ENG18

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BSC(HONS) MECHATRONICS

SEMESTER 1 EXAM 2024-25

ELECTRONIC ENGINEERING FOR MECHATRONICS

MODULE NO: MEC6005

Date: Thursday 9th January 2025 **Time: 10:00am – 12:00pm**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions.

Answer ANY FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Formulae sheet is attached at the end of the paper.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

Question 1

a) Based on the waveform below in Fig. Q1a, work out the following terms

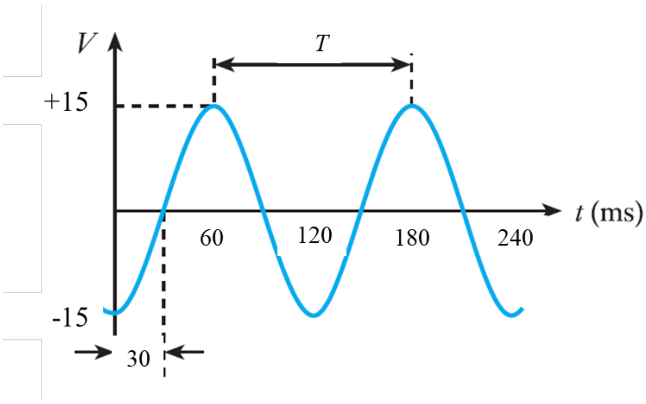

Fig. Q1a Waveform of voltage signal

i. Period
ii. Frequency
iii. Peak to peak value
iv. RMS value
v. The equation of this voltage signal

[10 marks]

b) For the diagram in Fig.Q1b, calculate the equivalent resistance R_E between terminals *a* and *b*.

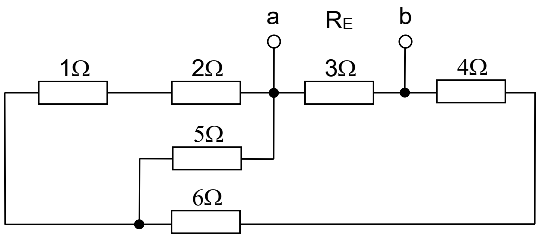

Fig. Q1b Circuit diagram to calculate equivalent resistance

[8 marks]

c) An AC ammeter reads 8 A rms current through a resistive load, and a voltmeter reads 230 V rms drop across the load.

(i) What are the peak value of the alternating current, and the average value of the alternating voltage? **[5 marks]**

(ii) Calculate the load resistance. **[2 marks]**

Total Marks: 25

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Question 2

a) For the circuit shown below (Fig. Q2a), considering the RLoad as the load resistance, V1 = 1V, R1 = 100Ω, R2 = 47Ω, R3 = 22Ω, R4 = 100Ω, RL = 47Ω.

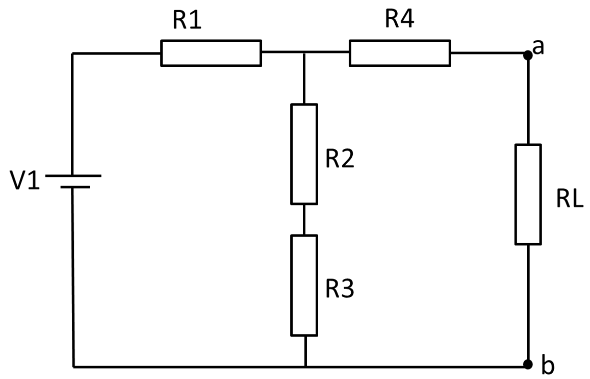

Fig. Q2a Circuit Diagram

(i) Derive the equivalent Thevenin circuit between points “a” and “b” **[10 marks]**

(ii) Derive the equivalent Norton circuit between points “a” and “b” **[5 marks]**

b) A 13 μF capacitor has 12 V across it. What quantity of charge is stored in it? **[2 marks]**

c) For the capacitor **charging** circuit shown in Figure Q2b below, where the capacitor is initially discharged, sketch two separate graphs for the current *I* versus time and the capacitor voltage V_c versus time. **[6 marks]**

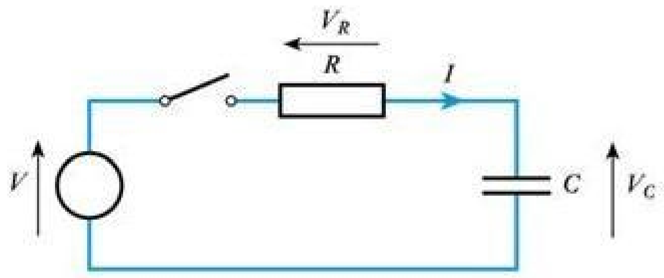

Fig. Q2b An initially uncharged capacitor being charged through a resistor.

Q2 continues over the page
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Q2 continued

d) Explain with the assistance of a diagram what happens to the structure of the curves for *I* versus time and V_c versus time if the time constant $\tau = RC$ for the circuit increases?

