UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BSc(Hons) MECHATRONICS

SEMESTER 1 EXAMINATION 2023-24

ELECTRONIC ENGINEERING FOR MECHATRONICS

MODULE NO: MEC6005

Date: Thursday 11th January 2024 **Time: 10:00 – 12:00**

INSTRUCTIONS TO CANDIDATES:

There are SIX 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.

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Question 1

a) Define the following terms (**1.5 marks for each definition**):

i. Current
ii. Resistance
iii. Phase angle
iv. Internal resistance **[6 marks]**

b) You did a measurement between two points in your circuit, and the measured waveform shown on the oscilloscope is presented in the Figure 1.b. Based on the diagram, work out the following: **(2 marks for each)**

i. Frequency
ii. Period
iii. Peak to Peak value
iv. RMS Value
v. The equation of this voltage signal [**10 marks]**

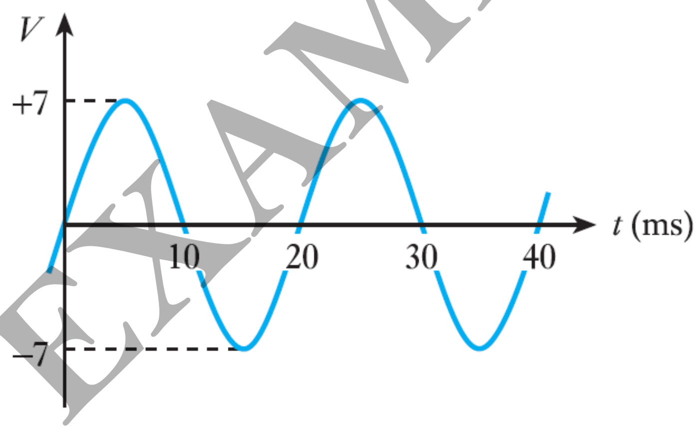

Figure 1.b, Diagram of the measured voltage signal

c) An AC ammeter reads 11A rms current through a resistive load, and a voltmeter reads 350V rms drop across the load.

(i) What are the peak values and the average values of the alternating current and voltage? **[6 marks]**

(ii) Calculate the load resistance. **[3 marks]**

Total Marks: 25
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Question 2:

a) For the circuit shown below (Figure 2.a), considering the RLoad as the load resistance

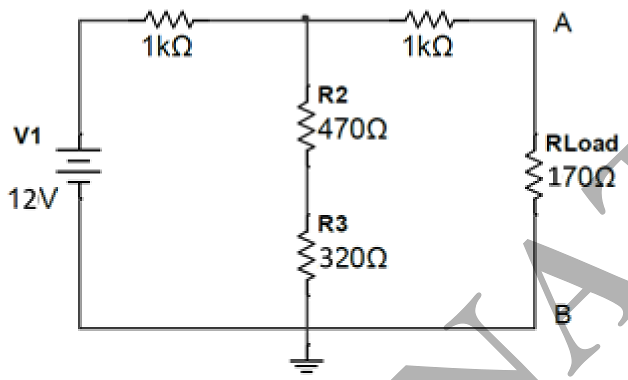

Figure 2.a

(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) For the following circuit (Figure 2.b), using superposition theorem or otherwise, find out the current flowing through the 10 Ω resistor.

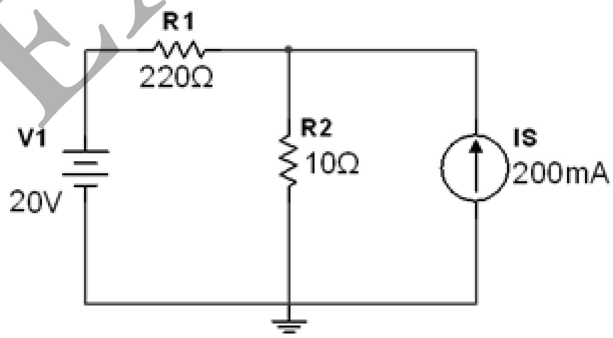

Figure 2.b

[10 marks]

Total Marks: 25

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Question 3

a) Draw a diagram of a parallel plate capacitor showing the charge on the plates and the **E** field in the region between the plates. **[4 marks]**

b) Explain what is meant by the dielectric strength $\mathbf{E_m}$ of an insulator? **[5 marks]**

c) A 15 μF capacitor has 12 V across it. What quantity of charge is stored in it? **[5 marks]**

d) For the capacitor **charging** circuit shown in Figure 3.d 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]**

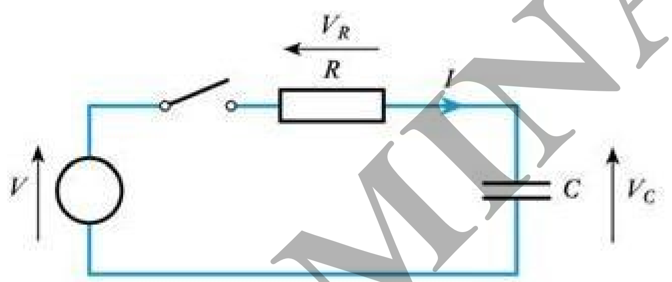

Figure 3.d An initially uncharged capacitor being charged through a resistor.

e) 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?

