Year 13 Science: AC circuits

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Find the peak voltage of a 12.0 V rms AC supply.

2. Find the reactance of a 0.0500 H inductor at 1000 Hz.

3. A 1.00 kΩ resistor and a 2.20 µF capacitor are in series with a 10.0 V rms, 100 Hz supply. Find X_C, the impedance and the current.

4. An AM tuner has a 250 µH coil and a 177 pF capacitor. Find its resonant frequency.

Exam-style question: a series LCR circuit

In a school lab, a 50.0 Ω resistor, a 0.150 H inductor and a 22.0 µF capacitor are connected in series to a 6.00 V rms supply whose frequency can be varied.

5. Calculate the resonant frequency of the circuit.

6. Calculate the rms current at resonance.

7. Calculate the rms current when the frequency is 50.0 Hz.

8. At 50.0 Hz, state whether the current leads or lags the supply voltage, calculate the phase angle, and explain why.

Fix the mistake

9. Correct this statement: "The supply voltage is 7.28 + 9.54 = 16.8 V."

10. Correct this statement: "Mains is 230 V, so the voltage never goes above 230 V."

11. Correct this statement: "In an inductor the current leads the voltage."

12. Correct this statement: "X_L = fL = 50.0 × 0.500 = 25.0 Ω."

Answer key (for parents and tutors)

1. Find the peak voltage of a 12.0 V rms AC supply.
   $V_{max} = \sqrt{2} \times 12.0 = 17.0$ V.
2. Find the reactance of a 0.0500 H inductor at 1000 Hz.
   $X_L = 2\pi fL = 2\pi \times 1000 \times 0.0500 = 314\ \Omega$.
3. A 1.00 kΩ resistor and a 2.20 µF capacitor are in series with a 10.0 V rms, 100 Hz supply. Find X_C, the impedance and the current.
   $X_C = 1 \div (2\pi \times 100 \times 2.20 \times 10^{-6}) = 723\ \Omega$; $Z = \sqrt{(1000^2 + 723^2)} = 1234\ \Omega$, about 1.23 kΩ; $I = 10.0 \div 1234 = 8.10 \times 10^{-3}$ A (8.10 mA).
4. An AM tuner has a 250 µH coil and a 177 pF capacitor. Find its resonant frequency.
   $f_0 = 1 \div (2\pi\sqrt{(250 \times 10^{-6} \times 177 \times 10^{-12})}) = 7.57 \times 10^5$ Hz, about 757 kHz.
5. Calculate the resonant frequency of the circuit.
   $f_0 = 1 \div (2\pi\sqrt{(0.150 \times 22.0 \times 10^{-6})}) = 1 \div (2\pi \times 1.817 \times 10^{-3}) = 87.6$ Hz (Achieved).
6. Calculate the rms current at resonance.
   At resonance $X_L = X_C$, so $Z = R = 50.0\ \Omega$ and $I = 6.00 \div 50.0 = 0.120$ A (Merit with the reason).
7. Calculate the rms current when the frequency is 50.0 Hz.
   $X_L = 2\pi \times 50.0 \times 0.150 = 47.1\ \Omega$; $X_C = 1 \div (2\pi \times 50.0 \times 22.0 \times 10^{-6}) = 144.7\ \Omega$; $Z = \sqrt{(50.0^2 + (47.1 - 144.7)^2)} = 109.6\ \Omega$; $I = 6.00 \div 109.6 = 0.0547$ A (Excellence for the full calculation).
8. At 50.0 Hz, state whether the current leads or lags the supply voltage, calculate the phase angle, and explain why.
   Below resonance X_C is larger than X_L, so the capacitor's voltage outweighs the inductor's and the circuit behaves as a capacitor: the current leads the supply voltage. $\tan\varphi = (X_C - X_L) \div R = 97.6 \div 50.0$, so $\varphi = 62.9°$. On the phasor diagram the net reactive voltage points down, so the supply voltage lies below the current phasor (Excellence links the reactances to the phase).
9. Correct this statement: "The supply voltage is 7.28 + 9.54 = 16.8 V."
   V_R and V_L are 90° out of phase, so they add as phasors: $\sqrt{(7.28^2 + 9.54^2)} = 12.0$ V.
10. Correct this statement: "Mains is 230 V, so the voltage never goes above 230 V."
    230 V is the rms value; the peak is $230 \times \sqrt{2} = 325$ V.
11. Correct this statement: "In an inductor the current leads the voltage."
    In an inductor the voltage leads the current by 90°; in a capacitor the current leads.
12. Correct this statement: "$X_L = fL = 50.0 \times 0.500 = 25.0\ \Omega$."
    $X_L = \omega L = 2\pi fL$, so it is 157 Ω; leaving out 2π is a common slip.