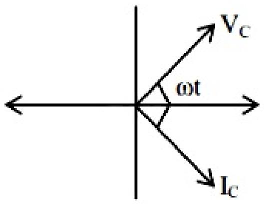
In a circuit consisting of a capacitance and a generator with alternating emf $E_g = E_{g_0} \sin \omega t$, V_C and I_C are the voltage and current. Correct phasor diagram for such circuit is :



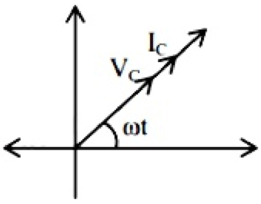
[22 Jul 2021 Shift 2]

Options:

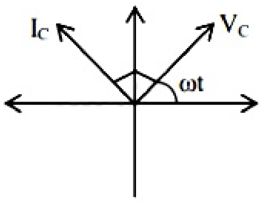
A.



B.



C.



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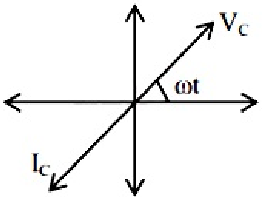


Answer: C

Solution:

Solution:

In capacitor, current lead voltage by $\frac{\pi}{2}$

Question84

Match List-I with List-II :

	List–I		List–II
(a)	$\omega L > \frac{1}{\omega C}$	(i)	Current is in phase with emf
(b)	$\omega L = \frac{1}{\omega C}$	(ii)	Current lags behind the applied emf
(c)	$\omega L < \frac{1}{\omega C}$	(iii)	Maximum current occurs
(d)	Resonant frequency	(iv)	Current leads the emf

Choose the correct answer from the options given below :
[22 Jul 2021 Shift 2]

Options:

A. (a) – (ii) ; (b) – (i) ; (c) - (iv) ; (d) – (iii)

B. (a) – (ii) ; (b) – (i) ; (c) - (iii) ; (d) – (iv)

C. (a) – (iii) ; (b) – (i) ; (c) - (iv) ; (d) – (ii)

D. (a) – (iv) ; (b) – (iii) ; (c) - (ii) ; (d) – (i)

Answer: A

Solution:

Solution:
(a) For $x_L > x_C$, voltage leads the current
(ii)
(b) For $x_L = x_C$, voltage & current are in same phase
(i)(c) For $x_L < x_C$, current leads the voltage
(iv)
(d) For resonant frequency $x_L = x_C$, current is maximum
(iii)

Question85

For a series LCR circuit with $R = 100\Omega, L = 0.5mH$ and $C = 0.1pF$ connected across $220V - 50Hz$ AC supply, the phase angle between current and supplied voltage and the nature of the circuit is :
[20 Jul 2021 Shift 2]

Options:

A. 0°, resistive circuit

B. ≈90°, predominantly inductive circuit

C. 0°, resonance circuit

D. ≈90°, predominantly capacitive circuit

Answer: D

Solution:

Solution:
$R = 100\Omega$
$X_L = \omega L = 50\pi \times 10^{-3}$
$X_C = \frac{1}{\omega C} = \frac{10^{11}}{100\pi}$
$X_C >> X_L$
$\& \mid X_C - X_L \mid >> R$

Question86

A series LCR circuit of $R = 5\Omega$, $L = 20mH$ and $C = 0.5\mu F$ is connected across an AC supply of $250V$, having variable frequency. The power dissipated at resonance condition is ______ $\times 10^2 W$.
[20 Jul 2021 Shift 2]

Answer: 125

Solution:

Solution:
$X_L = X_C$ (due to resonance)
$Z = R$ so $i_{rms} = V Z = \frac{V}{R}$
$\frac{V^2}{R} = \frac{250 \times 250}{5} = 125 \times 10^2 W$

Question87

AC voltage $V(t) = 20 \sin\omega t$ of frequency $50Hz$ is applied to a parallel plate capacitor. The separation between the plates is 2mm and the area is $1m^2$.
The amplitude of the oscillating displacement current for the applied AC voltage is ______.
[Take $\varepsilon_0 = 8.85 \times 10^{-12} F/m$]
[20 Jul 2021 Shift 1]

Options:

A. $21.14\mu A$

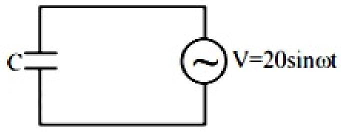
B. $83.37\mu A$

C. $27.79\mu A$

D. $55.58\mu A$

Answer: C

Solution:



From the given information,

$C = \frac{\varepsilon_0 A}{d} = \frac{\in_0 \times 1}{2 \times 10^{-3}} F$

$\therefore X_C = \frac{1}{\omega C} = \frac{2 \times 10^{-3}}{2 \times 50\pi \times \in_0} = \frac{2 \times 10^{-3}}{25 \times 4\pi \in_0} \Omega$

$\therefore X_C = \frac{2 \times 10^{-3}}{25} \times 9 \times 10^9 = \frac{18}{25} \times 10^6 \Omega$

$\therefore i_0 = \frac{V_0}{X_C} = \frac{20 \times 25}{18} \times 10^{-6} A = 27.47 \mu A.$

The value of amplitude of displacement current will be same as value of amplitude of conventional current.
Hence option 3.

Question88

In an LCR series circuit, an inductor 30mH and a resistor 1Ω are connected to an AC source of angular frequency 300rad / s. The value of capacitance for which, the current leads the voltage by 45° is $\frac{1}{x} \times 10^{-3}$F. Then the value of x is ______.
[20 Jul 2021 Shift 1]

Answer: 3

$\tan \phi = \frac{x_C - x_L}{R}$

$\tan 45 = \frac{x_C - x_L}{R}$

$x_C - x_L = R$

$\frac{1}{\omega C} - \omega L = R$

$\frac{1}{\omega C} - 300 \times 0.03 = 1$

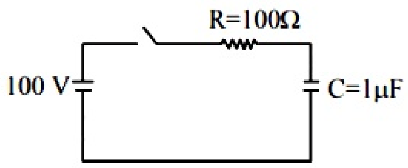
$\frac{1}{\omega C} = 10$

$C = \frac{1}{10\omega} = \frac{1}{10 \times 300}$

$C = \frac{1}{3} \times 10^{-3}$

$X = 3$

Question89



A capacitor of capacitance $C = 1\mu F$ is suddenly connected to a battery of 100 volt through a resistance $R = 100\Omega$. The time taken for the capacitor to be charged to get 50V is :
[Take $\ln 2 = 0.69$]
[27 Jul 2021 Shift 1]

Options:

A. $1.44 \times 10^{-4}s$

B. $3.33 \times 10^{-4}s$

C. $0.69 \times 10^{-4}s$

D. $0.30 \times 10^{-4}s$

Answer: C

Solution:

$$\upsilon \quad 1 - e^{-\frac{t}{RC}})$$

$$50 = 100\left(1 - e^{-\frac{t}{RC}}\right)$$

$$t = 0.69 \times 10^{-4}\sec$$

Question90

An inductor of 10mH is connected to a 20V battery through a resistor of $10k\Omega$ and a switch.
After a long time, when maximum current is set up in the circuit, the current is switched off. The current in the circuit after $1\mu s$ is $\frac{x}{100}$mA. Then xis equal to ______. (Take $e^{-1} = 0.37$)
[25 Jul 2021 Shift 1]

Answer: 74

Solution:

$I_{max} = \frac{V}{R} = \frac{20V}{10K\Omega} = 2mA$
For LR − decay circuit
$I = I_{max} e^{-R/L}$
$I = 2mAe^{\frac{-10 \times 10^3 \times 1 \times 10^{-6}}{10 \times 10^{-3}}}$
$I = 2mA\, e^{-1}$
$I = 2 \times 0.37mA$
$I = \frac{74}{100} mA$
$x = 74$

Question91

An AC circuit has an inductor and a resistor of resistance R in series, such that $X_L = 3R$. Now, a capacitor is added in series such that $X_C = 2R$. The ratio of new power factor with the old power factor of the circuit is $\sqrt{5}$: x The valueof x is.
[27 Aug 2021 Shift 2]

Solution:

Given, resistance of resistor $= R$
Inductance, $X_L = 3R$
Capacitance $X_C = 2R$
As we know that,
Power factor, $\cos\varphi = \frac{R}{Z}$
where, Z is impedance,
$Z = \sqrt{R^2 + (X_L - X_C)^2}$
For case I, an inductance connected in series with resistance

$$\cos\varphi_1 = \frac{R}{Z_1} = \frac{R}{\sqrt{R^2 + (X_L - 0)^2}}$$

$$= \frac{R}{\sqrt{R^2 + (3R)^2}} = \frac{R}{R\sqrt{10}} = \frac{1}{\sqrt{10}} \quad \cdots\cdots\text{(i)}$$

For case II, A capacitor is also connected in series with resistance

$$\therefore \cos\varphi_2 = \frac{R}{Z_2}$$

$$\Rightarrow \cos\varphi_2 = \frac{R}{\sqrt{R^2 + (3R - 2R)^2}}$$

$$= \frac{R}{\sqrt{R^2 + R^2}} = \frac{R}{R\sqrt{2}} = \frac{1}{\sqrt{2}} \ldots \text{(ii)}$$

Now, ratio of Eqs. (ii) and (i), we get

$$\frac{\cos\varphi_2}{\cos\varphi_1} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{10}}} = \sqrt{\frac{10}{2}} = \sqrt{5} : 1$$

$\therefore x = 1$

Question92

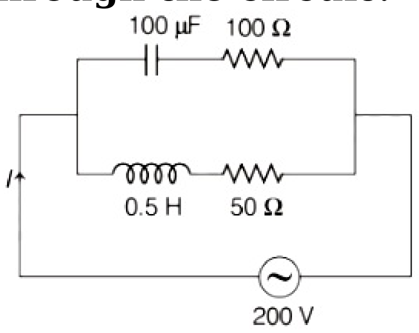
The alternating current is given by i = $\left\{\sqrt{42}\sin\left(\frac{2\pi}{T}t\right)+10\right\}$ A
The rms value of this current is .... A.
[27 Aug 2021 Shift 1]

Solution:

Given, equation of alternating current,
$i=\left[\sqrt{42}\sin\left(\frac{2\pi}{T}t\right)+10\right]A$
From given equation, we get
$i=i_1+i_2$
where, $i_1=\sqrt{42}\sin\left(\frac{2\pi}{T}t\right)$ A and $i_2=10A$
Now, i_1 is oscillating current, whereas i_2 is direct current and its value does not change with time.
$(i_1)_{rms}=\frac{\sqrt{42}}{\sqrt{2}}=\sqrt{21}A$
$(i_2)_{rms}=10A$
We know that, ${i_{rms}}^2={(i_1)_{rms}}^2+{(i_2)_{rms}}^2$
Substituting the values, we get
$i_{rms}=\sqrt{(\sqrt{21})^2+10^2}=\sqrt{121}$
$\Rightarrow i_{rms}=11A$
Thus, RMS value of given equation of current is 11 A.

Question93

In the given circuit the AC source has $\omega=100\,rad\,s^{-1}$. Considering the inductor and capacitor to be ideal, what will be the current / flowing through the circuit?



[26 Aug 2021 Shift 2]

Options:

A. 5.9A

B. 4.24A

C. 0.94A

D. None of the above

Answer: D

Solution:

Solution:
Given, angular frequency, $\omega = 100\,\text{rad / s}$
Capacitance of capacitor, $C = 100\mu F = 100 \times 10^{-6} F$
Inductance of inductor coil, L = 0.5 H
Resistance in upper branch, $R_1 = 100\Omega$
Resistance in lower branch, $R_2 = 50\Omega$,
In the given circuit consider current in upper branch be i_1 and current flowing in lower branch be i_2. The net current flowing in circuit will be I.
Impedance of upper branch can be calculated as

$$Z_1 = \sqrt{X_C{}^2 + R_1{}^2} = \sqrt{\left(\frac{1}{\omega C}\right)^2 + R_1{}^2}$$

$$= \sqrt{\left(\frac{1}{100 \times 100 \times 10^{-6}}\right)^2 + 100^2}$$

$$= \sqrt{100^2 + 100^2} = 100\sqrt{2}\Omega$$

Impedance of lower branch can be calculated as

$$Z_2 = \sqrt{X_L{}^2 + R_2{}^2}$$

$$= \sqrt{(\omega L)^2 + R_2{}^2}$$

$$= \sqrt{(100 \times 0.5)^2 + 50^2} = \sqrt{50^2 + 50^2}$$

$$= 50\sqrt{2}\Omega$$

Current flowing in upper branch,

$$i_1 = \frac{V}{Z_1} = \frac{200}{100\sqrt{2}} = \sqrt{2}A$$

Phase of current in upper branch,

$$\cos\phi_1 = \frac{R_1}{Z_1} = \frac{100}{100\sqrt{2}} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \phi_1 = 45°$$

Thus, in upper branch, current leads voltage by 45° as capacitor ispresent.
Current flowing in lower branch i_2 is

$$i_2 = \frac{V}{Z_2} = \frac{200}{50\sqrt{2}} = 2\sqrt{2}A$$

Phase of current in lower branch is

$$\cos\phi_2 = \frac{R_2}{Z_2} = \frac{50}{50\sqrt{2}}$$

$$\Rightarrow \phi_2 = 45°$$

Thus, in lower branch current lags voltage by 45° as inductor ispresent.
Thus, the net current, $I = \sqrt{i_1{}^2 + i_2{}^2}$

$$I = \sqrt{(\sqrt{2})^2 + (2\sqrt{2})^2}$$

$$I = \sqrt{10} = 3.16A$$

Thus, no option in the given question is correct.
If $I = i_1 + i_2$ is taken then $I = \sqrt{2} + 2\sqrt{2} = 4.24A$ is obtained which is incorrect method of solution.

