PHYSICS

BOOKS - HC VERMA

ALTERNATING CURRENT

Examples

1. The peak value of an alternating current is 5A and its frequency is 60Hz. Find its rms value. How long will the cukrgrenQt current IS 5 A and its frequency is 60 Hz. Find its runs value.

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2. Find the reactance of a capacitor $(C = 200\mu F)$ when it is connected to (a) $a10HzACsource$, (b) $a50HzAC$ source and (c) $a500HzAC$ source.

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3. An inductor $(L = 200mH)$ is connected to an AC source of peak $emf210V$ and frequency $50Hz$. Calculate the peak current. What is the instantaneous voltage of the source when the current is at its peak value?

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4. An LCR series circuit with $L = 100mH, C = 100\mu F, R = 120\Omega$ is connected to an AC source of emf $\varepsilon = (30V)\sin\left(100s^{-1}\right)t$. Find the impedance, the peak current and the resonant frequency of the circuit.

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5. A radio set operates at $6VDC$. A transformer with 18 turns in the secondary coil is used to step down the input $220VACemf \rightarrow 6VACemf$. This $ACemf$ is then rectified by another circuit to give $6VDC$

which is fed to the radio. Find the number of turns in the primary.

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Worked Out Examples

1. A resistance of 20Ω is connected to a source of alternating current rated $110V, 50Hz$. Find (a) the rms current, (b) the maxium instantaneous current in the resistor and (c) the time taken by the current to change from its maximum value to the rms value.

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2. The current in a discharging LR circuit is given by $I = i_0 e^{-\frac{t}{\tau}}$ where τ is the time constant of the circuit. Calculate the rms current for the period $t = 0$ to $t = \tau$.

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3. A coil having a resistance of 50.0Ω and an inductance of $0.500 henry is co \cap ected \rightarrow an$AC $source of$110 volts, 50.0` cycle//s. Find the rms value of the current in the circuit.

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4. A capacitor of capacitance $100\mu F$ and a coil of resistance 50Ω and inductance $0.5H$ are connected in series with $a110V, 50HzAC$ source. Find the rms value of the current.

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5. A capacitor of capacitance $12.0\mu F$ is joined to an AC source of frequency $200Hz$. The rms current in the circuit is $2.00A$. (a) Find the rms voltage across the capacitor. (b) Find the average energy stored in the electric field between the plates of the capacitor.

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6. A series AC circuit contains an inductor $(20mH)$, a capacitor $(100\mu F)$, a resistor (50Ω) and an AC source of $12V, 50Hz$. Find the energy dissipated in the circuit in $1000s$.

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7. An inductor of inductance $100mH$ is connected in series with a resistance, a variable capacitance and an AC source of frequency $2.0kHz$. What should be the value of the capacitance so that maximum current may be drawn into the circuit?

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8. An inductor coil joined to a $6V$ battery draws a steady current of $12A$. This coil is connected to a capacitor and an AC source of rms voltage $6V$ in series. If the current in the circuit is in phase with the emf, find the rms current.

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Short Answer

1. What is the reactance of a capacitor connected to a constant DC source?

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2. The voltage and current in a series AC circuit are given by

$V = V_0 \cos \omega t \text{ and } I = i_0 \sin \omega t.$

What is the power dissipated in the circuit?

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3. Two alternating currents are given by

$i_1 = i_0 \sin \omega t$ and $i_2 = i_0 \sin\left(\omega t + \frac{\pi}{3}\right)\Big)$.

Will the rms values of the currents be equal or different?

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4. Can the peak voltage across the inductor be greater than the peak voltage of the source in an LCR circuit?

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5. In a circuit containing a capacitor and an AC source, the current is zero at the instant the source voltage is maximum. Is it consistent with Ohm's law?

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6. An AC source is connected to a capacitor. Will the rms current increase, decrease or remain constnat if a dielectric slab is inserted into the capacitor?

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7. When the frequency of the AC source in an LCR circuit equals the resonant frequency, the reactance of the circuit is zero. Does it mean that there is no current through the inductor or the capacitor?

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8. When an AC source is connected to a capacitor there is a steady-state current in the circuit. Does it mean that the charges jump from one plate to the other to complete the circuit?

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9. A current $i_1 = i_{10} \sin \omega t$ passes through a resistor of resistance R. How much thermal energy is produced in one time period? A current $i_2 = -i_0 \sin \omega t$ passes through the resistor. How much thermal energy is produced in one time period? If i_1 and i_2 both pass through the resistor simultaneously, how much thermal energy is produced? Is the principle of superposition obeyed in this case?

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10. Is energy produced when a transformer steps up the voltage?

