PHYSICS

BOOKS - NEW JYOTHI PHYSICS (TAMIL ENGLISH)

ALTERNATING CURRENT

Solved Problem

1. A light bulb is at 100 W for a 220 V supply . Find (a) the resistance of the bulb , (b) the

peak voltage of the source , and (c) the rms current through the bulb.

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2. A pure inductor of 25.0 mH is connected to a source of 220V . Find the inductive reactance and rms current in the circuit if the frequency of the source is 50 Hz .

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3. A lamp is connected in series with a capacitor. Predict your observations for dc and ac connections. What happens in each case if the capacitance of the capacitor is reduced?

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4. A 15.0 μF capacitor is connected to a 220V, 50Hz source. Find the capacitive reactance and the current (rms and peak) in the circuit. If the

frequency is doubled, what happens to the capacitive reactance and the current?

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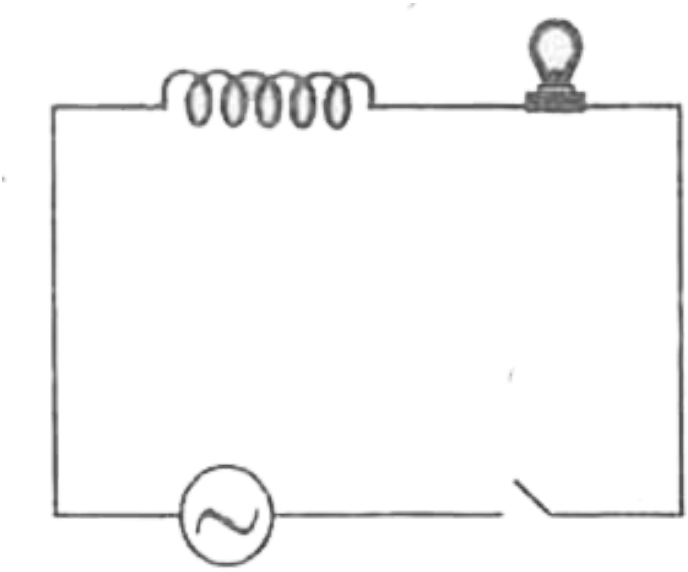
5. A light bulb and an open coil inductor are connected to an ac source through a key as shown in figure. The switch is closed and after sometime, an iron rod is inserted into the interior of the inductor. The glow of the light bulb (a) increases, (b) decreases, (c) is unchanged, as the iron rod is inserted. Give

your answer with reasons.



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6. A resistor of 200Ω and a capacitor of $15.0\mu F$ are connected in series to a 220V , 50Hz ac source . (a) Calculate the current in

the circuit, (b) Calculate the voltage (rms) across the resistor and the capacitor . Is the algeraic sum of these voltages more than source voltage ? if yes, resolve the paradox.

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7. a. For circuits used for transporting electric power, a low power factor implies large power loss in transmission. Explain.

b. Power factor can often be improved by the

use of a capacitor of appropriate capacitance in the circuit. Explain.

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8. A sinusoidal voltage of peak value 283 V and frequency 50Hz is applied to a series LCR circuit in which R= 3 ohm L= 25.48mH C= 796 mu F. Suppose the frequency of the source can be varied. (a) What is the frequency of the source at which resonance occurs? (b)

Calculate the impedance, the current, and the power dissipated at the resonant condition.

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9. A sinusoidal voltage of peak value 283 V and frequency 50Hz is applied to a series LCR circuit in which R= 3 ohm L= 25.48mH C= 796 mu F. Suppose the frequency of the source can be varied. (a) What is the frequency of the source at which resonance occurs? (b)

Calculate the impedance, the current, and the power dissipated at the resonant condition.

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10. At an airport, a person is made to walk through the doorway of a metal detector, for security reasons. If she/he is carrying anything made of metal, the metal detector emits a sound. On what principle does this detector work?

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11. If the effective value of current on 50 Hz a.c. circuit is 5.0 A. What is (i) peak value of current, (ii) the mean value of current over a half a cycle and (iii) the value of current $\frac{1}{300}$s after it was zero?

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12. An electric lamp which runs at 40 V consumes 10 A current is connected to AC

mains at 100 V, 50 cycles per second. Calculate the inductance of the choke.