Question94

A series L − C − R circuit driven by 300V at a frequency of 50 Hz contains a resistance R = 3kΩ, an inductor of inductive reactance $X_L = 250\pi\Omega$ and an unknown capacitor. The value of capacitance to maximise the average power should be (Take, $\pi^2 = 10$)
[26 Aug 2021 Shift 1]

Options:

A. 4μF

B. 25μF

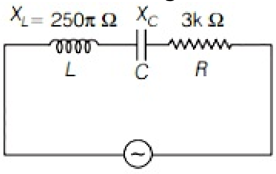
C. 400μF

D. 40μF

Answer: A

Solution:

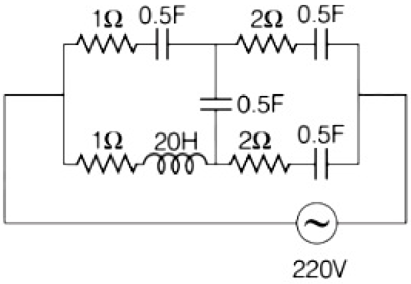
Solution:
The circuit diagram can be drawn as,



Average power of an L-C-R circuit is given by
$P_{av} = V_{rms} i_{rms} \cos\phi$
For P_{av} to be maximum, $\cos\phi = 1$ ...(i)
We know that,
$\cos\phi = \frac{R}{Z}$,
where, R = resistance
and Z = impedance of L-C-R circuit.
Now,
$Z = \sqrt{(X_L - X_C)^2 + R^2}$
As, $\cos\phi = 1 = \frac{R}{Z}$ [using Eq, (i)]
$\Rightarrow R = Z$
$\Rightarrow R = \sqrt{(X_L - X_C)^2 + R^2}$
Squaring both sides, we get
$R^2 = (X_L - X_C)^2 + R^2$
$\Rightarrow (X_L - X_C)^2 = 0$
$\Rightarrow X_L = X_C$
Since, $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$
and $X_L = 250\pi\Omega$ (given)
$\Rightarrow 250\pi = \frac{1}{2\pi \times 50 \times C}$
$\Rightarrow C = \frac{1}{2\pi^2 \times 50 \times 250}$
$\Rightarrow C = 4 \times 10^{-6} F = 4\mu F$

Question95

At very high frequencies, the effective impedance of the given circuit will be ....Ω.



[31 Aug 2021 Shift 2]

Answer: 2

Solution:

Solution:
We know that, at very high frequency capacitive reactance becomes negligible i.e. short circuit (SC) and inductive reactance becomes very large i.e. open circuit (OC).
i.e. $X_C \to 0$ and $X_L \to \infty$.
Now, the circuit can be rearranged as shown in figure.

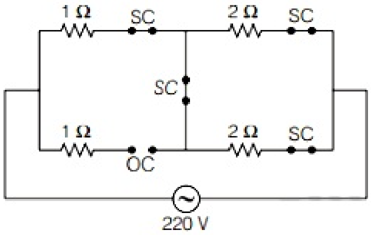


Fig. (i)

Final circuit is

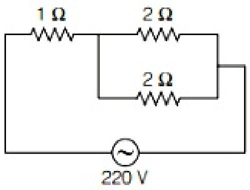
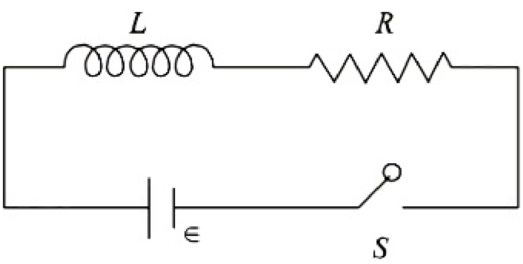


Fig. (ii)

Hence, equivalent resistance,
$R_{eq} = 1 + \frac{2 \times 2}{2 + 2} = 2\Omega$
Thus, correct answer is 2.

Question96



As shown in the figure, a battery of emf ∈ is connected to an inductor L and resistance R in series. The switch is closed at t = 0. The total charge that flows from the battery, between t = 0 and t = t_c(t is the time constant of the circuit) is:
[8 Jan. 2020 II]

Options:

A. $\frac{\in R}{e I^2}$

B. $\frac{\in L}{R^2}\left(1 - \frac{1}{e}\right)$

C. $\frac{\in L}{R^2}$

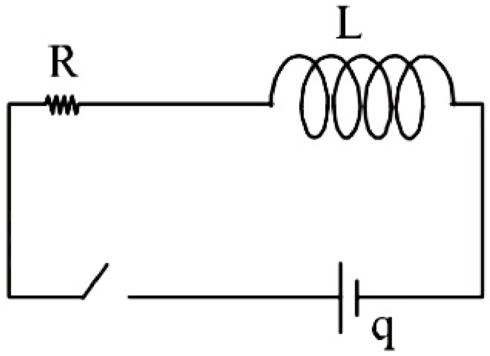
D. $\frac{\in R}{eL^2}$

Answer: A

Solution:

Solution:

For series connection of a resistor and inductor, time variation of current is $I = I_0\left(1 - e^{-t/T_c}\right)$



Here, $T_C = \frac{L}{R}$

$q = \int_0^{T_c} i\,dt$

$\Rightarrow \int dq = \int \frac{E}{R}\left(1 - e^{-t/t_c}\right)dt$

$\Rightarrow q = \frac{\in}{R}\left[t + t_C e^{-t/t_c}\right]_0^{t_c}$

$\Rightarrow q = \frac{\in}{R}\left[t_C + \frac{t_C}{e} - t_C\right]$

$\Rightarrow q = \frac{\in L}{R}\frac{L}{Re}$

$\therefore q = \frac{\in L}{R^2 e}$

Question97

A LCR circuit behaves like a damped harmonic oscillator. Comparing it with a physical spring-mass damped oscillator having damping constant ' b ', the correct equivalence would be:
[7 Jan. 2020 I]

Options:

A. $L \leftrightarrow m$, $C \leftrightarrow k$, $R \leftrightarrow b$

B. $L \leftrightarrow \frac{1}{b}$, $C \leftrightarrow \frac{1}{m}$, $R \leftrightarrow \frac{1}{k}$

C. $L \leftrightarrow k$, $C \leftrightarrow b$, $R \leftrightarrow m$

D. $L \leftrightarrow m$, $C \leftrightarrow \frac{1}{k}$, $R \leftrightarrow b$

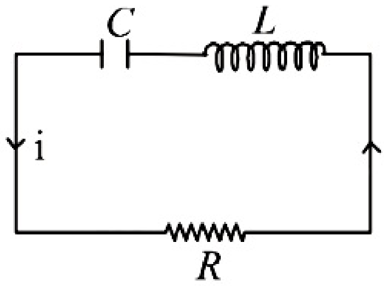
Answer: D

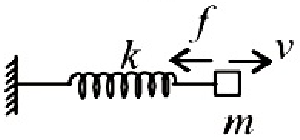
Solution:

In damped harmonic oscillation,

$\frac{md^2x}{dt^2} = -kx - bv$

$\Rightarrow \frac{md^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$ ....(i)





In LCR circuit, $\frac{-q}{C} - iR - \frac{Ldi}{dt} = 0$

$L\frac{d^2}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = 0$ ....(ii)

Comparing equations (i) & (ii)

$L \leftrightarrow m, C \leftrightarrow \frac{1}{k}, R \leftrightarrow b$

Question98

An emf of 20 V is applied at time t = 0 to a circuit containing in series 10 mH inductor and 5 Ω resistor. The ratio of the currents at time t = ∞ and at t = 40 s is close to:
(Take $e^2 = 7.389$)
[7 Jan. 2020 II]

Options:

A. 1.06

B. 1.15

C. 1.46

D. 0.84

Answer: A

Solution:

Solution:
The current (I) in LR series circuit is given by

$I = \frac{V}{R}\left(1 - e^{-\frac{tR}{L}}\right)$

At t = ∞,

$I_{\infty} = \frac{20}{5}\left(I - e^{\frac{-\infty}{L/R}}\right) = 4$ ......(i)

At t = 40s,

$\left(1 - e^{\frac{-40 \times 5}{10 \times 10^{-3}}}\right) = 4(1 - e^{-20,000})$ ....(i)

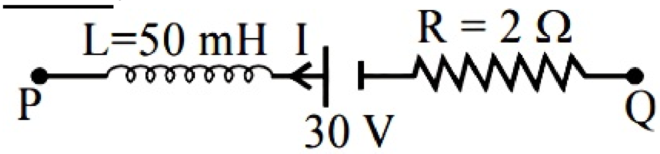
Dividing (i) by (ii) we get

$\Rightarrow \frac{I_{\infty}}{I_{40}} = \frac{1}{1 - e^{-20,000}}$,

---

Question99

A part of a complete circuit is shown in the figure. At some instant, the value of current I is 1 A and it is decreasing at a rate of $10^2 As^{-1}$. The value of the potential difference $V_P - V_Q$, (in volts) at that instant, is ______.



[NA Sep. 06, 2020 (I)]

Answer: 33

Solution:

Solution:

Here, $L = 50mH = 50 \times 10^{-3}H$; $I = 1A$, $R = 2\Omega$

$V_P - L\frac{dI}{dt} - 30 + RI = V_Q$

$\Rightarrow V_P - V_Q = 50 \times 10^{-3} \times 10^2 + 30 - 1 \times 2$

$= 5 + 30 - 2 = 33V$

Question100

An AC circuit has R = 100 Ω, C = 2 μF and L = 80 mH, connected in series. The quality factor of the circuit is :
[Sep. 06, 2020 (I)]

Options:

A. 2

B. 0.5

C. 20

D. 400

Answer: A

Solution:

Quality factor,

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{100}\sqrt{\frac{80 \times 10^{-3}}{2 \times 10^{-6}}}$$

$$= \frac{1}{100}\sqrt{40 \times 10^{3}} = \frac{200}{100} = 2$$

Question101

In a series LR circuit, power of 400 W is dissipated from a source of 250 V, 50 Hz. The power factor of the circuit is 0.8. In order to bring the power factor to unity, a capacitor of value C is added in series to the L and R. Taking the value C as $\left(\frac{n}{3\pi}\right)\mu F$, then value of n is ______.

