Electromagnetic Induction And Alternating Currents JEE Main PYQ - 1

Total Time: 25 Minute **Total Marks:** 40

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Electromagnetic Induction And Alternating Currents

1. 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 : **(+4, -1)**

8 April 2019 I

a. $\frac{2}{\ell n 2}$

b. $\ell n 2$

c. $2 \ell n 2$

d. $\frac{1}{2} \ell n 2$

Click Here for Solution

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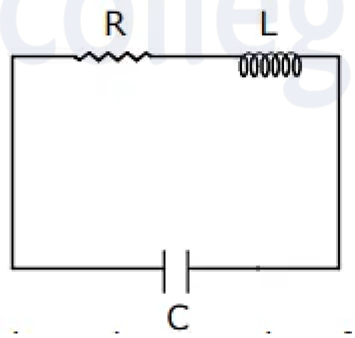
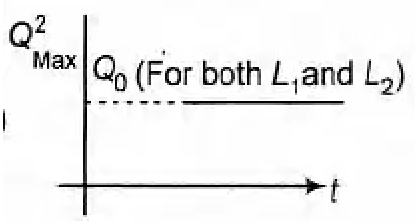
2. An LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below : **(+4, -1)**

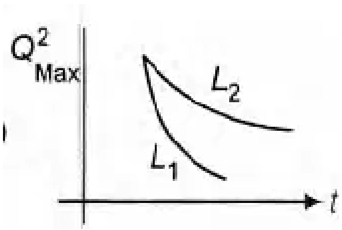
[2015

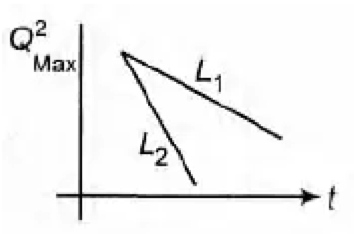


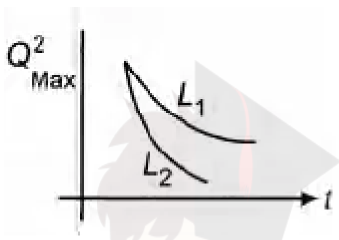
R If a student plots graphs of the square of maximum charge (Q^2_{max}) on the capacitor with time (t) for two different values L_1 and L_2 $(L_1 > L_2)$ of L then which of the following represents this graph correctly ? (Plots are shematic and not drawn to scale)

a. 

Click Here for Solution

b. 

c. 

d. 

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3. 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 : 30-Jan-2024 Shift 2 **(+4, -1)**

a. $50\,A$

b. $45\,A$ Click Here for Solution

c. $25\,A$

d. $20\,A$

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4. A series AC circuit containing an inductor $(20\,mH)$, a capacitor $(120\,\mu F)$ and a resistor (60Ω) is driven by an AC source of $24\,V/50\,Hz$. The energy dissipated in the circuit in $60\,s$ is : 9 Jan. 2019 I **(+4, -1)**

a. $2.26 \times 10^3\,J$

b. $3.39 \times 10^{3}\ J$

Click Here for Solution

c. $5.65 \times 10^{2}\ J$

d. $5.17 \times 10^{2}\ J$

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5. A sinusoidal voltage of peak value $283\,V$ and angular frequency $320/s$ is applied to a series LCR circuit. Given that $R = 5\,\Omega, L = 25\,mH$ and $C = 1000\,\mu F$. The total impedance, and phase difference between the voltage across the source and the current will respectively be : **(+4, -1)**

April 9, 2017

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

b. 7Ω and 45°

Click Here for Solution

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

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

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6. 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 : **(+4, -1)**

2016

a. 80 H

b. 0.08 H

Click Here for Solution

c. 0.044 H

d. 0.065 H

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7. An ideal capacitor of capacitance $0.2\,\mu F$ is charged to a potential difference of $10\,V$. The charging battery is then disconnected. The capacitor is then connected to an ideal inductor of self inductance $0.5\,mH$. The current at a time when the potential difference across the capacitor is $5\,V$, is : **(+4, -1)**

April 15, 2018

a. $0.34\,A$

b. $0.25\,A$

Click Here for Solution

c. $0.17\,A$

d. $0.15\,A$

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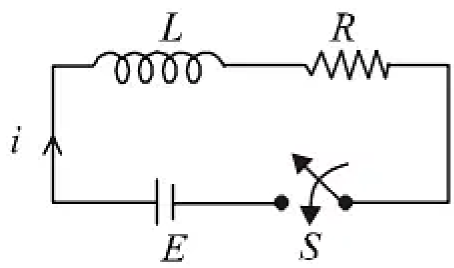
8. Consider the LR circuit shown in the figure. If the switch S is closed at $t = 0$ then the amount of charge that passes through the battery between $t = 0$ and $t = \frac{L}{R}$ is: (+4, -1)