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13. A $100\mu F$ capacitor in series with a 40Ω resistance is connected to 110 V, 60 Hz supply .

a. What is the maximum current in the circuit ?

b. What is the time lag between the current maximum and the voltage maximum ?

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14. Find the value of current(rms and peak) through a capacitor of $10\mu F$ when connected to a source of 110 V at 50 cycles supply. What is its capacitive reactance?

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15. $A2\mu F$ capacitor is charged to a p.d. of 60V. The charging battery is disconnected and the capacitor is connected in series with a coil of inductance 10mH, so that LC oscillations occur.

What is the maximum current in the coil? Assume that the circuit contains no resistance.

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16. The maximum kinetic energy of a photoelectron is 3eV . What is its stopping potential ?

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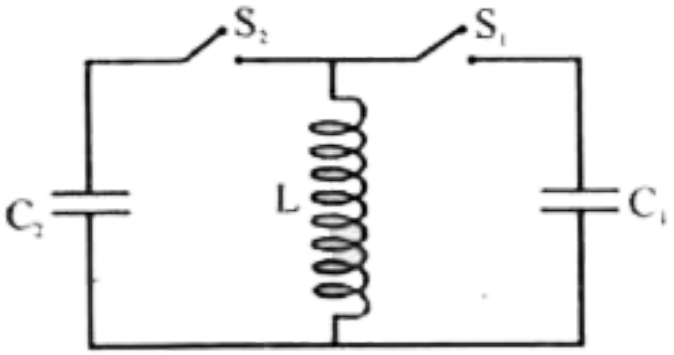
17. In the following circuit $C_1 = 900\mu F$ which is charged to a p.d of 100V and $C_2 = 100\mu F$ is an unchanged capacitor L = 10 henry . Explain how will you change C_2 to a.p.d of 300V by adjusting the switched S_1 and S_2



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18. An LCR circuit consists of L = 230 mH, $C = 70\mu F$ and $R = 200\Omega$. The frequency of AC main is 60Hz and E = 36V . Calculate impedance Z, current I and angle ϕ .

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19. In an LCR circuit , can the amplitude of the voltage across L be greater than that of an emf of the generator . The LCR circuit contains an AC source of emf (Generator emf) $E = 10V$

, $R = 10\Omega, L = 1H, C = 1\mu F$. Find the amplitude of the voltage across L at resonance condition .

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20. In an LCR circuit , L = 88 mH and C $= 1\mu F$ and the value of the resistor is unknown . The AC source has a frequency of 1000 Hz and the phase between emf and current is 70° . Calculate the value of R of the resistor .

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21. Show that in the free oscillationsof an LC circuit , the sum of energies stored in the capacitor and the inductor is constant in time .

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22. When a voltage of 120V is impressed across the primary of a transformer , the current in the primary is 1.85mA . Find the voltage across

the secondary , when it delivers 150mA . The transformer has an efficiency of 95%

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23. In a transformer primary has 50 turns and secondary has 10 turns . The RMS voltage in the primary is 120V . Find the RMS secondary voltage in the open circuit .if the secondary has a load of 12Ω . What are the currents in the primary and secondary ?

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Solutions To Exercises From Ncert Test

1. A 100Ω resistor is connected to a 220 V , 50 Hz are supply .

a. What is the rms of current in the circuit ?

b. What is the net power consumed over a full cycle ?

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2. a. The peak voltage of an ac supply is 300V. What is the rms voltage ?

b. The rms value of current in an ac circuit is 10A. What is the peak current ?

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3. A 44mH inductor is connected to 220V, 50 Hz ac supply . Determine the rms value of the current in the circuit .

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4. A $60\mu F$ capacitor is connected to a 110V, 60 Hz ac supply , determine the rms value of the current circuit .

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5. What is the net power absorbed by each circuit over a complete cycle. Explain your answer. 1. A 44mH is connected into 220V, 50Hz ac supply. Determine the rms value of the current in the circuit. 2. A 60 μF capacitor is

connected to a 110V,60Hz ac supply. Determine the rms value of the current in the circuit.

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6. Obtain the resonant frequency ω of a series LCR circuit with L = 2.0 H, $C = 32\mu F$ and $R = 10\Omega$. What is the Q-value of this circuit ?