[NA Sep. 06, 2020 (II)]

Answer: 400

Solution:

Solution:

Given: Power $P = 400W$, Voltage $V = 250V$

$P = V_m . I_{rms} . \cos\phi$

$\Rightarrow 400 = 250 \times I_{rms} \times 0.8 \Rightarrow I_{rms} = 2A$

Using $P = I_{rms}{}^2 R$

$(I_{rms})^2 . R = P \Rightarrow 4 \times R = 400$

$\Rightarrow R = 100\Omega$

Power factor is

$$\cos\phi = \frac{R}{\sqrt{R^2 + X_L{}^2}}$$

$$\Rightarrow 0.8 = \frac{100}{\sqrt{100^2 + X_L{}^2}} \Rightarrow 100^2 + X_L{}^2 = \left(\frac{100}{0.8}\right)^2$$

$$\Rightarrow X_L = \sqrt{-100^2 + \left(\frac{100}{0.8}\right)^2} \Rightarrow X_L = 75\Omega$$

When power factor is unity,

$$X_C = X_L = 75 \Rightarrow \frac{1}{\omega C} = 75$$

$$\Rightarrow C = \frac{1}{75 \times 2\pi \times 50} = \frac{1}{7500\pi}F$$

$$= \left(\frac{10^6}{2500} \times \frac{1}{3\pi}\right)\mu F = \frac{400}{3\pi}\mu F$$

$N = 400$

Question102

A series $L - R$ circuit is connected to a battery of emf V. If the circuit is switched on at $t = 0$, then the time at which the energy stored in the inductor reaches $\left(\frac{1}{n}\right)$ times of its maximum value, is:

[Sep. 04, 2020 (II)]

Options:

A. $\frac{L}{R}\ln\left(\frac{\sqrt{n}}{\sqrt{n}-1}\right)$

B. $\frac{L}{R}\ln\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)$

C. $\frac{L}{R}\ln\left(\frac{\sqrt{n}}{\sqrt{n}+1}\right)$

D. $\frac{L}{R}\ln\left(\frac{\sqrt{n}-1}{\sqrt{n}}\right)$

Answer: A

Solution:

Solution:
Potential energy stored in the inductor
$U = \frac{1}{2}LI^2$
During growth of current,
$i = I_{max}(1 - e^{-Rt/L})$
For U to be $\frac{U_{max}}{n}$; i has to be $\frac{I_{max}}{\sqrt{n}}$
$\therefore \frac{I_{max}}{\sqrt{n}} = I_{max}(1 - e^{-Rt/L})$
$\Rightarrow e^{-Rt/L} = 1 - \frac{1}{\sqrt{n}} = \frac{\sqrt{n}-1}{\sqrt{n}}$
$\Rightarrow -\frac{Rt}{L} = \ln\left(\frac{\sqrt{n}-1}{\sqrt{n}}\right)$
$\Rightarrow t = \frac{L}{R}\ln\left(\frac{\sqrt{n}}{\sqrt{n}-1}\right)$

Question103

A 750 Hz, 20 V (rms) source is connected to a resistance of 100 Ω, an inductance of 0.1803 H and a capacitance of 10 μF all in series. The time in which the resistance (heat capacity 2 J/°C) will get heated by 10°C. (assume no loss of heat to the surroundings) is close to : [Sep. 03, 2020 (I)]

Options:

A. 418 s

B. 245 s

C. 365 s

D. 348 s

Answer: D

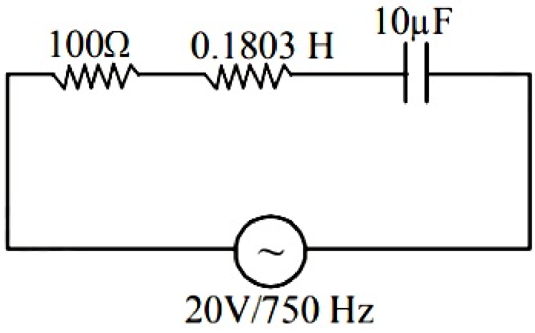
Solution:

Here, $R = 100$, $X_L = L\omega = 0.1803 \times 750 \times 2\pi = 850\Omega$,

$X_C = \frac{1}{C\omega} = \frac{1}{10^{-5} \times 2\pi \times 750} = 21.23\Omega$

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

$= \sqrt{100^2 + (850 - 21.23)^2} = 834.77 \simeq 835$



$H = i_{rms}^2 Rt = \left(\frac{V_{rms}}{|Z|}\right)^2 RT = (ms)\Delta t$

$\Rightarrow \frac{20}{835} \times \frac{20}{835} \times 100t = (2) \times 10$

$\because V_{rms} = 20V$ and $\Delta t = 10°C$

$\therefore$ Time, $t = 348.61s$.

Question104

An inductance coil has a reactance of 100Ω. When an AC signal of frequency 1000Hz is applied to the coil, the applied voltage leads the current by 45°. The self-inductance of the coil is :
[Sep. 02, 2020 (II)]

Options:

A. $1.1 \times 10^{-2}H$

B. $1.1 \times 10^{-1}H$

C. $5.5 \times 10^{-5}H$

D. $6.7 \times 10^{-7}H$

Answer: A

Solution:

Solution:
Given,
Reactance of inductance coil, $Z = 100\Omega$
Frequency of AC signal, $v = 1000Hz$
Phase angle, $\phi = 45°$

$\tan\phi = \frac{X_L}{R} = \tan 45° = 1$

$\Rightarrow X_L = R$

Reactance, $Z = 100 = \sqrt{X_L^2 + R^2}$

$\Rightarrow 100 = \sqrt{R^2 + R^2}$

$\Rightarrow \sqrt{2}R = 100 \Rightarrow R = 50\sqrt{2}$

$\therefore X_L = 50\sqrt{2}$

$\Rightarrow L\omega = 50\sqrt{2}$ $(\because X_L = \omega L)$

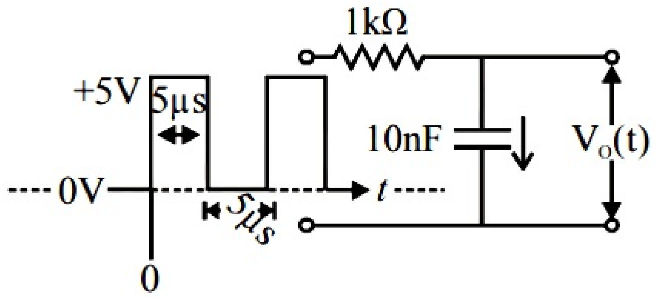
$\Rightarrow L = \frac{50\sqrt{2}}{2\pi \times 1000}$ $(\because \omega = 2\pi v)$

$= \frac{25\sqrt{2}}{\pi} mH$

$= 1.1 \times 10^{-2} H$

Question105

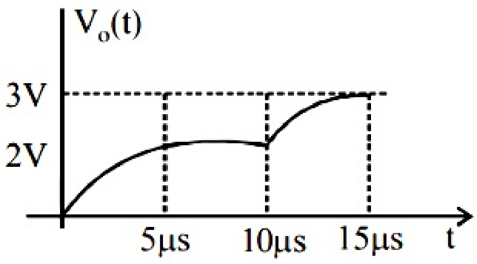
TOPIC 3 - Transformers and LCOscillations
For the given input voltage waveform $V_{in}(t)$, the output voltage waveform $V_0(t)$, across the capacitor is correctly depicted by:



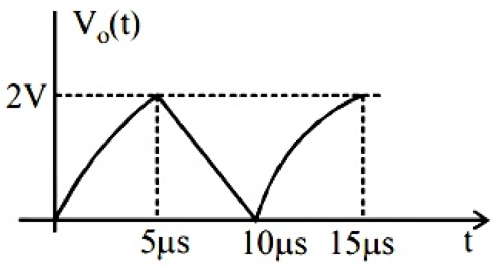
[Sep. 06, 2020 (I)]

Options:

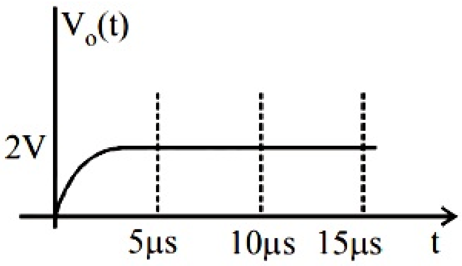
A.



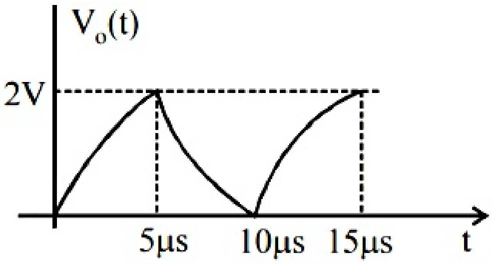
B.



C.



D.



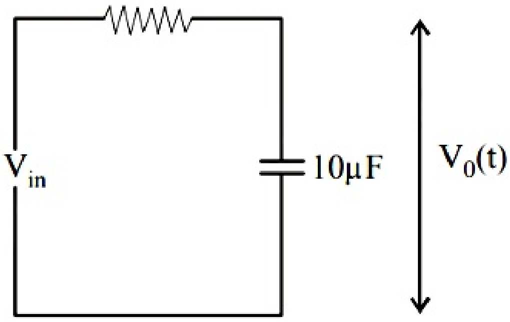
Answer: A

Solution:

Solution:
When first pulse is applied, the potential across capacitor

$V_0(t) = V_{in}\left(1 - e^{\frac{1}{RC}}\right)$

At $t = 5\mu s = 5 \times 10^{-6} s$



$V_0(t) = 5\left(1 - e^{\frac{5 \times 10^{-6}}{10^3 \times 10 \times 10^{-9}}}\right) = 5(1 - e^{-0.5}) = 2V$

When no pulse is applied, capacitor will discharge.
Now, $V_{in} = 0$ means discharging.

$V_0(t) = 2e^{\frac{1}{RC}} = 2e^{-0.5} = 1.21V$

Now for next 5μs

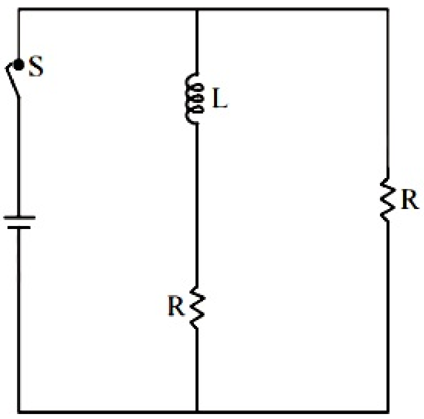
$V_0(t) = 5 - 3.79e^{\frac{1}{RC}}$

After 5μ s again, $V_0(t) = 2.79$ Volt $\approx 3V$

Hence, graph (a) correctly depicts.

Question106

In the figure shown, a circuit contains two identical resistors with resistance R = 5 Ω and an inductance with L = 2 mH. An ideal battery of 15 V is connected in the circuit. What will be the current through the battery long after the switch is closed?



[12 Jan. 2019 I]

Options:

A. 5.5 A

B. 7.5 A

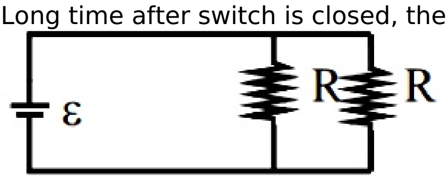
C. 3 A

D. 6 A

Answer: D

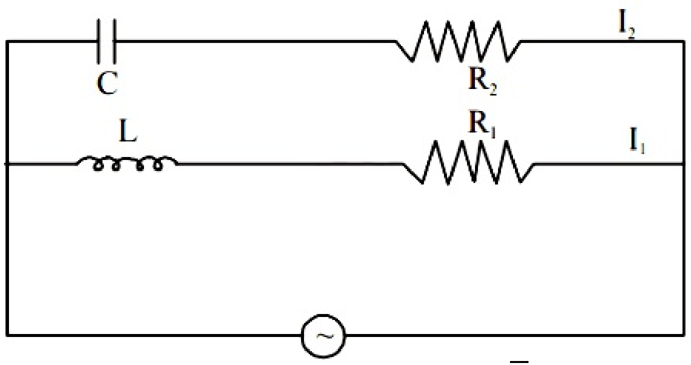
Solution:

Solution:
Long time after switch is closed, the inductor will be idle so, the equivalent diagram will be as below



$$I = \frac{\varepsilon}{\left(\frac{R \times R}{R + R}\right)} = \frac{2\varepsilon}{R} = \frac{2 \times 15}{5} = 6A$$

Question107



In the above circuit, $C = \frac{\sqrt{3}}{2}\mu F$, $R_2 = 20\Omega$, $L = \frac{\sqrt{3}}{10}H$ and$R_1 = 10\Omega$. Current in $L - R_1$ path is I_1 and in $C - R_2$ path it isI_2. The voltage of A. C source is given by, $V = 200\sqrt{2}\sin(100\ t)$ volts. The phase difference between I_1 and I_2 is :
[12 Jan. 2019 II]

Options:

A. 60°

B. 30°

C. 90°

D. 0

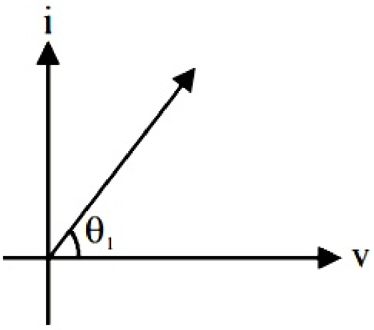
E. (Bonus)

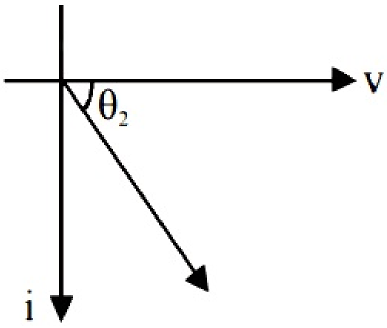
Answer: E

Solution:

Capacitive reactance,

$$X_c = \frac{1}{\omega C} = \frac{4}{10^{-6} \times \sqrt{3} \times 100} = \frac{2 \times 10^4}{\sqrt{3}}$$





$$\tan\theta_1 = \frac{X_C}{R_2} = \frac{10^3}{\sqrt{3}}$$

θ_1 is close to 90°

For L-R circuit

$$X_L = \omega L = 100 \times \frac{\sqrt{3}}{10} = 10\sqrt{3}$$

$R_1 = 10$

$$\tan\theta_2 = \frac{X_L}{R_1}$$

$\tan\theta_2 = \sqrt{3} \Rightarrow \theta_2 = \tan^{-1}(\sqrt{3})$

$\theta_2 = 60°$

So, phase difference comes out $90° + 60° = 150°$

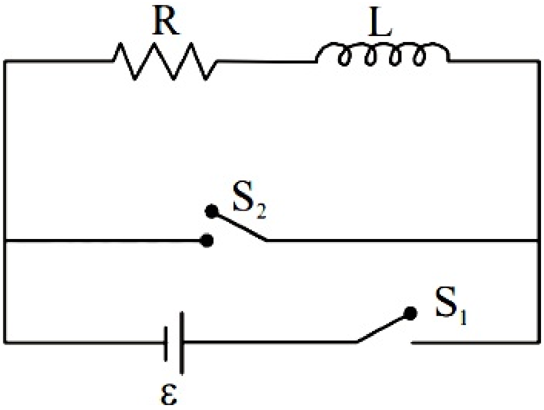
If R_2 is $20K\,\Omega$

then phase difference comes out to be $60 + 30 = 90°$.