[5 marks]

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Question 4

a) For the combinational digital circuit shown below in Figure 4.a:

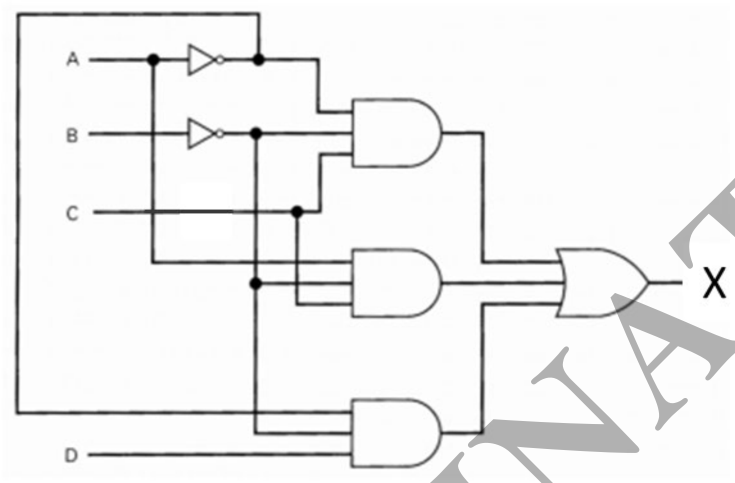

Figure 4.a Digital Circuit diagram

i) Find out the Boolean expressions at output Q. **[5 marks]**

ii) Complete the truth table for this digital circuit: **[9 marks]**

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

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

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

iii) $\_\_\_\_\_\_\__{16}$ = 1306_{10}

iv) $1101_2 + 101_2$ = $\_\_\_\_\_\_\_\_\__2$ = $\_\_\_\_\_\_\_\_\_\__{10}$

[5 marks]

c) Explain what are Von Neuman and Harvard Architectures in computer architectures and identify at least two differences?

[6 marks]

Total Marks: 25

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Question 5

For the circuit shown in figure 5, 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 $v = 17cos314t$, $R_1 = R_2 = 2\Omega$, $R_3 = 4\Omega$, $X_{L2} = j2\Omega$, $X_{L3} = j6\Omega$, $X_C = -j4\Omega$

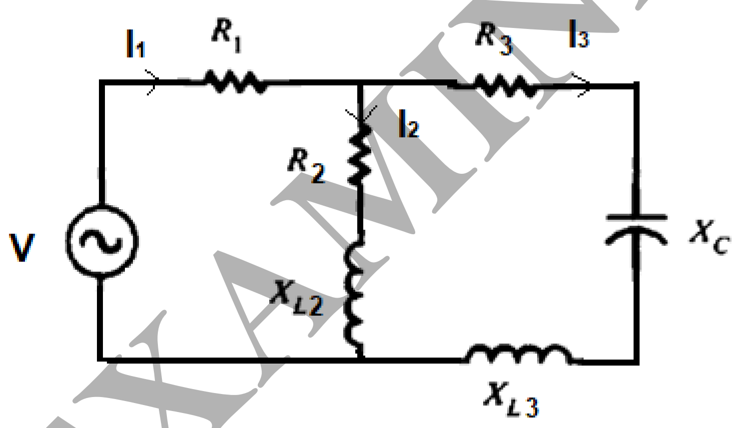

Figure 5

Total Marks: 25

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Question 6

a) A wheatstone bridge arrangement uses strain gauges and resistances of nominal value $R_2 = R_3 = R_4 = 150$ ohm, and a 12V excitation voltage. R1 is the active gauge and R2 is the dummy gauge.

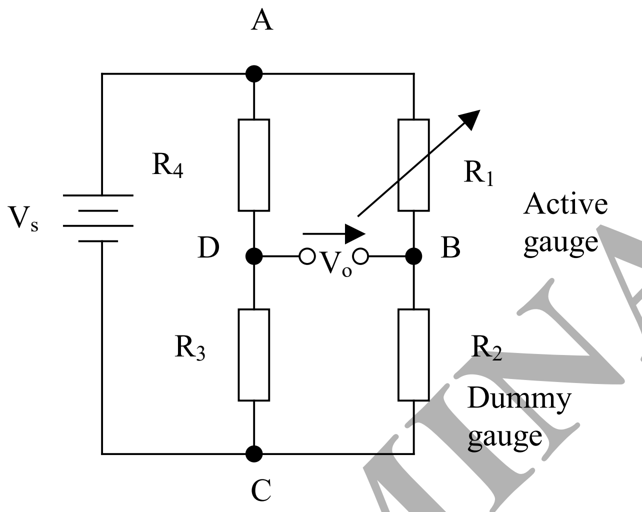

Figure 6.a Wheatstone bridge circuit with strain gauges.

i) When the bridge is balanced, what value R1 should be? **[3 marks]**
ii) An applied loading causes the active strain gauge R1 to have a resistance increase of R = 0.0145 ohm. Find the bridge output voltage, V_o, under this condition. **[6 marks]**
iii) A temperature change causes the two strain gauges to have a resistance change of 8.6 ohm. Find the output voltage in the presence of both stress and temperature resistance changes. **[8 marks]**

b) For diagram in Figure 6.b, calculate the equivalent resistance RE between terminals a and b.

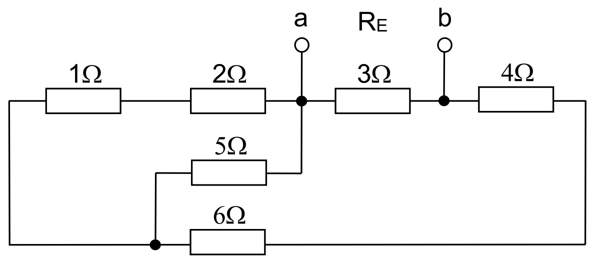

Figure 6.b **[8 marks]**

Total Marks: 25

End of questions
Formula Sheet follows over the page

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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 = $qvB\sin\theta$

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

$L = \frac{\mu_o \mu_r A N^2}{l}$, $E = \frac{1}{2} L I^2$

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

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

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

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

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

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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° $\theta = \arctan \frac{I_C}{I_R}$

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