[ENG25]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BSC(Hons) MECHATRONICS

SEMESTER 1 EXAM 2022-23

ELECTRONIC ENGINEERING FOR MECHATRONICS

MODULE NO: MEC6005

Date: Wednesday 11th January 2023 **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.

School of Engineering
BSc(Hons) Mechatronics
Semester 1 Exam 2022-23
Electronic Engineering for Mechatronics
Module No. MEC6005

Question 1

a) The alternating voltages shown in Fig1(a) is connected across a 10 kΩ resistor. Calculate;
   (i) The RMS current, **[4 marks]**
   (ii) The Frequency **[4 marks]**
   (iii) The mean power dissipated in the resistor **[4 marks]**

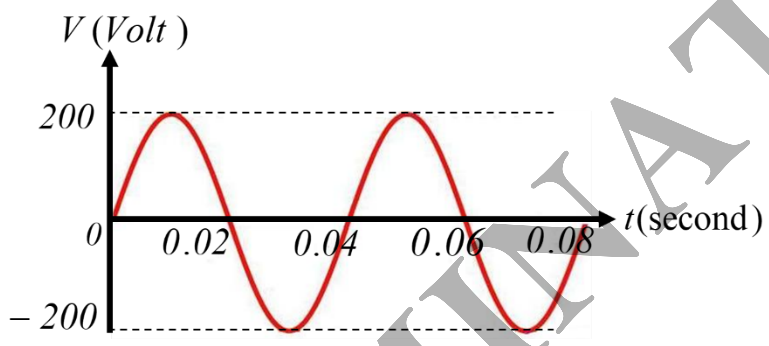

Fig 1(a)

b) Derive the instantaneous equation that predicts the waveform in Fig1(a) and calculate the value when t = 1.25 ms. **[8 marks]**

c) Find the Thevenin equivalent of the circuit given in Fig 1(b) . **[5 marks]**

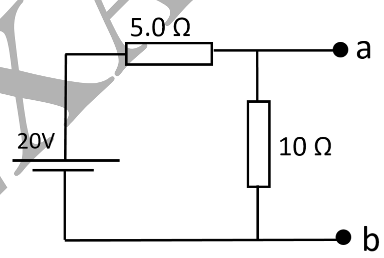

Fig.1b

Total Marks: 25

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School of Engineering
BSc(Hons) Mechatronics
Semester 1 Exam 2022-23
Electronic Engineering for Mechatronics
Module No. MEC6005

Question 2:

a) For the circuit shown below (Figure Q2.a), considering the R2 as the load resistance

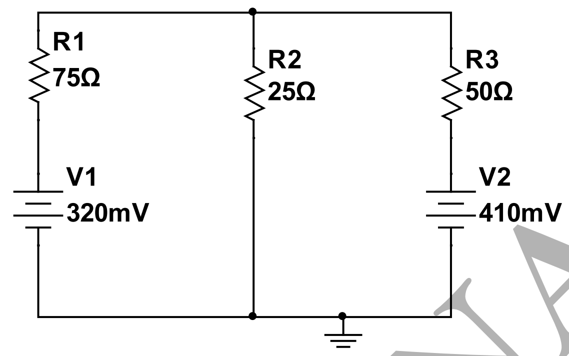

Figure Q2a

(i) Calculate all the currents and voltages using mesh current analysis. **[10 marks]**

(ii) Calculate the power in the resistors. **[5 marks]**

b) For the following circuit (Figure Q2b), using superposition theorem or otherwise, find out the current flowing through the 10 Ω resistor.

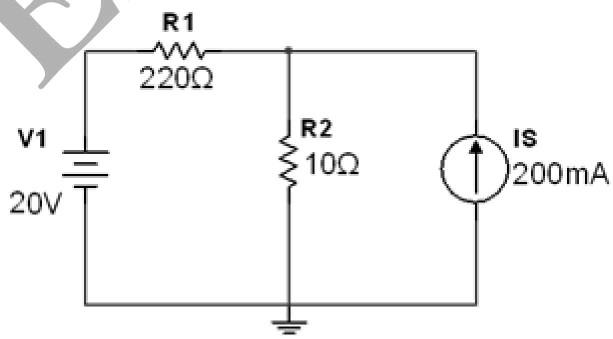

Figure Q2b

[10 marks]

Total Marks: 25

Please turn the page….