Therefore Ans. is **Bonus**

Question108

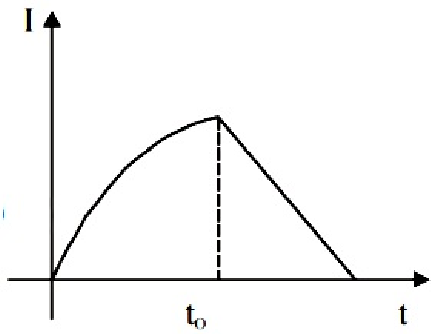
In the circuit shown,



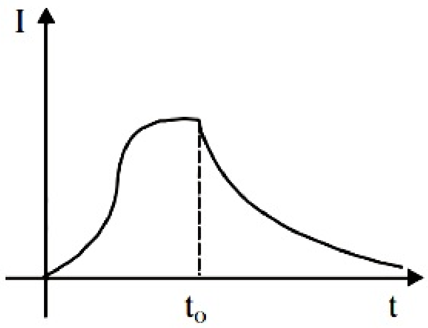
the switch S_1 is closed at time t = 0 and the switch S_2 is kept open. At some later time (t_0), the switch S_1 is opened and S_2 is closed. the behaviour of the current I as a function of time 't' is given by:
[11 Jan. 2019 II]

Options:

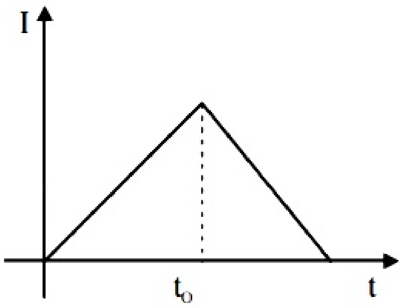
A.



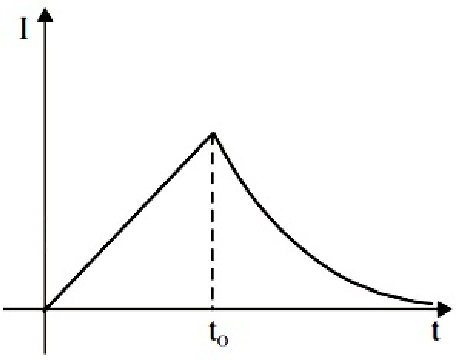
B.



C.

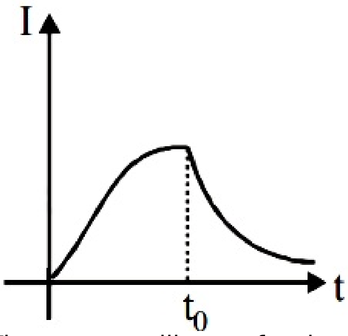


D.



Answer: B

Solution:



The current will grow for the time $t = 0$ to $t = t_0$ and after that decay of current takes place.

Question109

A series AC circuit containing an inductor (20mH), a capacitor (120μF) and a resistor (60Ω) is driven by an AC source of 24V / 50Hz. The energy dissipated in the circuit in 60 s is:
[9 Jan. 2019 I]

Options:

A. $5.65 \times 10^2 J$

B. $2.26 \times 10^3 J$

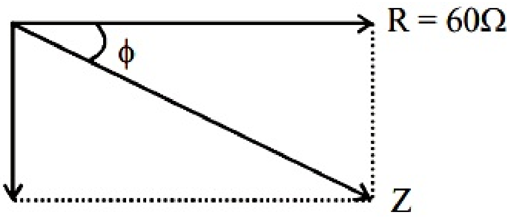
C. $5.17 \times 10^2 J$

D. $3.39 \times 10^3 J$

Answer: C

Solution:

Solution:
Given: $R = 60\Omega$, $f = 50Hz$, $\omega = 2\pi f = 100\pi$ and $v = 24v$
$C = 120\mu f = 120 \times 10^{-6} f$
$x_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 120 \times 10^{-6}} = 26.52\Omega$
$x_L = \omega L = 100\pi \times 20 \times 10^{-3} = 2\pi\Omega$
$x_C - x_L = 20.24 \approx 20$



$z = \sqrt{R^2 + (x_C - x_L)^2}$
$z = 20\sqrt{10}\Omega$
$\cos\phi = \frac{R}{z} = \frac{60}{20\sqrt{10}} = \frac{3}{\sqrt{10}}$
$P_{avg} = VI\cos\phi$, $I = \frac{v}{z} = \frac{v^2}{z}\cos\phi = 8.64$ watt
Energy dissipated (Q) in time $t = 60s$ is $Q = P.t = 8.64 \times 60 = 5.17 \times 10^2 J$

Question110

In LC circuit the inductance $L = 40$ mH and capacitance $C = 100\mu F$. If a voltage $V(t) = 10\sin(314t)$ is applied to the circuit, the current in the circuit is given as:
[9 Jan. 2019 II]

Options:

A. 0.52 cos 314 t

B. 10 cos 314 t

C. 5.2 cos 314 t

D. 0.52 sin 314 t

Answer: A

Solution:

Solution:
Given, Inductance, $L = 40 mH$
Capacitance, $C = 100 \mu F$
Impedance, $Z = X_C - X_L$
$\Rightarrow Z = \frac{1}{\omega C} - \omega L \left(\because X_c = \frac{1}{\omega C} \text{ and } X_L = \omega L \right)$
$= \frac{1}{314 \times 100 \times 10^{-6}} - 314 \times 40 \times 10^{-3}$
$= 19.28 \Omega$
Current, $i = \frac{V_0}{Z} \sin(\omega t + \pi / 2)$
$\Rightarrow i = \frac{10}{19.28} \cos \omega t = 0.52 \cos(314t)$

Question111

A power transmission line feeds input power at 2300 Vto 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 5A and its efficiency is 90%, the output current would be:
[9 Jan. 2019 II]

Options:

A. 50 A

B. 45 A

C. 35 A

D. 25 A

Answer: B

Solution:

Efficiency, $\eta = \frac{P_{out}}{P_{in}} = \frac{V_s I_s}{V_p I_p}$

$\Rightarrow 0.9 = \frac{230 \times I_s}{2300 \times 5}$

$\Rightarrow I_s = 0.9 \times 50 = 45A$

Output current $= 45A$

Question112

An alternating voltage v(t) = 220 sin 100Ât volt is applied to a purely resistive load of 50Ω. The time taken for the current to rise from half of the peak value to the peak value is :
[8 April 2019 I]

Options:

A. 5 ms

B. 2.2 ms

C. 7.2 ms

D. 3.3 ms

Answer: D

Solution:

Solution:

As $V(t) = 220 \sin 100\pi t$

so, $I(t) = \frac{220}{50} \sin 100\pi t$

i.e., $I = I_m = \sin(100\pi t)$

For $I = I_m$

$t_1 = \frac{\pi}{2} \times \frac{1}{100\pi} = \frac{1}{200}$ sec.

and for $I = \frac{I_m}{2}$

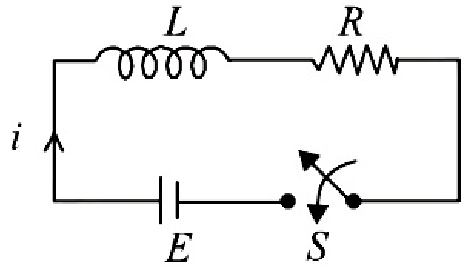
$\Rightarrow \frac{I_m}{2} = I_m \sin(100\pi t_2) \Rightarrow \frac{\pi}{6} = 100\pi t_2$

$\Rightarrow t_2 = \frac{1}{600} s$

$\therefore t_{req} = \frac{1}{200} - \frac{1}{600} = \frac{2}{600} = \frac{1}{300} s = 3.3ms$

Question113

Consider the LR circuit shown in the figure. If the switch S is closed at t = 0 then the amount of charge that passes through the battery between t = 0 and t = $\frac{L}{R}$ is :



[12 April 2019 II]

Options:

A. $\frac{2.7EL}{R^2}$

B. $\frac{EL}{2.7R^2}$

C. $\frac{7.3EL}{R^2}$

D. $\frac{EL}{7.3R^2}$

Answer: B

Solution:

Solution:

We have, $i = i_0(1 - e^{-t/c}) = \frac{\varepsilon}{R}(1 - e^{-t/c})$

Charge, $q = \int_0^{\tau} i\, dt$

$= \frac{\varepsilon}{R}\int_0^{\tau}(1 - e^{-t/\tau})dt = \frac{E\tau}{Re} = \frac{E}{R} \times \frac{(L/R)}{e} = \frac{EL}{2.7R^2}$

Question114

A coil of self inductance 10 mH and resistance 0.1 Ω is connected through a switch to a battery of internal resistance 0.9 Ω. After the switch is closed, the time taken for the current to attain 80% of the saturation value is[take ln 5 = 1.6]
[10 April 2019 II]

Options:

A. 0.324 s

B. 0.103 s

C. 0.002 s

D. 0.016 s

Answer: D

Solution:

$I = I_0\left(1 - e^{-\frac{Rt}{L}}\right)$ Here $R = R_L + r = 1\Omega$

$0.8I_0 = I_0\left(1 - e^{-\frac{t}{01}}\right)$

$\Rightarrow 0.8 = 1 - e^{-100t}$

$\Rightarrow e^{-100t} = 0.2 = \left(\frac{1}{5}\right)$

$\Rightarrow 100t = \ln 5 \Rightarrow t = \frac{1}{100}\ln 5 = 0.016s$

Question115

A 20 Henry inductor coil is connected to a 10 ohm resistance in series as shown in figure. The time at which rate of dissipation of energy (Joule's heat) across resistance is equal to the rate at which magnetic energy is stored in the inductor, is :
[8 April 2019 I]

Options:

A. $\frac{2}{\ln 2}$

B. $\frac{1}{2}\ln 2$

C. $2\ln 2$

D. $\ln 2$

Answer: C

Solution:

Solution:

$i^2R = \left(\tau\frac{di}{dt}\right)i$

$\Rightarrow \frac{di}{dt} = \frac{i}{\tau}$

$\Rightarrow t = \tau\ln 2 = 2\ln 2 \left[\text{as } \tau = \frac{L}{R} = \frac{20}{10} = 2\right]$

Question116

A circuit connected to an ac source of emf $e = e_0\sin(100t)$ with t in seconds, gives a phase difference of $\frac{\pi}{4}$ between the emf e and current i. Which of the following circuits will exhibit this?
[8 April 2019 II]

Options:

A. RL circuit with R = 1 kΩ and L = 10 μH

B. RL circuit with R = 1 kΩ and L = 1 μH

C. RC circuit with R = 1 kΩ and C = 1 μF

D. RC circuit with R = 1 kΩ and C = 10 μF.

Answer: D

Solution:

Solution:
$\omega = 100 \text{ rad / s}$
We know that
$\tan \pi = \frac{X_C}{R} = \frac{1}{\omega CR}$
or $\tan 45^\circ = \frac{1}{\omega CR}$
or $\omega CR = 1$
$\text{LHS} : \omega CR = 10 \times 10 \times 10^{-6} \times 10^3 = 1$

Question117

A transformer consisting of 300 turns in the primary and 150 turns in the secondary gives output power of 2.2kW. If the current in the secondary coil is 10 A, then the input voltage and current in the primary coil are : [10 April 2019 I]