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7. A charged $30\mu F$ capacitor is connected to a 27 mH inductor. What is the angular frequency of free oscillations of the circuit?

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8. Suppose the initial charge on the capacitor is 6 mC. What is the total energy stored in the circuit initially? What is the total energy at later time?

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9. A series LCR circuit with R=20Ω, L = 1.5 H and C = 35μF is connected to a variable frequency 200 V ac supply. When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one complete cycle?

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10. A radio can tune over the frequency range of a portion of MW broadcast band: (800 kHz

to 1200 kHz). If its LC circuit has an effective inductance of $200\mu H$, what must be the range of its variable capacitor?

(Hint: For tuning, the natural frequency i.e., the frequency of free oscillations of the LC circuit should be equal to the frequency of the radio wave.]

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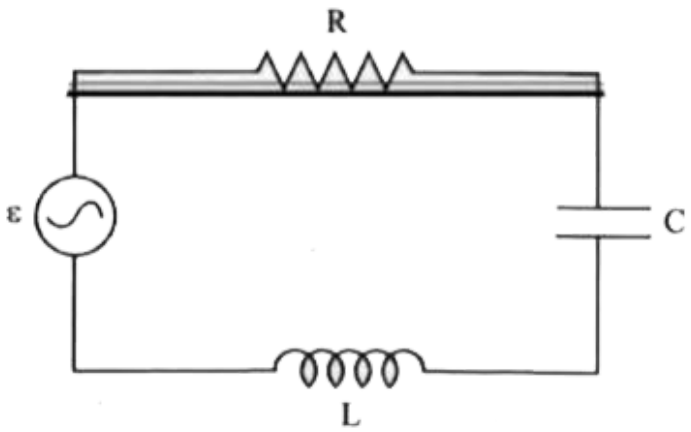
11. Figure shows a series LCR circuit connected to a variable frequency 230 V source.

$L = 5.0H, C = 80\mu F, R = 40\Omega$



a. Determine the source frequency which drives the circuit in resonance

b. Obtain the impedance of the circuit and the amplitude of current at the resonating frequency.

c. Determine the rms potential drops across the three elements of the circuit. Show that

the potential drop across the LC combination is zero at the rasonating frequency .

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12. An LC circuit contains a 20 mH inductor and a $50\mu F$ capacitor with an initial charge of 10 mC. The resistance of the circuit is negligible. Let the instant the circuit is closed be t = 0.

a. What is the total energy stored initially? Is it conserved during LC oscillations?

b. What is the natural frequency of the circuit?

c. At what time is the energy stored

i. completely electrical (i.e., stored in the capacitor)

ii. completely magnetic (i.e., stored in the inductor)

d. If a resistor is inserted in the circuit, how much energy is eventually dissipated as heat?

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13. A coil of inductance 0.50 H and resistance 100Ω is connected to a 240 V, 50 Hz ac supply.

a. What is the maximum current in the coil? . b. What is the time lag between the voltage maximum and the current maximum?

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14. If the circuit is connected to a high frequency supply (240 V, 10 kHz). Hence, explain the statement that at very high frequency, an inductor in a circuit nearly amounts to an open circuit. How does an

inductor behave in a dc circuit after the steady state?

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15. A $100\mu F$ capacitor in series with a 40Ω resistance is connected to 110 V, 60 Hz supply .

a. What is the maximum current in the circuit ?

b. What is the time lag between the current maximum and the voltage maximum ?

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16. if the circuit is connected to a 110 V, 12 kHz supply? Hence, explain the statement that a capacitor is a conductor at very high frequencies. Compare this behaviour with that of a capacitor in a de circuit after the steady state.

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17. A circuit containing a 80 mH inductor and a $60\mu F$ capacitor in series is connected to a 230 V, 50 Hz supply. The resistance of the circuit is

negligible.

a. Obtain the current amplitude and rms values.

b. Obtain the rms values of potential drops across each element.

c. What is the average power transferred to the inductor?

d. What is the average power transferred to the capacitor?

e. What is the total average power absorbed by the circuit? ['Average' implies "averaged over one cycle'.]