12 April 2019 II



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

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

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

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

Click Here for Solution

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9. A series LCR circuit is connected to an ac source of $220\,V, 50\,Hz$ The circuit contain a resistance $R = 100\,\Omega$ and an inductor of inductive reactance $X_L = 796\,\Omega$ The capacitance of the capacitor needed to maximize the average rate at which energy is supplied will be ________ μF (+4, -1)

Click Here for Solution

1-Feb-2023

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10. An inductor of $0.5mH$, a capacitor of $20\mu F$ and resistance of 20Ω are connected in series with a $220V$ ac source If the current is in phase with the emf, the amplitude of current of the circuit is $\sqrt{x}$ A The value of x is - (+4, -1)

29-Jun-2022

Click Here for Solution

Answers

1. **Answer: c**

Explanation:

$$LIdI = I^2R$$
$$L \times \frac{E}{10}\left(-e^{-t/2}\right) \times \frac{-1}{2} = \frac{E}{10}\left(1 - e^{-t/2}\right) \times 10$$
$$e^{-t/2} = 1 - e^{-t/2}$$
$$t = 2\ell n2$$

Concepts:

1. **Alternating Current:**

An alternating current can be defined as a current that changes its magnitude and polarity at regular intervals of time. It can also be defined as an electrical current that repeatedly changes or reverses its direction opposite to that of Direct Current or DC which always flows in a single direction as shown below.

Alternating Current Production

Alternating current can be produced or generated by using devices that are known as alternators. However, alternating current can also be produced by different methods where many circuits are used. One of the most common or simple ways of generating AC is by using a basic single coil AC generator which consists of two-pole magnets and a single loop of wire having a rectangular shape.

Application of Alternating Current

AC is the form of current that are mostly used in different appliances. Some of the examples of alternating current include audio signal, radio signal, etc. An alternating current has a wide advantage over DC as AC is able to transmit power over large distances without great loss of energy.

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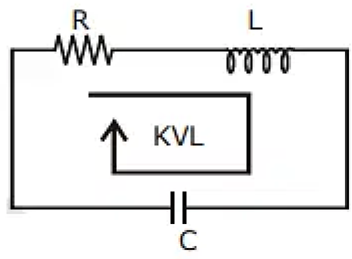
2. **Answer: d**

Explanation:



$IR + L\frac{dI}{dt} - \frac{q}{C} = 0$
$L\frac{d^2q}{dt^2} = -R\frac{dq}{dt} + \frac{q}{C}$
comparing with equation of damped oscillation
$d\frac{d^2y}{dt^2} = -\gamma\frac{dy}{dt} - ky$
The eqution of amplitude is $y = Ae^{-bt}$
where $b = \frac{\gamma}{2m} = \frac{R}{2L}$
$\therefore q_{\max} = q_0 e^{-\frac{Rt}{2L}}$
$\therefore q_{\max}^2 = q_0^2 e^{-\frac{Rt}{L}}$
$\therefore$ time constant $\tau = \frac{R}{L}$
since $L_1 > L_2$
$\tau_1 < \tau_2$
Hence correct graph is 3.

The value of $Q_{\max}$ reduces because of energy dissipation in resistor. As the value of inductor increases the time taken for capacity to discharge or charge increases therefore heat dissipation time decreases. Hence corrcect graph is 3 .

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3. **Answer: b**

Explanation:

We know that, efficiency is given by

$\eta = \frac{\text{output power}}{\text{input ower}}$

$= \frac{E_s \cdot I_s}{E_p \cdot I_p}$

Here, $\eta = 90\%, E_p = 2300\,V,\ I_p = 5\,A$ and $E_s = 230\,V$

Therefore, $\frac{90}{100} = \frac{230 \times I_s}{2300 \times 5}$

$I_s = \frac{90 \times 2300 \times 5}{230 \times 100} = 45\,A$

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4. **Answer: d**

Explanation:

$R = 60\Omega\ f = 50Hz, \omega = 2\pi f = 100\pi$
$x_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 120 \times 10^{-6}}$
$x_C = 26.52\Omega$
$x_L = \omega L = 100\pi \times 20 \times 10^{-3} = 2\pi\Omega$
$x_C - x_L = 20.24 \approx 20$
$z = \sqrt{R^2 + (x_C - x_L)^2}$
$z = 20\sqrt{10}\Omega$
$\cos\phi = \frac{R}{z} = \frac{3}{\sqrt{10}}$
$P_{avg} = VI\cos\phi, I = \frac{v}{z}$
$= \frac{v^2}{z}\cos\phi$
$= 8.64$ watt
$Q = P.t = 8.64 \times 60 = 5.18 \times 10^2$