Options:

A. 220 V and 20 A

B. 440 V and 20 A

C. 440 V and 5 A

D. 220 V and 10 A

Answer: C

Solution:

Solution:
Power output $(V_2 I_2) = 2.2\text{kW}$
$\therefore V_2 = \frac{2.2\text{kW}}{(10\text{A})} = 220 \text{ volts}$
∴ Input voltage for step-down transformer
$\frac{V_1}{V_2} = \frac{N_1}{N_2} = 2$
$V_{\text{input}} = 2 \times V_{\text{output}} = 2 \times 220$
$= 440\text{V}$
Also $\frac{I_1}{I_2} = \frac{N_2}{N_1}$
$\therefore \text{quad} I_1 = \frac{1}{2} \times 10 = 5\text{A}$

Question118

In an a.c. circuit, the instantaneous e.m.f. and current are given by
$e = 100 \sin 30t$
$i = 20 \sin\left(30t - \frac{\pi}{4}\right)$
In one cycle of a.c., the average power consumed by the circuit and the wattless current are, respectively:
[2018]

Options:

A. 50W , 10A

B. $\frac{1000}{\sqrt{2}}$W , 10A

C. $\frac{50}{\sqrt{2}}$W , 0

D. 50W , 0

Answer: B

Solution:

Solution:
As we know, average power $P_{avg} = V_{rms} I_{rms} \cos\theta$

$= \left(\frac{V_0}{\sqrt{2}}\right)\left(\frac{I_0}{\sqrt{2}}\right)\cos\theta = \left(\frac{100}{\sqrt{2}}\right)\left(\frac{20}{\sqrt{2}}\right)\cos 45°(\because \theta = 45°)$

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

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

$= \frac{I_0}{\sqrt{2}}\sin\theta = \frac{20}{\sqrt{2}}\sin 45° = 10A$

Question119

For an RLC circuit driven with voltage of amplitude v_m and frequency $\omega_0 = \frac{1}{\sqrt{LC}}$ the current exhibits resonance. The quality factor, Q is given by:
[2018]

Options:

A. $\frac{\omega_0 L}{R}$

B. $\frac{\omega_0 R}{L}$

C. $\frac{R}{(\omega_0 C)}$

D. $\frac{CR}{\omega_0}$

Answer: A

Solution:

Solution:
Quality factor $Q = \frac{\omega_0}{2\Delta\omega} = \frac{\omega_0 L}{R}$

Question120

A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns, giving the output power at 230 V. If the current in the primary of the transformer is 5 A, and its efficiency is 90%, the output current would be:
[Online April 16, 2018]

Options:

A. 20 A

B. 40 A

C. 45 A

D. 25 A

Answer: C

Solution:

Solution:
Given : $V_P = 2300V$, $V_s = 230V$, $I_p = 5A$, $n = 90\% = 0.9$

Efficiency $n = 0.9 = \frac{P_s}{P_P} \Rightarrow P_s = 0.9P_p$

$V_s I_s = 0.9 \times V_P I_P$ ($\because P = VI$)

$I_s = \frac{0.9 \times 2300 \times 5}{230} = 45A$

Question121

A small circular loop of wire of radius a is located at the centre of a much larger circular wire loop of radius b. The two loops are in the same plane. The outer loop of radius b carries an alternating current $I = I_0 \cos(\omega t)$. The emf induced in the smaller inner loop is nearly:
[Online April 8, 2017]

Options:

A. $\frac{\pi\mu_0 I_0}{2} . \frac{a^2}{b} \omega \sin(\omega t)$

B. $\frac{\pi\mu_0 I_0}{2} \cdot \frac{a^2}{b}\omega\cos(\omega t)$

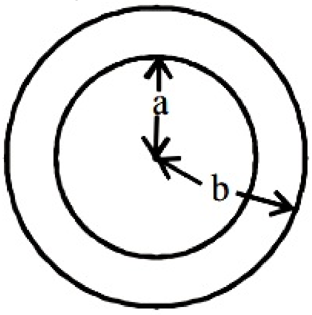
C. $\pi\mu_0 I_0 \frac{a^2}{b}\omega\sin(\omega t)$

D. $\frac{\pi\mu_0 I_0 b^2}{a}\omega\cos(\omega t)$

Answer: A

Solution:

Solution:
For two concentric circular coil,
Mutual Inductance $M = \frac{\mu_0 \pi N_1 N_2 a^2}{2b}$
here, $N_1 = N_2 = 1$
Hence, $M = \frac{\mu_0 \pi a^2}{2b}$ ..... (i)
and given $I = I_0 \cos\omega t$ ..... (ii)
Now according to Faraday's second law induced emf
$e = -M\frac{dI}{dt}$
From eq. (ii),



$e = \frac{-\mu_0 \pi a^2}{2b}\frac{d}{dt}(I_0 \cos\omega t)$
$e = \frac{\mu_0 \pi a^2}{2b} I_0 \sin\omega t(\omega)$
$e = \frac{\pi\mu_0 I_0}{2} \cdot \frac{a^2}{b}\omega\sin\omega t$

Question122

A sinusoidal voltage of peak value 283V and angular frequency 320 / s is applied to a series LCR circuit. Given that R = 5Ω, L = 25mH and C = 1000μF. The total impedance, and phase difference between the voltage across the source and the current will respectively be : [Online April 9, 2017]

Options:

A. 10Ω and $\tan^{-1}\left(\frac{5}{3}\right)$

B. 7Ω and $45°$

C. 10Ω and $\tan^{-1}\left(\frac{8}{3}\right)$

D. 7Ω and $\tan^{-1}\left(\frac{5}{3}\right)$

Answer: B

Solution:

Solution:
Given,
$V_0 = 283$ volt, $\omega = 320$, $R = 5\Omega$, $L = 25mH$, $C = 1000\mu F$
$x_L = \omega L = 320 \times 25 \times 10^{-3} = 8\Omega$
$x_C = \frac{1}{\omega C} = \frac{1}{320 \times 1000 \times 10^{-6}} = 3.1\Omega$
Total impedance of the circuit:
$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{25 + (4.9)^2} = 7\Omega$
Phase difference between the voltage and current
$\tan\phi = \frac{X_L - X_C}{R}$
$\tan\phi = \frac{4.9}{5} \approx 1 \Rightarrow \phi = 45°$

Question123

An arc lamp requires a direct current of 10 A at 80 V to function. If it is connected to a 220 V (rms), 50 Hz AC supply, the series inductor needed for it to work is close to :
[2016]

Options:

A. 0.044 H

B. 0.065 H

C. 80 H

D. 0.08 H

Answer: B

Solution:

Solution:
Here
$i = \frac{e}{\sqrt{R^2 + X_L^2}} = \frac{e}{\sqrt{R^2 + \omega^2 L^2}} = \frac{e}{\sqrt{R^2 + 4\pi^2 v^2 L^2}}$
$10 = \frac{220}{\sqrt{64 + 4\pi^2 (50)^2 L}}$
$\left[\because R = \frac{V}{I} = \frac{80}{10} = 8\right]$
On solving we get
$L = 0.065H$

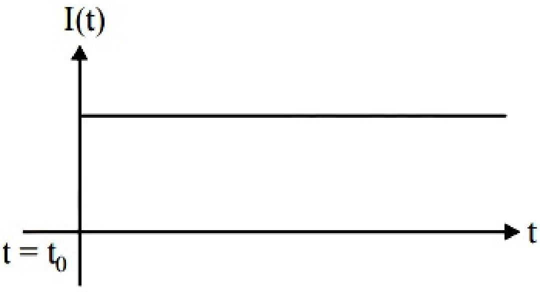
Question124

A series LR circuit is connected to a voltage source with $V(t) = V_0 \sin \omega t$. After very large time, current $I(t)$ behaves as $\left(t_0 >> \frac{L}{R}\right)$:

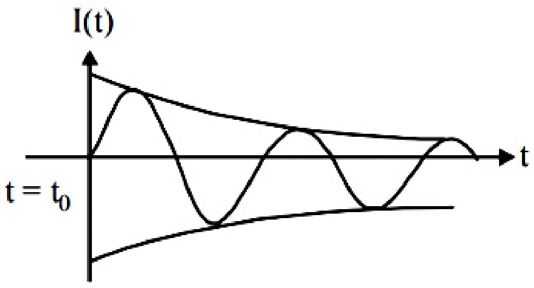
[Online April 9, 2016]

Options:

A.

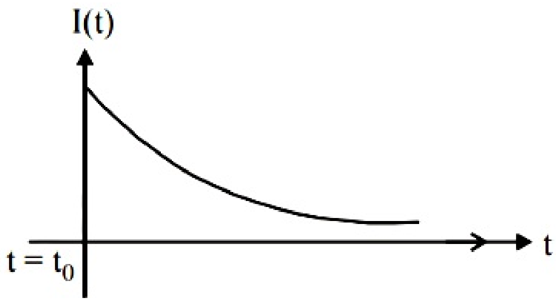


B.

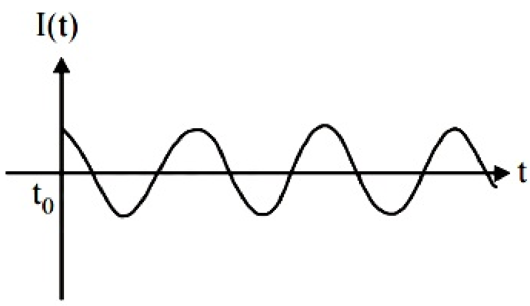


I(t)

C.



D.

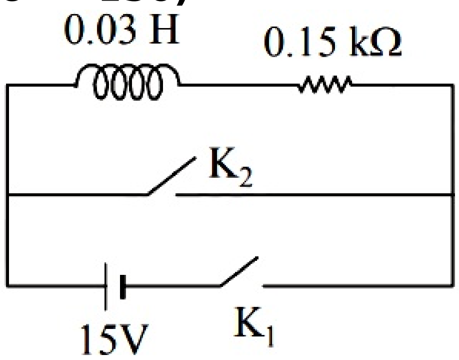


Answer: D

Solution:

Question125

An inductor ($L = 0.03H$) and a resistor ($R = 0.15k\Omega$) are connected in series to a battery of 15V emf in a circuit shown below. The key K_1 has been kept closed for a long time. Then at t = 0, K_1 is opened and key K_2 is closed simultaneously. At t = 1ms, the current in the circuit will be: ($e^5 \cong 150$)



[2015]

Options:

A. 6.7 mA

B. 0.67 mA

C. 100 mA

D. 67 mA

Answer: B

Solution:

Solution:

$I(0) = \frac{15 \times 100}{0.15 \times 10^3} = 0.1A$

$I(\infty) = 0$

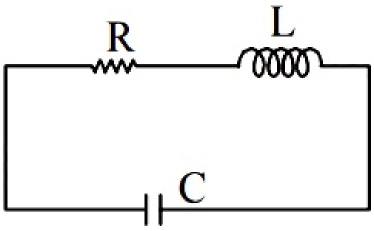
$I(t) = [I(0) - I(\infty)]e^{\frac{-t}{L/R}} + i(\infty)$

$I(t) = 0.1e^{\frac{-t}{L/R}} = 0.1e^{\frac{R}{L}}$

$I(t) = 0.1e^{\frac{0.15 \times 1000}{0.03}} = 0.67mA$

Question126

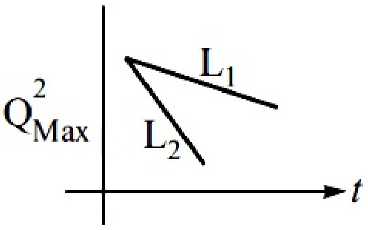
An LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below :



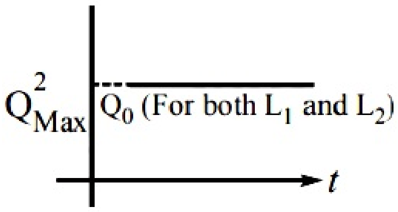
If a student plots graphs of the square of maximum charge (Q_{Max}^2) on the capacitor with time(t) for two different values L_1 and L_2($L_1 > L_2$) of L then which of the following represents this graph correctly? (plots are schematic and not drawn to scale)
[2015]

Options:

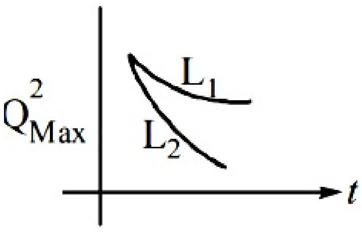
A.



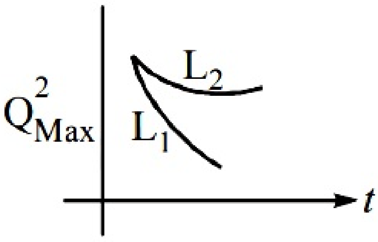
B.