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18. A circuit containing $80mH$ inductor and a $60\mu F$ capacitor in series is connected to a $230V$, $50Hz$ supply has a resistance of 15Ω . Obtain the average power transferred to each element of the circuit, and the total power absorbed.

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19. A series LCR circuit with L = 0.12 H, C = 480 nF, R = 23Ω is connected to a 230 V variable frequency supply.

a. What is the source frequency for which current amplitude is maximum? Obtain this maximum value.

b. What is the source frequency for which average power absorbed by the circuit is maximum? Obtain the value of this maximum power.

c. For which frequencies of the source is the power transferred to the circuit half the power

at resonant frequency? What is the current amplitude at these frequencies?

d. What is the Q-factor of the given circuit?

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20. Obtain the resonant frequency and Q-factor of a series LCR circuit with L = 3.0 H, $C = 27\mu F$, and $R = 7.4\Omega$. It is desired to improve the sharpness of the resonance of the circuit by reducing its 'full width at half

maximum' by a factor of 2. Suggest a suitable way.

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21. A power transmission line feeds input power at 2300 V to a stepdown transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V?

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22. At a hydroelectric power plant, the water pressure head is at a height of 300 m and the water flow available is $100 m^3 s^{-1}$. If the turbine generator efficiency is 60%, estimate the electric power available from the plant $\left(g = 9.8 m s^{-2}\right)$.

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23. A small town with a demand of 800 kW of electric power at 220 V is situated 15 km away

from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5Ω per km. The town gets power from the line through a 4000-220 V step-down transformer at a sub-station in the town.

a. Estimate the line power loss in the form of heat. b. How much power must the plant supply assuming there is negligible power less due to leakage? c. Characterise the step up transformer at the plant.

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24. Do the same exercise as above with the replacement of the earlier transformer by a 40,000-220 V step-down transformer (Neglect, as before, leakage losses though this may not be a good assumption any longer because of the very high voltage transmission involved). Hence, explain why high voltage transmission is preferred.

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Practice Problems For Self Assessment

1. An electric lamp runs at 120 V d.c and consumes 12 A. It is connected to 200 V, 50 Hz a.c. Find the inductance required and the power factor.

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2. In a car spark coil, e.m.f 40 kV is induced in the secondary when the primary current changes from 4A to 0 in $10\mu s$. Find the mutual inductance between the coils

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3. A coil of inductance L, resistor of resistance R and an ammeter are connected in series with a 110 V DC supply. The ammeter reads 1.1A. The combination is then connected in series with a 110 VAC and 50Hz lines. Now the ammeter reads 0.55A. Calculate the values of R and L.

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4. The effective current in a 50 c.p.s. A.C. circuit is 20A. What is the peak value of the current and current after $\frac{1}{600}$ sec after it was zero?

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5. A coil of inductance 0.1H and resistance 100 Ω are connected to a 210V, 50Hz AC supply. Find the maximum current in the coil and time lag between maximum voltage and maximum current.

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6. An LCR series circuit consists L = 80 mH, $C = 60\mu F$ and $R = 15\Omega$. The combination is connected to a 230 V, 50 Hz AC supply. Calculate the impedance in the circuit.

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7. An LCR series circuit with L = 80 mH, $C = 60\mu F$ and $R = 100\Omega$ is connected to a

230 V, 50 Hz AC source. Calculate the p.d. across L,C and R

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8. A radio can tune over the frequency range of a portion of MW broadcast band: (800 kHz to 1200 kHz). If its LC circuit has an effective inductance of $200\mu H$, what must be the range of its variable capacitor?

(Hint: For tuning, the natural frequency i.e., the frequency of free oscillations of the LC

circuit should be equal to the frequency of the radio wave.]

9. A transformer has an efficiency of 80% and works at 100 V and 4 kW. The secondary voltage is 240 V. Calculate the current in the primary and secondary.

10. A step down transformer convert a voltage of 2200 V into 220V in the transmission line. Number of turns in the primary coil is 5000. Efficiency of transformer is 90% and its output power is 8kW. Calculate (i) the number of turns in the secondary coil, (ii) input power.

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11. A step down transformer has turns ratio 40:1. (i) If the primary voltage is 240V, calculate

the secondary voltage. (ii) If the secondary current is 4A, calculate the primary current.

