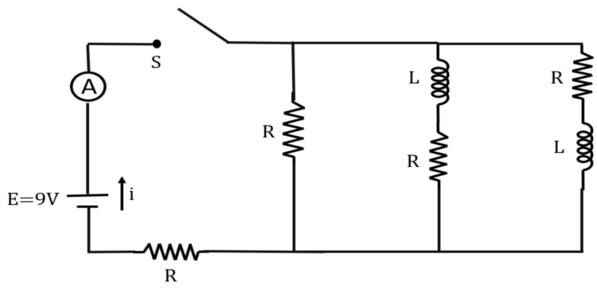
Topic : EMI, AC and EM Waves

1. The figure shows a circuit that contains four identical resistors with resistance $R = 2.0\ \Omega$. Two identical inductors with inductance $L = 2.0\ \mathrm{mH}$ and an ideal battery with emf $E = 9\ \mathrm{V}$. The current(i) just after the switch $'s'$ is closed will be:



A. $9\ \mathrm{A}$

B. $3\ \mathrm{A}$

C. $2.25\ \mathrm{A}$

D. $3.37\ \mathrm{A}$

2. Match List I with List II.

List I	List II
	i. Radioactive decay of nucleus
a. Source of microwave frequency	ii. Magnetron
b. Source of infrared frequency	iii. Inner shell electrons
c. Source of Gamma Rays	iv. Vibration of atoms and molecules
d. Source of X-rays	v. LASER
	vi. RC circuit

Choose the correct answer from the option given below:

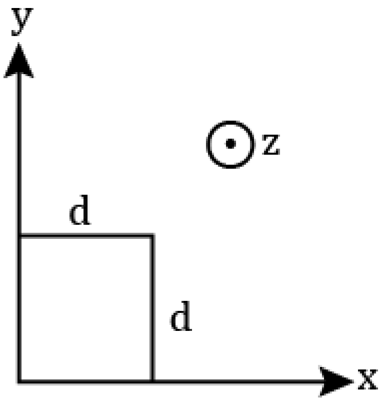
A. (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

B. (a)-(vi), (b)-(iv), (c)-(i), (d)-(v)

C. (a)-(ii), (b)-(iv), (c)-(vi), (d)-(iii)

D. (a)-(vi), (b)-(v), (c)-(i), (d)-(iv)

3. The magnetic field in a region is given by $\overrightarrow{B} = B_0\left(\frac{x}{a}\right)\hat{k}$. A sqaure loop of side d is placed with its edges along the x and y axes. The loop is moved with a constant velocity $\overrightarrow{v} = v_0\hat{i}$. The emf induced in the loop is:



A. $\frac{B_0 v_o d^2}{2a}$

B. $\frac{B_0 v_o d^2}{a}$

C. $\frac{B_0 v_o d}{2a}$

D. $\frac{B_0 v_0^2 d}{2a}$

4. Two identical antennas mounted on identical towers are separated from each other by a distance of $45\ \mathrm{km}$. What should nearly be the minimum height of receiving antenna to receive the signals in line of sight? (Assume radius of earth is $6400\ \mathrm{km}$)

A. $19.77\ \mathrm{m}$

B. $79.1\ \mathrm{m}$

C. $158.2\ \mathrm{m}$

D. $39.55\ \mathrm{m}$

5. What happens to the inductive reactance and the current in a purely inductive circuit if the frequency is halved?

A. Both, including reactance and current will be doubled

B. Both, including reactance and current will be halved

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

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

6. The time taken for the magnetic energy to reach 25% of its maximum value, when a solenoid of resistance R and inductance L is connected to a battery, is -

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

B. $\frac{L}{R}\ln 10$

C. Infinite

D. $\frac{L}{R}\ln 5$

7. A planer loop of wire rotates in a uniform magnetic field. Initially, at $t = 0$, the plane of the loop is perpendicular to the magnetic field. If it rotates with a period of $10\ \mathrm{s}$ about an axis in its plane, then the magnitude of induced emf will be maximum and minimum, respectively at:

A. $2.5\ \mathrm{s}$ and $7.5\ \mathrm{s}$

B. $2.5\ \mathrm{s}$ and $5.0\ \mathrm{s}$

C. $5.0\ \mathrm{s}$ and $7.5\ \mathrm{s}$

D. $5.0\ \mathrm{s}$ and $10.0\ \mathrm{s}$

8. An inductor coil stores $64 \mathrm{~J}$ of magnetic field energy and dissipates energy at the rate of $640 \mathrm{~W}$ when a current of $8 \mathrm{~A}$ is passed through it. If this coil is joined across an ideal battery, find the time constant of the circuit, in seconds.