C.



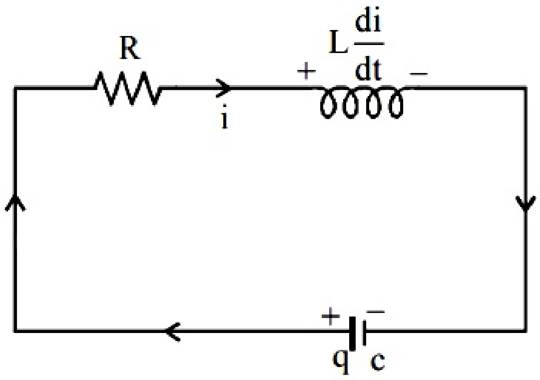
D.



Answer: C

Solution:

Solution:
From KVL at any time t



$\frac{q}{c} - iR - L\frac{di}{dt} = 0$

$i = -\frac{dq}{dt} \Rightarrow \frac{q}{c} + \frac{dq}{dt}R + \frac{Ld^2q}{dt^2} = 0$

$\frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{Lc} = 0$

From damped harmonic oscillator, the amplitude is given by $A = A_o e - \frac{dt}{2m}$

Double differential equation

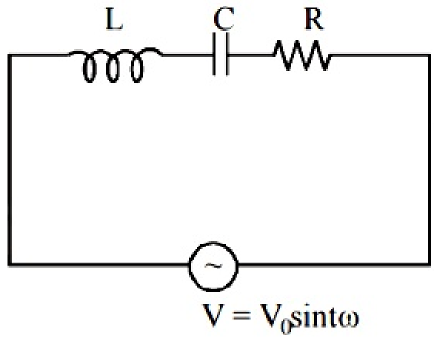
$\frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \frac{k}{m}x = 0$

$Q_{max} = Q_o e^{-\frac{Rt}{2L}} \Rightarrow Q_{max}{}^2 = Q_o{}^2 e^{-\frac{Rt}{L}}$

Hence damping will be faster for lesser self inductance.

Question127

For the LCR circuit, shown here, the current is observed to lead the applied voltage. An additional capacitor C', when joined with the capacitor C present in the circuit, makes the power factor of the circuit unity. The capacitor C', must have been connected in :



[Online April 11, 2015]

Options:

A. series with C and has a magnitude $\frac{C}{(\omega^2 LC - 1)}$

B. series with C and has a magnitude $\frac{1 - \omega^2 LC}{\omega^2 L}$

C. parallel with C and has a magnitude $\frac{1 - \omega^2 LC}{\omega^2 L}$

D. parallel with C and has a magnitude $\frac{C}{(\omega^2 LC - 1)}$

Answer: C

Solution:

Solution:
Power factor

$$\cos\phi = \frac{R}{\sqrt{R^2 + \left[\omega L - \frac{1}{\omega(C + C')}\right]^2}} = 1$$

On solving we get,

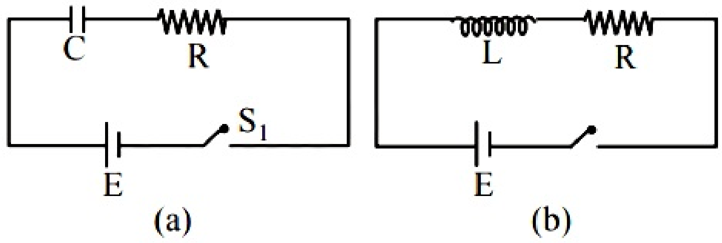
$$\omega L = \frac{1}{\omega(C + C')}$$

$$C' = \frac{1 - \omega^2 LC}{\omega^2 L}$$

Hence option (c) is the correct answer.

Question128

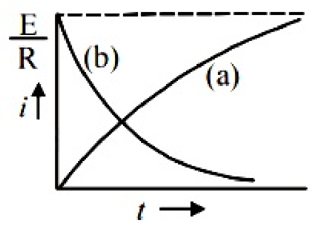
In the circuits (a) and (b) switches S_1 and S_2 are closed at $t = 0$ and are kept closed for a long time. The variation of current in the two circuits for t geq 0 are roughly shown by figure (figures are schematic and not drawn to scale):



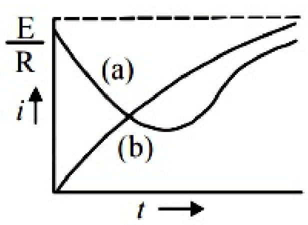
[Online April 10, 2015]

Options:

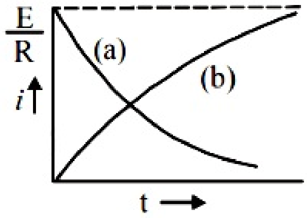
A.



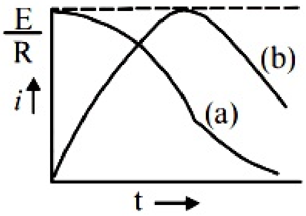
B.



C.



D.



Answer: C

Solution:

Solution:
For capacitor circuit, $i = i_0 e^{-t/RC}$

For inductor circuit, $i = i_0\left(1 - e^{-\frac{Rt}{L}}\right)$
Hence graph (c) correctly depicts i versus t graph.

Question129

A sinusoidal voltage V(t) = 100 sin (500t) is applied across a pure inductance of L = 0.02 H. The current through the coil is: [Online April 12, 2014]

Options:

A. 10 cos (500 t)

B. – 10 cos (500t)

C. 10 sin (500t)

D. – 10 sin (500t)

Answer: B

Solution:

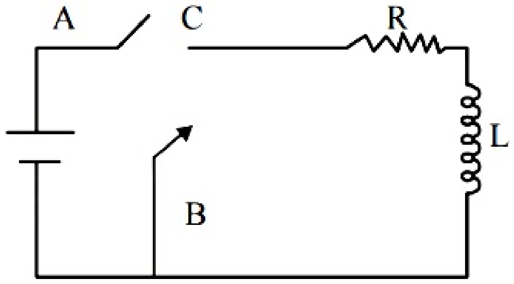
Solution:
In a pure inductive circuit current always lags behind the emf by $\frac{\pi}{2}$.

If $v(t) = v_0 \sin \omega t$
then $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$
Now, given $v(t) = 100 \sin(500t)$
and $I_0 = \frac{E_0}{\omega L} = \frac{100}{500 \times 0.02}$ $[\because L = 0.02H]$

$I_0 = 10\sin\left(500t - \frac{\pi}{2}\right)$
$I_0 = -10\cos(500t)$

Question130

In the circuit shown here, the point 'C' is kept connected to point 'A' till the current flowing through the circuit becomes constant. Afterward, suddenly, point 'C' is disconnected from point 'A' and connected to point 'B' at time t = 0. Ratio of the voltage across resistance and the inductor at t = L/R will be equal to:



[2014]

Options:

A. $\frac{e}{1-e}$

B. 1

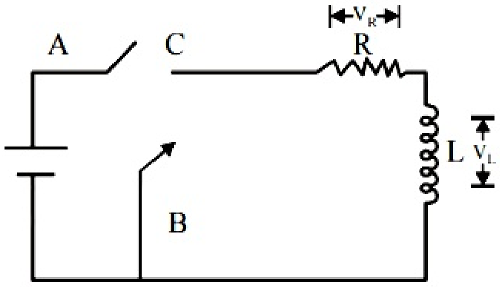
C. -1

D. $\frac{1-e}{e}$

Answer: C

Solution:

Solution:
Applying Kirchhoff's law of voltage in closed loop
$-V_R - V_C = 0 \Rightarrow \frac{V_R}{V_C} = -1$



Question131

When the rms voltages V_L, V_C and V_R are measured respectively across

the inductor L, the capacitor C and the resistor R in a series LCR circuit connected to an AC source,it is found that the ratio $V_L : V_C : V_R = 1 : 2 : 3$. If the rms voltage of the AC sources is 100V , the V_R is close to:

[Online April 9, 2014]

Options:

A. 50 V

B. 70 V

C. 90 V

D. 100 V

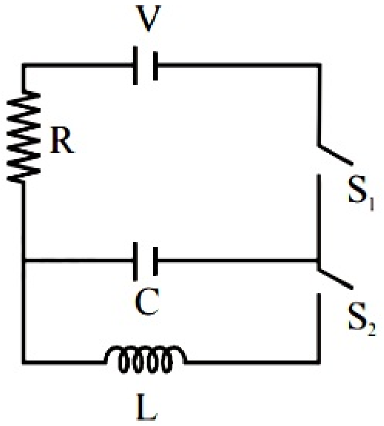
Answer: C

Solution:

Solution:
Given, $V_L : V_C : V_R = 1 : 2 : 3$
$V = 100V$
$V_R = ?$
As we know,
$V = \sqrt{V_R^2 + (V_L - V_C)^2}$
Solving we get, $V_R \simeq 90V$

Question132

In an LCR circuit as shown below both switches are open initially. Now switch S_1 is closed, S_2 kept open. (q is charge on the capacitor and $\tau = RC$ is Capacitive time constant). Which of the following statement is correct?



[2013]

Options:

A. Work done by the battery is half of the energy dissipated in the resistor

B. At, $t = \tau$, $q = CV / 2$

C. At, $t = 2\tau$, $q = CV(1 - e^{-2})$

D. At, $t = 2\tau$, $q = CV(1 - e^{-1})$

Answer: C

Solution:

(apacitor at any time t is given by
$q = CV(1 - e^{t/\tau})$
at $t = 2\tau$
$q = CV(1 - e^{-2})$

Question133

A series LR circuit is connected to an ac source of frequency ω and the inductive reactance is equal to 2R. A capacitance of capacitive reactance equal to R is added in series with L and R. The ratio of the new power factor to the old one is:
[Online April 25, 2013]

Options:

A. $\sqrt{\frac{2}{3}}$

B. $\sqrt{\frac{2}{5}}$

C. $\sqrt{\frac{3}{2}}$

D. $\sqrt{\frac{5}{2}}$

Answer: D

Solution:

Solution:

Power factor$_{(old)}$ $= \frac{R}{\sqrt{R^2 + X_L^{\ 2}}} = \frac{R}{\sqrt{R^2 + (2R)^2}} = \frac{R}{\sqrt{5}R}$

Power factor $_{(new}$ $= \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{R}{\sqrt{R^2 + (2R - R)^2}} = \frac{R}{\sqrt{2}R}$

$\therefore \frac{\text{New power factor}}{\text{Old power factor}} = \frac{\frac{R}{\sqrt{2}R}}{\frac{R}{\sqrt{5}R}} = \sqrt{\frac{5}{2}}$

Question134

When resonance is produced in a series LCR circuit, then which of the

following is not correct ?
[Online April 25, 2013]

Options:

A. Current in the circuit is in phase with the applied voltage.

B. Inductive and capacitive reactances are equal.

C. If R is reduced, the voltage across capacitor will increase.

D. Impedance of the circuit is maximum.

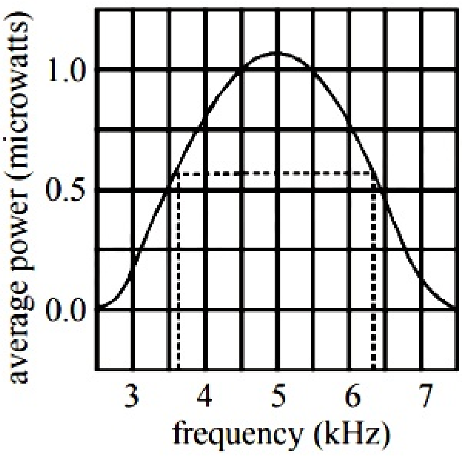
Answer: D

Solution:

Impedance (Z) of the series LCR circuit is
, $^{2} + (X_L - X_C)^2$
At resonance, $X_L = X_C$
Therefore, $Z_{minimum} = R$

Question135

The plot given below is of the average power delivered to an LRC circuit versus frequency. The quality factor of the circuit is :



[Online April 23, 2013]

Options:

A. 5.0

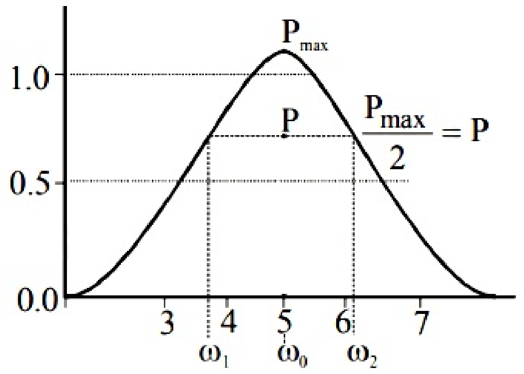
B. 2.0

C. 2.5

D. 0.4

Answer: B

Solution:



Quality factor of the circuit $= \frac{\omega_0}{\omega_2 - \omega_1} = \frac{5}{2.5} = 2.0$

Question136

In a series L – C -R circuit, C = 10^{-11} Farad, L = 10^{-5} Henry and R = 100Ohm, when a constant D.C. voltage E is applied to the circuit, the capacitor acquires a charge 10^{-9}C. The D. C. source is replaced by a sinusoidal voltage source in which the peak voltage E_0 is equal to the constant D.C. voltage E . At resonance the peak value of the charge acquired by the capacitor will be :
[Online April 22, 2013]

Options:

A. 10^{-15}C

B. 10^{-6}C

C. 10^{-10}C

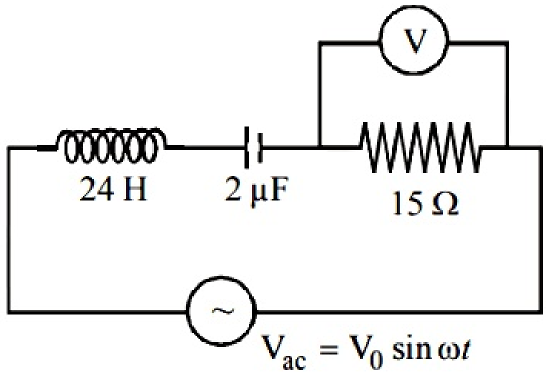
D. 10^{-8}C

Answer: D

Solution:

Question137

An LCR circuit as shown in the figure is connected to a voltage source V_{ac} whose frequency can be varied.