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Evaluation Questions And Answers

1. What is the average value of emf or current in one cycle?

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2. What is the average value of emf or current in one cycle?

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3. Even though the average current in the circuit is zero, how does an electric bulb glow?

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4. When ac is passing through a resistor, what is the instantaneous power?

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5. For one complete cycle, what is the average power?

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6. What is the maximum ac voltage in our household circuit?

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7. Impendence of a circuit may also be calculated using impendence triangle. Explain.

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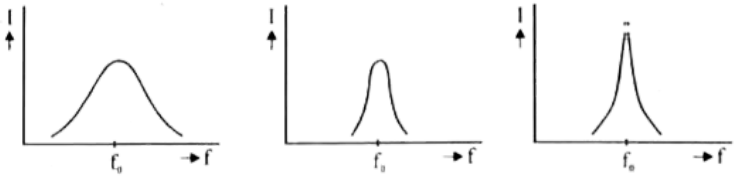
8. 

The current-frequency response curves are shown in figures above for three LCR circuits.

a. What is Q-factor of the LCR circuit? b. Which of the curves in the above figures has highest Q value? C. Write an expression for the value. d. Can any of the curves shown in the figures represent current-frequency response of a parallel LCR circuit?

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9. What is the frequency of direct current?

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10. i= 5 sin 314t. Which is the peak value of current?

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11. Which value of current do you measure with an A.C ammeter?

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12. A capacitor blocks D.C, but allows A.C to pass through it. Explain why.

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13. A transformer cannot work on D.C. Why?

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14. What is the function of a choke coil in a fluorescent tube?

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15. Draw the graph showing the variation of reactance of (a) C and (b) L with frequency v of an A.C circuit.

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16. Which is more dangerous, A.C or D.C? Why?

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Continuous Evaluation Project

1. Design of a transformer for producing separate secondary voltages from A.C main input.

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Continuous Evaluation Assignment

1. Explain the mechanism of generation and transmission of electricity.

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2. Write a note on transformer.

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3. Write a note on induction coil and choke coil.

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4. Mention the behaviour of real resistor, real inductor and real capacitor.

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5. Explain how transformer is used in long distance transmission.

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Previous Year Questions

1. A fascinating behaviour of the series RLC circuit is the phenomenon of resonance.

a. Explain Resonance in an LCR circuit. b. Draw a graphical representation of variation of

current amplitude in with frequency w. c. What do you mean by sharpness of resonance? Explain it.

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2. Transformers either increase or decrease AC voltage.

A. State the principle of a transformer. B. Explain with the help of a labelled diagram the working of a transformer C. Explain briefly any three energy losses in a transformer.

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Objective Type Question

1. In an LCR series circuit, at resonance

A. a. the current and voltage are in phase

B. b. the impedance is maximum

C. c. the current is minimum

D. d. the quality factor is independent of R

Answer: A

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2. A step down transformer increases the input current 4 A to 24 A at the secondary. If the number of turns in the primary coil is 330, the number of turns in the secondary coil is

A. a. 60

B. b. 50

C. c. 65

D. d. 55

Answer: D

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3. Transformer is used to

A. a. convert ac to dc voltage

B. b. convert dc to ac voltage

C. c. obtain desired dc power

D. d. obtain desired ac voltage and current

Answer: D

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4. If an LCR series circuit is connected to an ac source, then at resonance the voltage across

A. a) R is zero

B. b) R equals the applied voltage

C. c) C is zero

D. d) L equals the applied voltage

Answer: B

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5. A dynamo converts

A. a. mechanical energy into thermal energy

B. b. electrical energy into thermal energy

C. c. thermal energy into electrical energy

D. d. mechanical energy into electrical energy

Answer: D

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6. A transformer connected to 220 V mains is used to light a lamp of rating 100 W and 110 V. If the primary current is 0.5 A, the effeciency of the transformer is (approximately)

A. a. 6

B. b. 35

C. c. 0.5

D. d. 90

Answer: D

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7. A lamp consumes only 25% of the peak power in an ac circuit. The phase difference between the applied voltage and the current is

A. a) $\frac{\pi}{6}$

B. b) $\frac{\pi}{3}$

C. c) $\frac{\pi}{4}$

D. d) $\frac{\pi}{2}$

Answer: B

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