A. 0.2

B. 0.4

C. 0.8

D. 0.80

9. A light beam is described by $E=800 \sin \omega\left(t-\frac{x}{c}\right)$. An electron is allowed to move normal to the propagation of light beam with a speed of $3 \times 10^{7} \mathrm{~ms}^{-1}$. What is the maximum magnetic force exerted on the electron ?

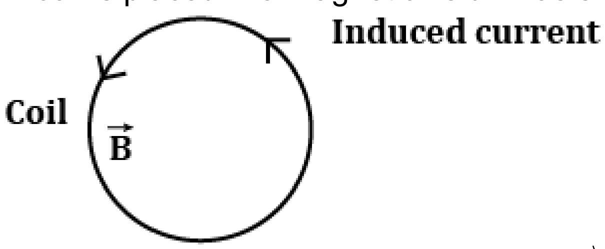
A. $1.28 \times 10^{-18} \mathrm{~N}$

B. $12.8 \times 10^{-18} \mathrm{N}$

C. $12.8 \times 10^{-17} \mathrm{~N}$

D. $1.28 \times 10^{-21} \mathrm{~N}$

10. A coil is placed in a magnetic field $\vec{B}$ as shown below:



A current is induced in the coil because $\vec{B}$ is

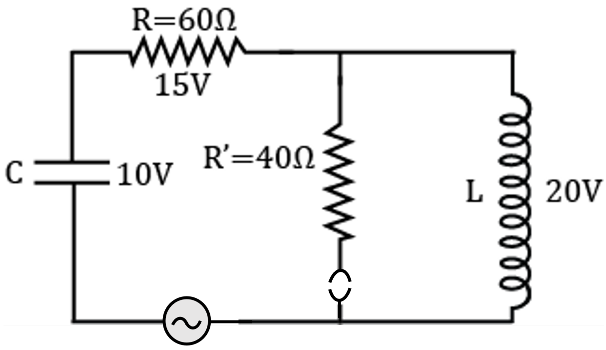
A. outward and increasing with time

B. outward and decreasing with time

C. parallel to the plane of coil and increasing with time

D. parallel to the plane of coil and decreasing with time

11. The angular frequency of alternating current in a LCR circuit is 100 rad/s. The components connected are shown in the figure. Find the value of inductance of the coil and capacity of condenser.



A. 0.8 H and $250\ \mu$F

B. 0.8 H and $150\ \mu$F

C. 1.33 H and $250\ \mu$F

D. 1.33 H and $150\ \mu$F

12. An alternating current is given by the equation, $i = i_1 \sin \omega t + i_2 \cos \omega t$. The RMS value of current will be :

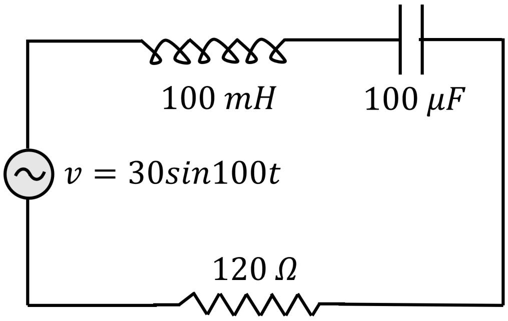
A. $\frac{1}{2}(i_1^2 + i_2^2)^{\frac{1}{2}}$

