Alternating Current

Standard difficulty · 20 questions · 40 marks · Time: 38 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. The peak value of a 110 V (rms) supply is:
(a) 110/√2 V **(b)** 110 V **(c)** 220 V **(d)** 110√2 V

2. The reactance of an 18×10^{-2} H inductor at an angular frequency of 950 rad/s is:
(a) 171 Ω **(b)** 0.00585 Ω **(c)** 342 Ω **(d)** 17.1 Ω

3. The reactance of a 1 μF capacitor at an angular frequency of 800 rad/s is:
(a) 12,500 Ω **(b)** 0.0008 Ω **(c)** 625 Ω **(d)** 1,250 Ω

4. In a series LCR circuit, R = 16 Ω, X_L = 64 Ω and X_C = 52 Ω. The impedance is:
(a) 12 Ω **(b)** 132 Ω **(c)** 20 Ω **(d)** 28 Ω

5. The rms value of an alternating current with peak I_0 is:
(a) $I_0/\sqrt{2}$ **(b)** $2I_0$ **(c)** $I_0\sqrt{2}$ **(d)** $I_0/2$

6. The power factor of a series circuit with R = 6 Ω, X_L = 10 Ω and X_C = 18 Ω is:
(a) 3/5 **(b)** 1 **(c)** 4/5 **(d)** 3/4

7. A series circuit has L = 1.5 H and C = 24 μF. Its resonant angular frequency is:
(a) 166.67 rad/s **(b)** 333.33 rad/s **(c)** 83.33 rad/s **(d)** 1,666.67 rad/s

8. Assertion (A): In a series LCR circuit with L = 0.1 H and C = 40 μF, the current is greatest at ω = 500 rad/s.
Reason (R): At resonance X_L = X_C, so the impedance equals R and is at its smallest.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. A 150 V (rms) supply drives a series circuit with R = 12 Ω, X_L = 58 Ω and X_C = 49 Ω. Find the current and the voltage across each element.

10. For a series circuit with R = 20 Ω, X_L = 30 Ω and X_C = 51 Ω across 290 V (rms), find the power factor and the average power.

11. An ideal transformer has 700 primary turns and 1500 secondary turns, with 2200 V across the primary. Find the secondary voltage, and the primary current when the secondary supplies 7 A.

12. A series circuit has R = 70 Ω, L = 1 H and C = 4 μF. Find the resonant angular frequency and the quality factor.

13. A 20 μF capacitor is connected to a 220 V, 50 Hz supply. Find its reactance and the rms current.

14. A pure inductor of 14×10^{-1} H is connected to a 220 V, 60 Hz supply. Find its reactance and the rms current.

15. A transformer takes 14 A at 220 V and is 85% efficient. Find the output power.

16. Find the phase angle between current and voltage in a series circuit with R = 10 Ω, X_L = 45 Ω and X_C = 69 Ω, and say which leads.

Section C — Word problems — 4 × 4 = 16 marks

17. A series LCR circuit has R = 80 Ω, X_L = 15 Ω and X_C = 99 Ω across a 464 V (rms) supply. Find the impedance, the current, the power factor, the average power and the voltage across each element.

18. A 90 V (rms) variable-frequency supply drives a series circuit with R = 90 Ω, L = 1.2 H and C = 30 μF. Find the resonant angular frequency, the current at resonance, and the voltage across the inductor then.

19. A step-down transformer changes 220 V to 11 V and has 1,600 turns in its primary. It supplies 1200 W to a load. Assuming it is ideal, find the number of secondary turns and the currents in both coils.

20. A power station sends 600 kW along lines of total resistance 8 Ω at 22,000 V. Find the current and the power lost in the lines. What is the loss if the voltage is first stepped up 10 times?

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Answer key

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Q	Answer	Working
1	**(d) 110√2 V**	$V_0 = \sqrt{2}\, V_{rms}$
2	**(a) 171 Ω**	$X_L = \omega L$
3	**(d) 1,250 Ω**	$X_C = 1/(\omega C)$
4	**(c) 20 Ω**	$Z = \sqrt{(R^2 + (X_L - X_C)^2)} = \sqrt{(16^2 + 12^2)}$
5	**(a) $I_0/\sqrt{2}$**	—
6	**(a) 3/5**	$\cos\varphi = R/Z = 6/10$
7	**(a) 166.67 rad/s**	$\omega_0 = 1/\sqrt{(LC)} = 1/\sqrt{(1.5 \times 24 \times 10^{-6})}$
8	**(a) Both A and R are true, and R is the correct explanation of A.**	A is true: $\omega_0 = 1/\sqrt{(LC)} = 500$ rad/s. R is true and explains A.
9	**I = 10 A; V_R = 120 V, V_L = 580 V, V_C = 490 V**	Z = 15 Ω
10	**20/29; 2,000 W**	$P = V_{rms} I_{rms} \cos\varphi = I^2R$
11	**4,714.29 V; 15 A**	$V_s/V_p = N_s/N_p$; $V_pI_p = V_sI_s$
12	**500 rad/s; Q = 7.14**	$\omega_0 = 1/\sqrt{(LC)}$; $Q = \omega_0 L/R$
13	**$500/\pi$ Ω; $4.4\pi \times 10^{-1}$ A**	$X_C = 1/(2\pi fC)$; $I = V/X_C$
14	**$1.68\pi \times 10^2$ Ω; $55/(42\pi)$ A**	$X_L = 2\pi fL$; $I = V/X_L$
15	**2,618 W**	P_{out} = 85% of 220 × 14
16	**$\tan\varphi = 12/5$, $\varphi = \tan^{-1}(12/5)$; the current leads the voltage**	$\tan\varphi = \lvert X_L - X_C\rvert/R$; Z = 26 Ω
17	**Z = 116 Ω; I = 4 A; $\cos\varphi = 20/29$; P = 1,280 W; V_R = 320 V, V_L = 60 V, V_C = 396 V**	$Z = \sqrt{(R^2 + (X_L - X_C)^2)}$
18	**166.67 rad/s; 1 A; 200 V (the same across the capacitor)**	at resonance Z = R; $V_L = I\,\omega_0 L$
19	**80 turns; secondary 109.09 A; primary 5.45 A**	$N_s/N_p = V_s/V_p$; P = VI on each side
20	**27.27 A; 5.95 kW; 0.0595 kW (100 times smaller)**	$I = P/V$; loss = I^2R

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