[2 marks]

Total Marks : 25

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Question 3

a) For the combinational digital circuit shown below in Fig. Q3a:

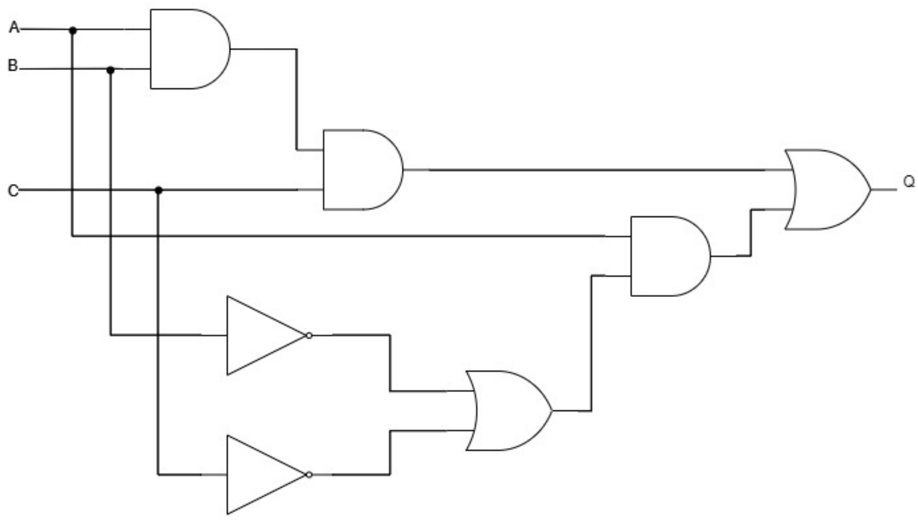

Figure Q3a Digital Circuit diagram with 3 inputs and 1 output

i) Find out the Boolean expressions at output Q. **[5 marks]**
ii) Simplify the expression obtained using Boolean algebra **[4 marks]**
iii) Write the truth table for this digital circuit **[10 marks]**

b) Fill in the blanks by converting the following numbers into their respective missing decimal and binary equivalents:

i) $11000_2 = \_\_\_\_\_\_\_\__{10}$

ii) $1001_2 + 011_2 = \_\_\_\_\_\_\_\__{10}$

iii) $A2_{16} = \_\_\_\_\_\_\_\__{10}$

iv) $\_\_\_\_\_\_\__2 = 26_{10}$

[6 marks]

Total Marks: 25

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Question 4

For the circuit shown in Fig. Q4, calculate:

a) Currents I1, I2, and I3 **[9 marks]**
b) Voltages across R1, R2, and R3 **[6 marks]**
c) Powers P1, P2, and P3 **[3 marks]**
d) Draw the complete voltages and currents phasor diagram **[3 marks]**
e) The peak I3 current at resonance frequency **[4 marks]**

Where $v = 17cos314t$, $R_1 = R_2 = 2\Omega$, $R_3 = 4\Omega$, $X_{L2} = j2\Omega$, $X_{L3} = j6\Omega$, $X_C = -j4\Omega$

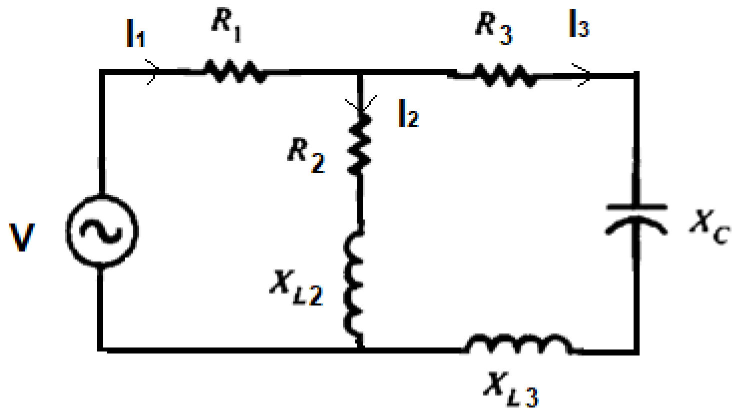

Fig. Q4 circuit diagram

Total Marks: 25

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Question 5

a) For the following circuit (Fig. Q5a), using superposition theorem or otherwise, find out the current flowing through the 10 Ω resistor.
[10 marks]

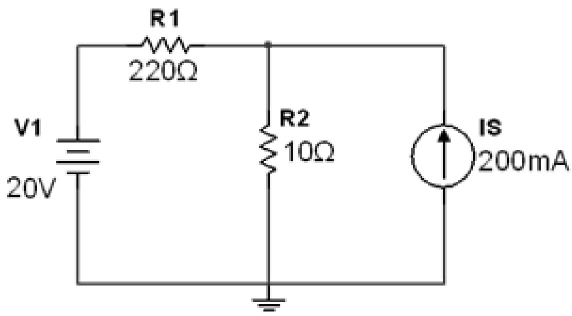

Fig. Q5a circuit diagram with both voltage source and current source

b) In a Wheatstone bridge ABCD, a galvanometer is connected between B & D, and a battery of 6V emf is connected between A & C. A resistor of unknown resistance, R1, is connected between A & B, the resistance between B&C is R2 = 50Ω, between C&D is R3 = 20Ω and between D&A is R4 = 100Ω. When the bridge is balanced, Calculate:

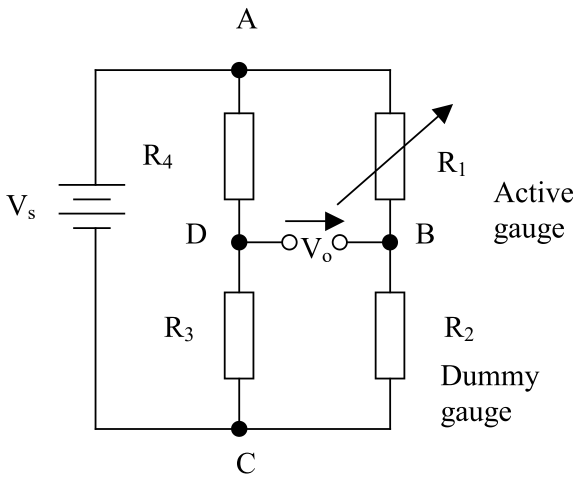

Fig. Q5b Wheatstone bridge circuit with strain gauges

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Q5 continued

(i) the value of unknown resistance between point A & B **[7 marks]**

(ii) an applied loading causes the active strain gauge R1 to have a resistance increase of R = 0.5 ohm. Find the bridge output voltage, Vo, under this condition.

[8 marks]

Total Marks: 25

END OF QUESTIONS

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APPENDIX: Formula Sheet

The following symbols in the formulae have their standard meaning:

Ohm's law: $V = IR$

Power: $P = IV$

Magnetic flux: $\Phi = BA$

Induced voltage: $V = \Delta\Phi/\Delta t$

Force experienced by charged particle = $qvBsin\theta$

Motional emf: $E = Blv$

$f = \frac{pn}{120}$

Magnitude of the Reactance of Inductor L: $X_L = 2\pi fL$

Magnitude of the Reactance of Capacitor C: $X_C = \frac{1}{2\pi fC}$

Pythagorean theorem: $c^2 = a^2 + b^2$

Tangent function: tanA=opposite/adjacent

$\mu_o = 4\pi X10^{-7}H/m$, $\epsilon_o = 8.85X10^{-12}F/m$

$H = \frac{N.I}{l}$, $B=uH$

MMF=N.I

$L = \frac{\mu_o\mu_r AN^2}{l}$, $E = \frac{1}{2}LI^2$

C=Q/V , $C=\frac{\epsilon A}{d}$, $E=\frac{1}{2}CV^2$

$v_L = L.\frac{di_L}{dt}$

$i_C = C\frac{dv_C}{dt}$

$f = \frac{pn}{120}$

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Transformer voltage ratio: $\frac{V_1}{V_2} = \frac{N_1}{N_2}$, $P=V_1.I_1=V_2.I_2$

Multiply the Value	By	To Get the Value
Peak	2	Peak-to-peak
Peak-to-peak	0.5	Peak
Peak	0.637	Average
Average	1.570	Peak
Peak	0.707	RMS (effective)
RMS (effective)	1.414	Peak
Average	1.110	RMS (effective)
RMS (effective)	0.901	Average

Summary Table for Series and Parallel *RL* Circuits

X_L and R in Series	X_L and R in Parallel
I the same in X_L and R $V_T = \sqrt{V_R^2 + V_L^2}$ $Z = \sqrt{R^2 + X_L^2} = \frac{V_T}{I}$ V_R lags V_L by 90° $\theta = \arctan \frac{X_L}{R}$	V_T the same across X_L and R $I_T = \sqrt{I_R^2 + I_L^2}$ $Z_T = \frac{V_T}{I_T}$ I_L lags I_R by 90° $\theta = \arctan \left(-\frac{I_L}{I_R}\right)$

Summary Table for Series and Parallel *RC* Circuits

X_C and R in Series	X_C and R in Parallel
I the same in X_C and R $V_T = \sqrt{V_R^2 + V_C^2}$ $Z = \sqrt{R^2 + X_C^2} = \frac{V_T}{I}$ V_C lags V_R by 90° $\theta = \arctan \left(-\frac{X_C}{R}\right)$	V_T the same across X_C and R $I_T = \sqrt{I_R^2 + I_C^2}$ $Z_T = \frac{V_T}{I_T}$ I_C leads I_R by 90° $\theta = \arctan \frac{I_C}{I_R}$

Boolean algebra rules

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1. $A + 0 = A$	7. $A \cdot A = A$
2. $A + 1 = 1$	8. $A \cdot \overline{A} = 0$
3. $A \cdot 0 = 0$	9. $\overline{\overline{A}} = A$
4. $A \cdot 1 = A$	10. $A + AB = A$
5. $A + A = A$	11. $A + \overline{A}B = A + B$
6. $A + \overline{A} = 1$	12. $(A + B)(A + C) = A + BC$

END OF PAPER