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11. A transformer is designed to convert an AC voltage of $110V$ to an AC voltage of $12V$. If the input terminals are connected to a DC voltage of $110V$, the transformer usually burns. Explain.

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12. Can you have an AC series circuit in which there is a phase difference of (a) 180^0 (b) 120^0 between the emf and the current?

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13. A resistance is connected to an AC source. If a capacitor is included in the series circuit, will the average power absorbed by the resistance increase or decrease? If an inductor of small inductance is also included in the series circuit, will the average power absorbed increase or decrease further?

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14. Can a hot-wire ammeter be used to measure a direct current having a constant value? Do we have to change the graduation?

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Objective 1

1. A capacitor acts as an infinite resistance for

A. DC

B. AC

C. DC as well as AC

D. Neither AC nor DC

Answer: A

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2. An AC source producing emf

$$\varepsilon = \varepsilon_0 \left[\cos\left(100\pi s^{-1}\right)t + \cos\left(500\pi s^{-1}\right)t\right]$$

is connected in series with a capacitor and a resistor.

The steady-state current in the circuit is found to be

$$I = i_1 \cos\left[\left(100\pi s^{-1}t + \varphi_1\right] + i_2 \cos\left[\left(500\pi s^{-1}\right)t + \phi_2\right]$$

.

A. $i_1 > i_2$

B. $i_1 = i_2$

C. $i_1 < i_2$

D. The information is insufficient to find the relation between i_1 and i_2.

Answer: C

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3. The peak voltage in a $220VAC$ source is

A. $220V$

B. about $160V$

C. about $310V$

D. $440V$

Answer: C

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4. An AC source is rated $220V, 50Hz$. The average voltage is calculated in a time interval of $0.01s$. It

A. must be zero

B. may be zero

C. is never zero

D. is $\left(\frac{220}{\sqrt{2}}\right)V$

Answer: B

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5. The magnetic field energy in an inductor changes from maximum value to minimum value in $5.0ms$ when connected to an AC source. The frequency of the source is

A. $20Hz$

B. $50Hz$

C. $200Hz$

D. $500Hz$.

Answer: B

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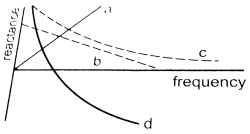
6. Which of the following plots may represent the reactance of a series LC combination?



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7. A series AC circuit has a resistance of 4Ω and a reactance of 3Ω. The impedance of the circuit is

A. 5Ω

B. 7Ω

C. $\frac{12}{7}\Omega$

D. $\frac{7}{12}\Omega$

Answer: A

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8. Transformer are used in .....

A. in DC circuits only

B. in AC circuits only

C. in both DC and AC circuits

D. neither in DC nor in AC circuits

Answer: B

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9. An alternating current is given by the equation $i = (i_1 \cos \omega t + i_2 \sin \omega t)$. The rms current is given by .....

A. $\frac{i_1 + i_2}{\sqrt{2}}$

B. $\frac{|i_1 + i_2|}{\sqrt{2}}$

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

D. $\sqrt{\frac{i_1^2 + i_2^2}{\sqrt{2}}}$

Answer: C

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10. An alternating current having peak value $14A$ is used to heat a metal wire. To produce the same heating effect, a constant current i can be used where i is

A. $14A$

B. about $20A$

C. $7A$

D. about $10A$

Answer: D

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11. A constant current of $2.8A$ exists in a resistor. The rms current is

A. $2.8A$

B. about $20A$

C. $1.4A$

D. undefined for a direct current

Answer: A

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Objective 2

1. An inductor, a resistor and a capacitor are joined in series with an AC source. As the frequency of the source is slightly increased from a very low value, the reactance

A. of the inductor increases

B. of the resistor increases

C. of the capacitor increases

D. of the circuit increases

Answer: A

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2. The reactance of a circuit is zero. It is possible that the circuit contains

A. an inductor and a capacitor

B. an inductor but no capacitor

C. a capacitor but no inductor

D. None of the Above

Answer: A

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3. In an AC series circuit, the instanctaneous current is zero when the instantaneous voltage is xamimum. Connected to the source may be a

A. pure inductor

B. pure capacitor

C. pure resistor

D. combination of an inductor and a capacitor

Answer: A::B::D

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4. An inductor-coil having some resistance is connected to an AC source. Which of the following quantities have zero average value over a cycle?