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

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

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

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



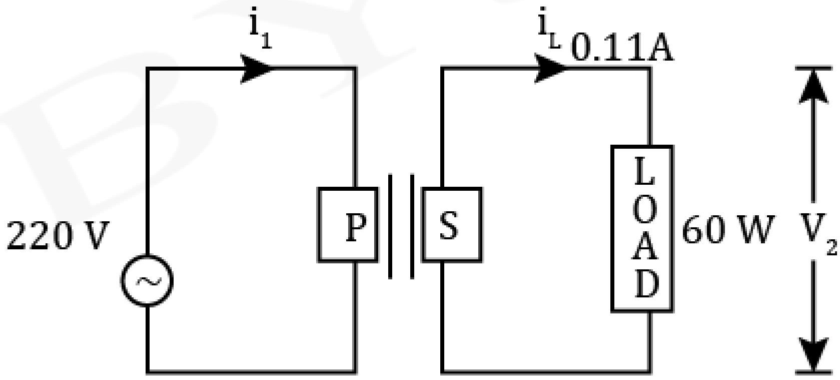
A. 0.2 A and 100 Hz

B. 2 A and 50 Hz

C. 2 A and 100 Hz

D. 0.2 A and 50 Hz

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



A. Step down transformer

B. Auxilliary transformer

C. Step up transformer

D. Auto transformer

15. In a series LCR resonance circuit, if we change the resistance only, from a lower to higher value:

A. The resonance frequency will increase.

B. The quality factor will increase.

C. The quality factor and the resonance frequency will remain constant.

D. The bandwidth of resonance circuit will increase.

16. An AC source rated $220 \mathrm{~V}$, $50 \mathrm{~Hz}$ is connected to a resistor. The time taken by the current to change from its maximum to the rms value is:

A. $0.25 \mathrm{~ms}$

B. $25 \mathrm{~ms}$

C. $2.5 \mathrm{~ms}$

D. $2.5 \mathrm{~s}$

17. Match List I with list II

List-I	List- II
(a) Phase difference between current and voltage in a purely resistive AC circuit	(i) π/2; current leads voltage
(b) Phase difference between current and voltage in a pure inductive AC circuit	(ii) zero
(c) Phase difference between current and voltage in a pure capacitive AC circuit	(iii) π/2; current lags voltage
(d) Phase difference between current and voltage in an LCR series circuit	(iv) $\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

A. $(a)-(ii),(b)-(iii),(c)-(iv),(d)-(i)$

B. $(a)-(i),(b)-(iii),(c)-(iv),(d)-(ii)$

C. $(a)-(ii),(b)-(iv),(c)-(iii),(d)-(i)$

D. $(a)-(ii),(b)-(iii),(c)-(i),(d)-(iv)$

18. In a series LCR circuit, the inductive reactance (X_L) is $10\ \Omega$ and the capacitive reactance (X_C) is $4\ \Omega$. The resistance (R) in the circuit is $6\ \Omega$. Find the power factor of the circuit.

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

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

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

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

19. For a series LCR circuit with $R = 100\ \Omega$, $L = 0.5\ \mathrm{mH}$ and $C = 0.1\ \mathrm{pF}$ connected across $220\ \mathrm{V} - 50\ \mathrm{Hz}\ \mathrm{AC}$ supply, the phase angle between current and supplied voltage and the nature of the circuit is :

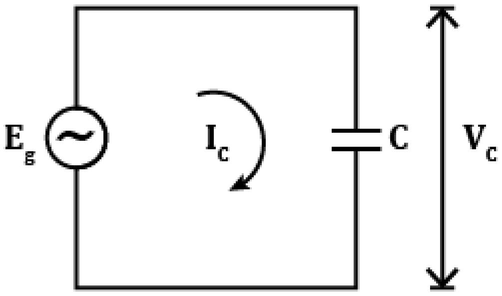
A. 0°, resistive circuit

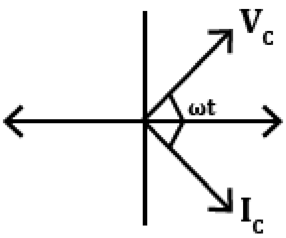
B. $\approx 90^\circ$, predominantly inductive circuit

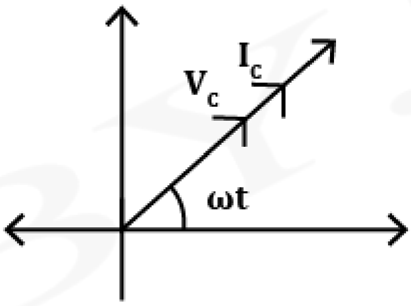
C. 0° , resonance circuit

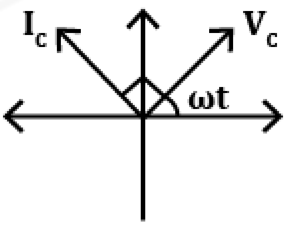
D. $\approx 90^\circ$, predominantly capacitive circuit

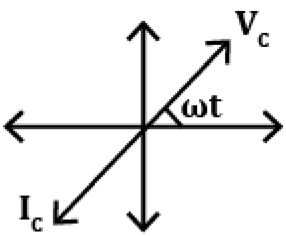
20. In a circuit consisting of a capacitance and a generator with alternating emf $E_g = E_g \sin\omega t$, where V_C and I_C are the voltage and current. Correct phasor diagram for such circuit is :



A. 