The frequency, at which the voltage across the resistor is maximum, is : [Online April 22, 2013]

Options:

A. 902 Hz

B. 143 Hz

C. 23 Hz

D. 345 Hz

Answer: C

Solution:

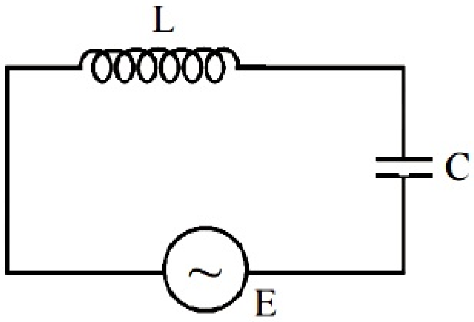
Solution:

Frequency $f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2 \times 3.4\sqrt{24 \times 2 \times 10^{-6}}}$

$\simeq 23 Hz$

Question138

In the circuit shown here, the voltage across E and C are respectively 300 V and 400 V. The voltage E of the ac source is :



[Online April 9, 2013]

Options:

A. 400 Volt

B. 500 Volt

C. 100 Volt

D. 700 Volt

Answer: C

Solution:

Solution:
Voltage E of the ac source $E = V_c - V_L = 400V - 300V = 100V$

Question139

A resistance R and a capacitance C are connected in series to a battery of negligible internal resistance through a key. The key is closed at t = 0. If after t sec the voltage across the capacitance was seven times the voltage across R, the value of t is
[Online May 12, 2012]

Options:

A. 3 RC ln 2

B. 2 RC ln 2

C. 2 RC ln 7

D. 3 RC ln 7

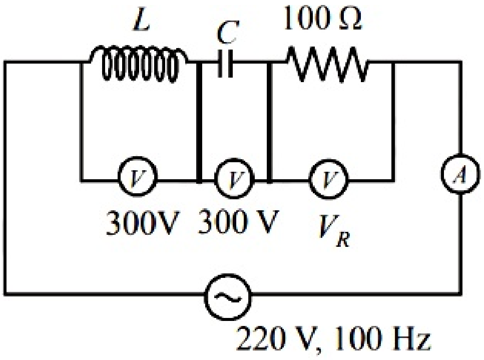
Answer: A

Solution:

Solution:
$t = 3RC \ln 2$

Question140

In an LCR circuit shown in the following figure, what will be the readings of the voltmeter across the resistor and ammeter if an a.c. source of 220V and 100 Hz is connected to it as shown?



[Online May 7, 2012]

Options:

A. 800 V, 8 A

B. 110 V, 1.1 A

C. 300 V, 3 A

D. 220V, 2.2 A

Answer: D

Solution:

Solution:
In case of series RLC circuit,
Equation of voltage is given by
$V^2 = V_R^2 + (V_L - V_C)^2$
Here, $V = 220V$; $V_L = V_C = 300V$
$\therefore V_R = \sqrt{V^2} = 220V$
Current $i = \frac{V}{R} = \frac{220}{100} = 2.2A$

Question141

A fully charged capacitor C with initial charge q_0 is connected to a coil of self inductance L at t = 0. The time at which the energy is stored equally between the electric and the magnetic fields is:
[2011]

Options:

A. $\frac{\pi}{4}\sqrt{LC}$

B. $2\pi\sqrt{LC}$

C. $\sqrt{LC}$

D. $\pi\sqrt{LC}$

Answer: A

Solution:

Solution:
Energystored in magnetic field $= \frac{1}{2}Li^2$

Energy stored in electric field $= \frac{1}{2}\frac{q^2}{C}$

Energy will be equal when
$\therefore \frac{1}{2}Li^2 = \frac{1}{2}\frac{q^2}{C}$
$\tan \omega t = 1$
$q = q_0 \cos \omega t$
$\Rightarrow \frac{1}{2}L(\omega q_0 \sin \omega t)^2 = \frac{(q_0 \cos \omega t)^2}{2C}$
$\Rightarrow \omega = \frac{1}{\sqrt{LC}} \Rightarrow \omega t = \frac{\pi}{4}$

$\Rightarrow t = \frac{\Pi}{4}\sqrt{LC}$

Question142

A resistor ' R ' and 2μF capacitor in series is connected through a switch to 200V direct supply. Across the capacitor is a neon bulb that lights up at 120V. Calculate the value of R to make the bulb light up 5 s after the switch has been closed. ($\log_{10}2.5 = 0.4$)
[2011]

Options:

A. $1.7 \times 10^5\Omega$

B. $2.7 \times 10^6\Omega$

C. $3.3 \times 10^7\Omega$

D. $1.3 \times 10^4\Omega$

Answer: B

Solution:

Solution:
We have, $V = V_0(1 - e^{-t/RC})$
$\Rightarrow 120 = 200(1 - e^{-t/RC})$
$e^{-t/r} = \frac{200 - 120}{200} = \frac{80}{200}$
$t = \log_e(2.5)$
$\Rightarrow t = RC$ in (2.5) $[\because r = RC]$
$\Rightarrow R = 2.71 \times 10^6\Omega$

Question143

Combination of two identical capacitors, a resistor R and a dc voltage source of voltage 6V is used in an experiment on a (C-R) circuit. It is found that for a parallel combination of the capacitor the time in which the voltage of the fully charged combination reduces to half its original voltage is 10 second. For series combination the time for needed for reducing the voltage of the fully charged series combination by half is
[2011 RS]

Options:

A. 10 second

B. 5 second

C. 2.5 second

D. 20 second

Answer: C

Solution:

Solution:

Time constant for parallel combination = 2RC

Time constant for series combination $= \frac{RC}{2}$

In first case :

$V = V_0\left(1 - e^{-\frac{t}{CR}}\right) \Rightarrow \frac{V_0}{2} = V_0 - V_0 e^{-\frac{t}{CR}}$

$V = V_0 e^{-\frac{t_1}{2RC}} = \frac{V_0}{2}$ ....(1)

In second case :

In series grouping, equivalent capacitance $= \frac{C}{2}$

$V = V_0 e^{-\frac{t_2}{(RC/2)}} = \frac{V_0}{2}$ ....(2)

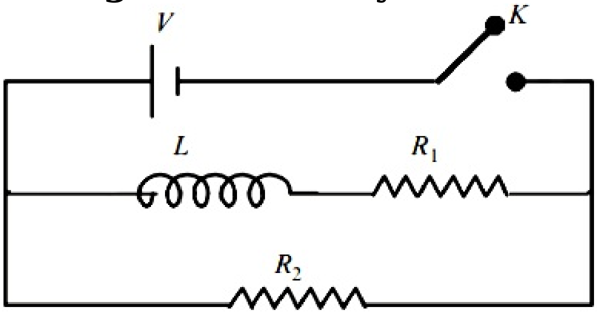
From (1) and (2)

$\frac{t_1}{2RC} = \frac{t_2}{(RC/2)}$

$\Rightarrow t_2 = \frac{t_1}{4} = \frac{10}{4} = 2.5\,\text{sec}$

Question144

In the circuit shown below, the key K is closed at t = 0. The current through the battery is



[2010]

Options:

A. $\frac{VR_1R_2}{\sqrt{R_1^2 + R_2^2}}$ at t = 0 and $\frac{V}{R_2}$ at $t = \infty$

B. $\frac{V}{R_2}$ at t = 0 and $\frac{V(R_1 + R_2)}{R_1R_2}$ at $t = \infty$

C. $\frac{V}{R_2}$ at t = 0 and $\frac{VR_1R_2}{\sqrt{R_1^2 + R_2^2}}$ at $t = \infty$

D. $\frac{V(R_1 + R_2)}{R_1R_2}$ at t = 0 and $\frac{V}{R_2}$ at $t = \infty$

Answer: C

Solution:

Solution:
At t = 0, no current will flow through L and R_1 as inductor will offer infinite resistance.

$\therefore$ Current through battery, $i = \frac{V}{R_2}$

At t = ∞, inductor behave as conducting wire

Effective resistance, $R_{eff} = \frac{R_1 R_2}{R_1 + R_2}$

$\therefore$ Current through battery $= \frac{V}{R_{eff}} = \frac{V(R_1 + R_2)}{R_1 R_2}$

Question145

In a series LCR circuit R = 200Ω and the voltage and the frequency of the main supply is 220V and 50 Hz respectively. On taking out the capacitance from the circuit the current lags behind the voltage by 30°. On taking out the inductor from the circuit the current leads the voltage by 30°. The power dissipated in the LCR circuit is [2010]

Options:

A. 305 W

B. 210 W

C. Zero W

D. 242 W

Answer: D

Solution:

Solution:
When only the capacitance is removed phase difference between current and voltage is

$\tan phi = frac X_L R \Rightarrow \tan\phi = \frac{\omega L}{R}$

$\Rightarrow \omega L = R\tan\phi = 200 \times \frac{1}{\sqrt{3}} = \frac{200}{\sqrt{3}}$

When only inductor is removed, phase difference between current and voltage is

$\therefore \tan\phi = \frac{1}{\omega CR}$

$\Rightarrow \frac{1}{\omega C} = R\tan\phi = 200 \times \frac{1}{\sqrt{3}} = \frac{200}{\sqrt{3}}$

Impedance of the circuit

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

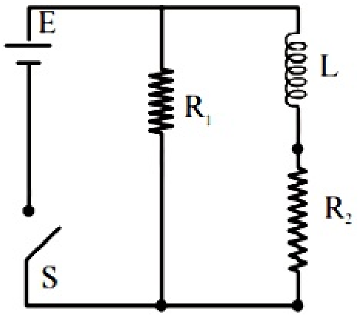
$= \sqrt{(200)^2 + \left(\frac{200}{\sqrt{3}} - \frac{200}{\sqrt{3}}\right)^2} = 200\Omega$

Power dissipated in the circuit $= V_{rms} I_{rms} \cos\phi$

$= V_{rms} \cdot \frac{V_{rms}}{Z} \cdot \frac{R}{Z} \left(\because \cos\phi = \frac{R}{Z}\right) = \frac{V_{rms}{}^2 R}{Z^2}$

$= \frac{(220)^2 \times 200}{(200)^2} = \frac{220 \times 220}{200} = 242\text{W}$

Question146



An inductor of inductance $L = 400mH$ and resistors of resistance $R_1 = 2\Omega$ and $R_2 = 2\Omega$ are connected to a battery of emf $12V$ as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at $t = 0$. The potential drop across L as a function of time is
[2009]

Options:

A. $\frac{12}{t}e^{-3t}V$

B. $6(1 - e^{-t/0.2})V$

C. $12e^{-5t}V$

D. $6e^{-5t}V$

Answer: C

Solution:

Solution:
Growth in current in branch containing L and R_2 when switch is closed is given by $i = \frac{E}{R_2}[1 - e^{-R_2t/L}]$

$\Rightarrow \frac{di}{dt} = \frac{E}{R_2} \cdot \frac{R_2}{L} \cdot e^{-R_2t/L} = \frac{E}{L}e^{-\frac{R_2t}{L}}$