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5. **Answer: b**

Explanation:

$e_0 = 283$ volt $\omega = 320$

$x_L = 320 \times 25 \times 10^{-3} = 8\,\Omega$

$x_C = \frac{1}{\omega C} = \frac{1}{320 \times 1000 \times 10^{-6}}$

$= \frac{1000}{320} = 3.1\,\Omega$

$R = 5\,\Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{50} = 7\,\Omega$

$tan\,\phi = \frac{X_L - X_C}{R}$

$= 1\,\phi = 45^\circ$

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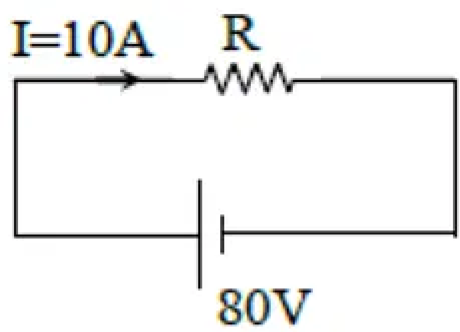
6. **Answer: d**

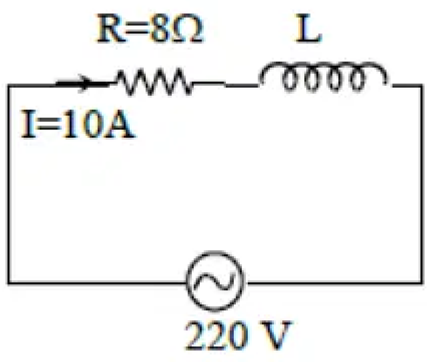
Explanation:

For dc



$R = \frac{80}{10} = 8\omega$

For ac



$$10 = \frac{220}{\sqrt{R^2+\omega^2L^2}}$$
$$R^2 + \omega^2L^2 = \left(\frac{220}{10}\right)^2$$
$$L^2 = \frac{22^2-8^2}{\omega^2}$$
$$\therefore L = \frac{\sqrt{30\times14}}{2\pi\times50} = \frac{\sqrt{420}}{100\pi} = 0.065\,H$$

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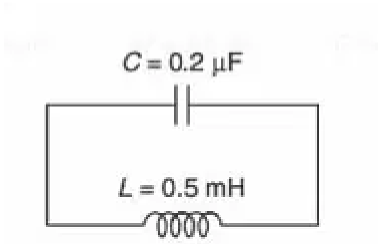
7. Answer: c

Explanation:

The given circuit is



Given: capacitor is charged to a potential difference of $10\,V \Rightarrow V_0 = 10\,V$
Therefore, charge on capacitor, $Q_0 = CV_0 = 0.2\,\mu F \times 10\,V$
Now, $E_c =$ Energy stored in capacitor $= \frac{1}{2}CV_0^2$
$\Rightarrow E_C = \frac{1}{2} \times 0.2\mu F \times (10V)^2 = 10\mu J = 10 \times 10^{-6}\,J$
When inductor is connected in parallel with the capacitor in the circuit, the energy stored in capacitor when potential difference across capacitor is $V' = 5K$ is
$E'_C = \frac{1}{2}CV'^2 = \frac{1}{2} \times 0.2\mu F \times (5V)^2$
$= 2.5\mu\,J = 2.5 \times 10^{-6}\,J$
Therefore, Energy stored in inductor $= E_c - E'_c = 10 \times 10^{-6} J - 2.5 \times 10^{-6}\,J$
$= 7.5 \times 10^{-6}\,J$
Also, we know energy stored in inductor $= \frac{1}{2}LI^2$
$\Rightarrow \frac{1}{2}LI^2 = 7.5 \times 10^{-6}$
$\Rightarrow I^2 = \frac{7.5\times10^{-6}\times2}{0.5\,mH} = 30 \times 10^{-3}$
$\Rightarrow I = \frac{\sqrt{3}}{10} = 0.17\,A$

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---

8. **Answer: b**

Explanation:

$$q = \int I dt$$
$$q = \int_0^{L/R} \frac{E}{R}\left[1 - e^{\frac{-Rt}{L}}\right] dt$$
$$q = \frac{EL}{R^2}\frac{1}{e}$$
$$q = \frac{EL}{2.7R^2}$$

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9. **Answer: 40 - 40**

Explanation:

The correct answer is 40.
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

$X_L = X_C$

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

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

$\therefore C = 40\mu F$

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10. **Answer: 242 - 242**

Explanation:

The correct answer is 242.

$X_L = X_C$

So, $Z = R = 20\Omega$

$i_{rms} = \frac{220}{20} = 11$

$i_{\max} = 11\sqrt{2} = \sqrt{242}$

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