B. 

C. 

D. 

21. In amplitude modulation, the message signal $V_m(t) = 1\sin(2\pi \times 10^5 t)$ volts and carrier signal $V_C(t) = 20\sin(2\pi \times 10^7 t)$ volts. The modulated signal now contains the message signal with lower side band and upper side band frequency. Therefore the bandwidth of modulated signal is α kHz. The value of α is :

A. 200 kHz

B. 50 kHz

C. 100 kHz

D. 0 kHz

22. A $10\ \Omega$ resistance is connected across $220\ \text{V} - 50\ \text{Hz}$ AC supply. The time taken by the current to change from its maximum value to the RMS value is

A. 2.5 ms

B. 1.5 ms

C. 3.0 ms

D. 4.5 ms

23. If a message signal of frequency f_m is amplitude modulated with a carrier signal of frequency f_c and radiated through an antenna , the wavelength of the corresponding signal in air is :
[Given , c = speed of electromagnetic wave in vacuum/air]

A. $\dfrac{c}{f_c + f_m}$

B. $\dfrac{c}{f_c - f_m}$

C. $\dfrac{c}{f_m}$

D. $\dfrac{c}{f_c}$

24. A signal of $0.1\ \mathrm{kW}$ is transmitted in a cable. The attenuation of cable is $-5\ \mathrm{dB}$ per km and cable length is $20\ \mathrm{km}$. The power received at receiver is $10^{-x}\ \mathrm{W}$. The value of x is .

[Gain in $dB = 10\log_{10}(\frac{P_0}{P_\mathrm{i}})$]

25. An audio signal $v_m = 20\sin 2\pi(1500t)$ amplitude modulates a carrier $v_c = 80\sin 2\pi(100,000t)$. The value of percent modulation is

26. Given below are two statements :

Statement I : A speech signal of $2\ \mathrm{kHz}$ is used to modulate a carrier signal of $1\ \mathrm{MHz}$. The bandwidth requirement for the signal is $4\ \mathrm{kHz}$.

Statement II : The sideband frequencies are $1002\ \mathrm{kHz}$ and $998\ \mathrm{kHz}$.

In the light of the above statements, choose the correct answer from the options given below.

A. Both statement I and statement II are false.

B. Statement I is false, but statement II is true.

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

D. Both statement I and statement II are true.

27. The maximum and minimum amplitude of an amplitude modulated wave is $16\ \mathrm{V}$ and $8\ \mathrm{V}$ respectively. The modulation index for this amplitude modulated wave is $x \times 10^{-2}$. The value of x is _____. (up to two significant figures)

28. If the highest frequency modulating a carrier is $5\ \mathrm{kHz}$, then the number of AM broadcast stations accommodated in a $90\ \mathrm{kHz}$ bandwidth are ______.

29. A carrier signal $C(t) = 25\sin(2.512 \times 10^{10} t)$ is amplitude modulated by a message signal $m(t) = 5\sin(1.57 \times 10^{8} t)$ and transmitted through an antenna. What will be bandwidth of the modulated signal?

A. 1987.5 MHz

B. 2.01 GHz

C. 50 MHz

D. 8 GHz

30. In a plane electromagnetic wave, the directions of electric field and magnetic field are represented by $\hat{k}$ and $2\hat{i} - 2\hat{j}$, respectively. What is the unit vector along direction of propagation of the wave ?

A. $\frac{1}{\sqrt{2}}(\hat{i} + \hat{j})$

B. $\frac{1}{\sqrt{2}}(\hat{j} + \hat{k})$

C. $\frac{1}{\sqrt{5}}(\hat{i} + 2\hat{j})$

D. $\frac{1}{\sqrt{5}}(2\hat{i} + \hat{j})$