A. Current

B. Induced emf in the inductor

C. Joule heat

D. Magnetic energy stored in the inductor

Answer: A::B::D

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5. The AC voltage across a resistance can be measured using

A. a potentiometer

B. a hot-wire voltmeter

C. a moving-coil galvanometer

D. a moving magnet galvanometer

Answer: B

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6. To convert mechanical energy into electrical energy, one can use

A. DC dynamo

B. AC dynamo

C. motor

D. transformer

Answer: A::B::D

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7. An AC source rated $100V(rms)$ supplies a current of $10A(rms)$ to a circuit. The average power delivered by the source

A. must be $1000W$

B. may be $1000W$

C. may be greater than $1000W$

D. may be less than $1000W$

Answer: B::D

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Exercises

1. Find the time required for a 50Hz alternating current to become its value from zero to the rms value.

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2. The household supply of electricity is at $220V$ (rms value) and $50Hz$. Find the peak voltage and the least possible time in which the voltage an change from the rms value to zero.

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3. A bulb rated $60W$ at $220V$ is connected across a household supply of alternating voltage of $220V$. Calculate the maximum instantaneous current through the filament.

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4. An electric bulb is designed to operate at $12v$ DC. If this bulb is connected to an AC source and gives normal brightness, what would be the peak voltage of the source?

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5. The peak power consumed by a resistive coil when connected to an AC source is $80W$. Find the energy consumed by the coil in 100 seconds which is many times larger than the time period of the source.

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6. The dielectric strength of air is $3.0 \times 10^6 \frac{V}{m}$. A parallel-plate air-capacitor has area $20cm^2$ and plate separation $0.10mm$.Find the maximum rms voltage of an AC source which can be safely connected to this capacitor.

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7. The electric current in a circuit is given by $I = i_0\left(\frac{t}{\tau}\right)$ for some time. Calculate the rms current for the period $t = 0$ to $t = (\tau)$.

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8. A capacitor of capacitance $10\mu F$ is connected to an oscillator giving an output voltage $\varepsilon = (10V)\sin\omega t$. Find the peak currents in the circuit for $\omega = 10s^{-1}, 100s^{-1}, 500s^{-1}, 1000s^{-1}$.

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9. A coil of inductance $5.0mH$ and negligible resistance is connected to the oscillator of the previous problem. Find the peak currents in the circuit for $\omega = 100s^{-1}, 500s^{-1}, 1000s^{-1}$.

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10. A coil has a resistance of 10Ω and an inductance of 0.4 henry. It is connected to an AC source of $6.5V, \frac{30}{\pi}Hz$. Find the average power consumed in the circuit.

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11. A resistor of resistance 100Ω is connected to an AC source $\varepsilon = (12V)\sin\left(250\pi s^{-1}\right)t$. Find the energy dissipated as heat during $t = 0$ to $t = 1.0ms$.

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12. In a series RC circuit with an AC source, $R = 300\Omega, C = 25\mu F, \varepsilon_0 50V$ and $v = \frac{50}{(\Pi)Hz}$. Find the peak current and the average power dissipated in the circuit.

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13. An electric bulb is designed to consume $55W$ when operated at 110 volts. It is connected to a $220V, 50Hz$ line through a choke coil in series. What should be the inductance of the coil for which the bulb gets correct voltage?

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14. In a series LCR circuit with an AC source, $R = 300\Omega, C = 20\mu F, L = 1.0henry, \varepsilon_{rms} = 50V$ and $v = \frac{50}{\pi} Hz$. Find (a) the rms current in the circuit and (b) the rms potential differences across the capacitor, the resistor and the inductor. Note that

the sum of the rms potential differences across the three elements is greater than the rms voltage of the source.

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15. Consider the situation of the previous problem. Find the average electric field energy stored in the capacitor and the average magnetic field energy stored in the coil.

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16. An inductance of $2.0H$, a capacitance of $18\mu F$ and a resistance of $10k\Omega$ are connected to an AC source of $20V$ with adjustable frequency. (a) What frequency should be chosen to maximise the current in the circuit? (b) What is the value of this maximum current?

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17. A coil a capacitor and an AC source of rms voltage $24V$ are connected in series. By varying the frequency of the source, a maximum rms current of 6 A is observed. If coil is connected is at DC batteryof

emf 12 volt and internal resistance 4Ω, then current through it in steady state is

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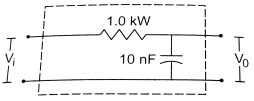
18. Figure shows a typical circuit for low-pass filter. An AC input $V_i = 10mV$ is applied at the left end and the output V_0 is received at the right end. Find the output voltages for $v = 10kHz, 100kHz, 1.0MHz$ and $10.0MHz$. Note that as the frequency is increased the output decreases and hence the name low-pass filter.



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19. A transformer has 50 turns in the primary and 100 in the secondary. If the primary is connected to a $220VDC$ supply, what will be the voltage across the secondary?

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