Hence, potential drop across L

$V_L = \frac{Ldi}{dt} = \left(\frac{E}{L}e^{-R_2t/L}\right)L$

$= Ee^{-R_2\frac{t}{L}} = 12e^{-\frac{2t}{400 \times 10^{-3}}} = 12e^{-5t}V$

Question147

In an a.c. circuit the voltage applied is $E = E_0 \sin \omega t$. The resulting current in the circuit is $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$. The power consumption in the circuit is given by
[2007]

Options:

A. $P = \sqrt{2}E_0 I_0$

B. $P = \frac{E_0 I_0}{\sqrt{2}}$

C. $P =$ zero

D. $P = \frac{E_0 I_0}{2}$

Answer: C

Solution:

Solution:
We know that power consumed in a.c. circuit is given by,
$P = E_{rms} I_{rms} \cos\phi$
Here, $E = E_0 \sin\omega t$
$I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$
This means the phase difference, is $\phi = \frac{\pi}{2}$
$\because \cos\phi = \cos\frac{\pi}{2} = 2$
$\therefore P = E_{rms} . I_{rms} . \cos\frac{\pi}{2} = 0$

Question148

In a series resonant LCR circuit, the voltage across R is 100 volts and $R = 1k\Omega$ with $C = 2\mu F$. The resonant frequency omega is 200 rad / s. At resonance the voltage across L is
[2006]

Options:

A. $2.5 \times 10^{-2} V$

B. 40V

C. 250V

D. $4 \times 10^{-3} V$

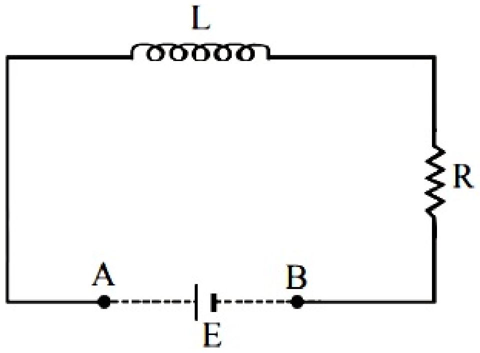
Answer: C

Solution:

stor, $I = \frac{V}{R} = \frac{100}{1000} = 0.1A$
At resonance, $X_L = X_C = \frac{1}{\omega C} = \frac{1}{200 \times 2 \times 10^{-6}} = 2500$
Voltage across L is $I X_L = 0.1 \times 2500 = 250V$

Question149

An inductor (L = 100 mH), a resistor (R = 100 Ω) and a battery (E = 100 V) are initially connected in series as shown in the figure. After a long time the battery is disconnected after short circuiting the points A and B. The current in the circuit 1 ms after the short circuit is



[2006]

Options:

A. 1/eA

B. eA

C. 0.1 A

D. 1 A

Answer: A

Solution:

Solution:
Initially, when steady state is achieved,

$i = \frac{E}{R}$

Let E is short circuited at t = 0. Then
At t = 0

Maximum current, $i_0 = \frac{E}{R} = \frac{100}{100} = 1A$

Let during decay of current at any time the current flowing is $-L\frac{di}{dt} - iR = 0$

$\Rightarrow \frac{di}{i} = -\frac{R}{L}dt$

$\Rightarrow \int_{i_0}^{i} \frac{di}{i} = \int_{i_0}^{i} -\frac{R}{L}dt$

$\Rightarrow \log_e \frac{i}{i_0} = -\frac{R}{L}t$

$\Rightarrow i = i_0 e^{-\frac{R}{L}t}$

$\Rightarrow i = \frac{E}{R}e^{-\frac{R}{L}t} = 1 \times e^{\frac{-100 \times 10^{-3}}{100 \times 10^{-3}}} = \frac{1}{e}$

Question150

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 [2006]

Options:

A. N.A.B.R.ω

B. N.A.B

C. N.A.B.R.

D. N.A.B.ω

Answer: D

Solution:

Solution:

$e = -\frac{d\phi}{dt} = -\frac{d\left(N\vec{B}.\vec{A}\right)}{dt}$

$= -N\frac{d}{dt}(BA\cos\omega t) = NBA\omega\sin\omega t$

$\Rightarrow e_{max} = NBA\omega$

Question151

The phase difference between the alternating current and emf is $\frac{\pi}{2}$. Which of the following cannot be the constituent of the circuit? [2005]

Options:

A. R, L

B. C alone

C. L alone

D. L, C

Answer: A

Solution:

Solution:

Phase difference for R–L circuit lies between $\left(0, \frac{\pi}{2}\right)$ but 0 or $\pi/2$

Question152

A circuit has a resistance of 12 ohm and an impedance of 15 ohm. The power factor of the circuit will be

[2005]

Options:

A. 0.4

B. 0.8

C. 0.125

D. 1.25

Answer: B

Solution:

Solution:
Given, Resistance of circuit, $R = 12\Omega$
Imedance of circuit, $Z = 15\Omega$
Power factor $= \cos\phi = \frac{R}{Z} = \frac{12}{15} = \frac{4}{5} = 0.8$

Question153

A coil of inductance 300 mH and resistance 2 Ω is connected to a source of voltage 2V. The current reaches half of its steady state value in [2005]

Options:

A. 0.1 s

B. 0.05 s

C. 0.3 s

D. 0.15 s

Answer: A

Solution:

Solution:
Current in inductor circuit is given by,
$i = i_0\left(1 - e^{-\frac{Rt}{L}}\right)$
$\frac{i_0}{2} = i_0\left(1 - e^{-\frac{Rt}{L}}\right) \Rightarrow e^{-\frac{Rt}{L}} = \frac{1}{2}$
Taking log on both the sides,
$-\frac{Rt}{L} = \log 1 - \log 2$
$\Rightarrow t = \frac{L}{R}\log 2 = \frac{300 \times 10^{-3}}{2} \times 0.69$
$\Rightarrow t = 0.1\,\text{sec}$

Question154

The self inductance of the motor of an electric fan is 10 H.
In order to impart maximum power at 50 Hz, it should be connected to a capacitance of
[2005]

Options:

A. 8μF

B. 4μF

C. 2μF

D. 1μF

Answer: D

Solution:

Solution:
For maximum power, $X_L = X_C$, which yields

$$C = \frac{1}{(2\pi n)^2 L} = \frac{1}{4\pi^2 \times 50 \times 50 \times 10}$$

$\therefore C = 0.1 \times 10^{-5} F = 1\mu F$

Question155

In a uniform magnetic field of induction B a wire in the form of a semicircle of radius r rotates about the diameter of the circle with an angular frequency ω. The axis of rotation is perpendicular to the field. If the total resistance of the circuit is R, the mean power generated per period of rotation is
[2004]

Options:

A. $\frac{(B\pi r\omega)^2}{2R}$

B. $\frac{(B\pi r^2\omega)^2}{8R}$

C. $\frac{B\pi r^2\omega}{2R}$

D. $\frac{(B\pi r\omega^2)^2}{8R}$

Answer: B

Solution:

$\phi = \vec{B} . \vec{A}$; $\phi = BA \cos \omega t$

$\varepsilon = -\frac{d\phi}{dt} = \omega BA \sin \omega t$; $i = \frac{\omega BA}{R} \sin \omega t$

$P_{inst} = i^2 R = \left(\frac{\omega BA}{R}\right)^2 \times R \sin^2 \omega t$

$$P_{avg} = \frac{\int_0^T P_{inst} \times dt}{\int_0^T dt} = \frac{(\omega BA)^2}{R} \frac{\int_0^T \sin^2 \omega t dt}{\int_0^T dt} = \frac{1}{2} \frac{(\omega BA)^2}{R}$$

$$\therefore P_{avg} = \frac{(\omega B \pi r^2)^2}{8R} \left[A = \frac{\pi r^2}{2}\right]$$

Question156

Alternating current can not be measured by D.C. ammeter because [2004]

Options:

A. Average value of current for complete cycle is zero

B. A.C. Changes direction

C. A.C. can not pass through D.C. Ammeter

D. D.C. Ammeter will get damaged.

Answer: A

Solution:

Solution:
D.C. ammeter measure average value of current. In AC current, average value of current in complete cycle is zero. Hence reading will be zero.

Question157

In an LCR series a.c. circuit, the voltage across each of the components, L, C and R is 50V. The voltage across the LC combination will be [2004]

Options:

A. 100 V

B. $50\sqrt{2}$ V

C. 50 V

D. 0 V (zero)

Answer: D

Solution:

In a series LCR circuit voltage across the inductor and capacitor are in opposite phase
∴ Net voltage difference across
LC = 50 – 50 = 0

Question158

In a LCR circuit capacitance is changed from C to 2 C. For the resonant frequency to remain unchanged, the inductance should be changed from L to
[2004]

Options:

A. L/2

B. 2 L

C. 4 L

D. L/4

Answer: A

Solution:

Solution:
Resonant frequency, $F_r = \frac{1}{2\pi\sqrt{LC}}$
For resonant frequency to remain same
LC = constant
$\therefore LC = L'C'$
$\Rightarrow LC = L' \times 2C$
$\Rightarrow L' = \frac{L}{2}$

Question159

In an oscillating LC circuit the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic field is
[2003]

Options:

A. $\frac{Q}{2}$

B. $\frac{Q}{\sqrt{3}}$

C. $\frac{Q}{\sqrt{2}}$

D. Q

Answer: C

Solution:

Solution:
When the capacitor is completely charged, the total energy in the LC circuit is with the capacitor and that energy is given by

$U_{max} = \frac{1}{2}\frac{Q^2}{C}$

When half energy is with the capacitor in the form of electric field between the plates of the capacitor we get

$\frac{U_{max}}{2} = \frac{1}{2}\frac{q'^2}{C}$

Here q′ is the charge on the plate of capacitor when energy is shared equally.

$\therefore \frac{1}{2} \times \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{q'^2}{C} \Rightarrow q' = \frac{Q}{\sqrt{2}}$

Question160

The core of any transformer is laminated so as to [2003]

Options:

A. reduce the energy loss due to eddy currents

B. make it light weight

C. make it robust and strong

D. increase the secondary voltage

Answer: A

Solution:

Solution:
Laminated core provide less area of cross-section for the current to flow. Because of this, resistance of the core increases and current decreases there by decreasing the energy loss due to eddy current.

Question161

The power factor of an AC circuit having resistance (R) and inductance (L) connected in series and an angular velocity ω is [2002]

Options:

A. $R / \omega L$

B. $R / (R^2 + \omega^2 L^2)^{1/2}$

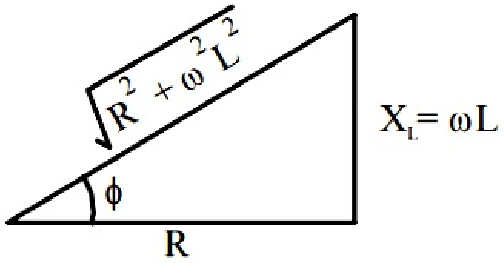
C. $\omega L / R$

D. $R / (R^2 - \omega^2 L^2)^{1/2}$

Answer: B

Solution:

Solution:
Resistance of the inductor, $X_L = \omega L$
The impedance triangle for resistance (R) and inductor (L) connected in series is shown in the figure.



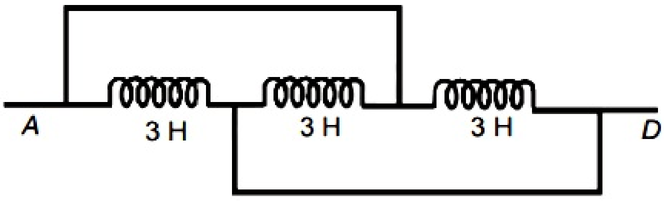
Net impedance of circuit $Z = \sqrt{X_L^{\ 2} + R^2}$

Power factor, $\cos\phi = \frac{R}{Z}$

$\Rightarrow \cos\phi = \frac{R}{\sqrt{R^2 + \omega^2 L^2}}$

Question162

The inductance between A and D is



[2002]

Options:

A. 3.66 H

B. 9 H

C. 0.66 H

D. 1 H

Answer: D

Solution:

Solution:
All three inductors are connected in parallel. The equivalent inductance L_p is given by

$\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3} = 1$

$\therefore L_p = 1$

Question163

In a transformer, number of turns in the primary coil are 140 and that in the secondary coil are 280. If current in primary coil is 4 A, then that in the secondary coil is
[2002]

Options:

A. 4 A

B. 2 A

C. 6 A

D. 10 A.

Answer: B

Solution:

Number of turns in primary
$N_{p} =$

Number of turns in secondary $N_s = 280$, $I_p = 4A$, $I_s = ?$

Using transformation ratio for a transformer $\frac{I_S}{I_p} = \frac{N_p}{N_s}$

$\Rightarrow \frac{I_S}{4} = \frac{140}{280}$
$\Rightarrow I_s = 2A$