School of Engineering
BSc(Hons) Mechatronics
Semester 1 Exam 2022-23
Electronic Engineering for Mechatronics
Module No. MEC6005

Question 3

a) A 10 μF capacitor has 15 V across it. What quantity of charge is stored in it? **[5 marks]**

b) Draw a diagram of a parallel plate capacitor showing the charge on the plates and the **E** field in the region between the plates. **[5 marks]**

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

d) For the capacitor **charging** circuit shown in Figure Q3d 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. **[5 marks]**

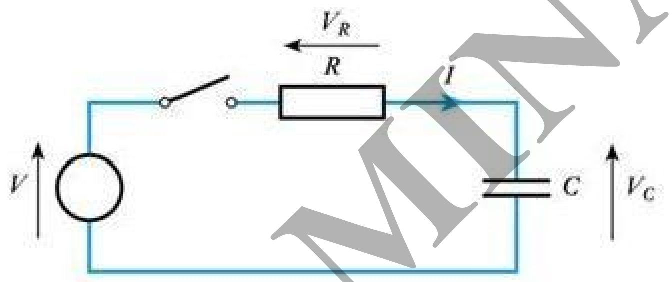

Figure Q3d An initially uncharged capacitor being charged through a resistor.

e) Calculate the time for the capacitor to reach 63% of it’s final voltage if the resistor has a value of 10kΩ and the capacitor is 15μF.

[5 marks]

Total Marks: 25

Please turn the page….

School of Engineering
BSc(Hons) Mechatronics
Semester 1 Exam 2022-23
Electronic Engineering for Mechatronics
Module No. MEC6005

Question 4

For the circuit shown in figure Q4 , calculate:

a) The impedance of the two parallel networks and total circuit impedance. **[7 marks]**
b) Currents IA, IB, and IT. **[5 marks]**
c) The circuit phase angle between V1 and IT. **[3 marks]**
d) Voltages across the series and parallel impedances V1 and V2. **[10 marks]**

Where V1 = 91 $\angle \mathbf{0^0} \boldsymbol{V}$ L1= j1.02Ω. L2 = j7Ω, C1 = -J15Ω

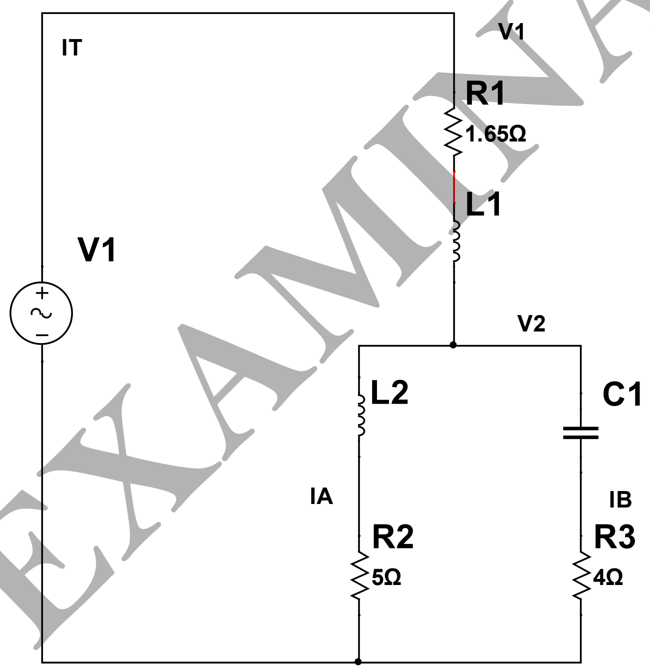

Figure Q4

Total Marks: 25

Question 5

a) For the combinational digital circuit shown below in Figure. Q5a:

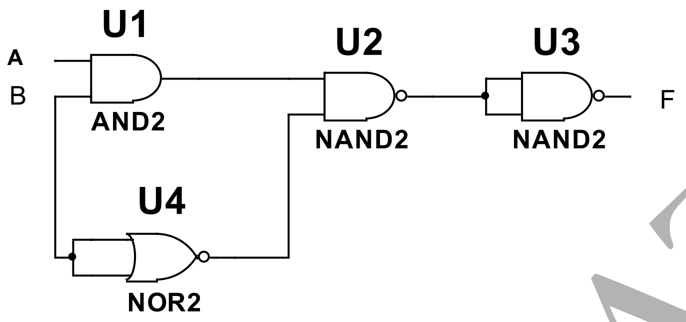

Figure Q5a Digital Circuit

i) Derive the Boolean equation for the output F. **[7 marks]**

ii) Simplify the circuit using Boolean algebra. **[8 marks]**

iii) Replace the simplified circuit with a new circuit. [**5 marks]**

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

i) 11001_2 = $\_\_\_\_\_\_\_\__{10}$

ii) 1000101_2 = $\_\_\_\_\_\_\_\__{10}$

iii) $B2_{16}$ = $\_\_\_\_\_\_\_\__{10}$

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

v) $\_\_\_\_\_\_\__{16}$ = 26_{10}

[5 marks]

Total Marks: 25

Please turn the page….

Question 6

(a) For the summing amplifier shown in Fig 6a, calculate Vo. **[10 marks]**

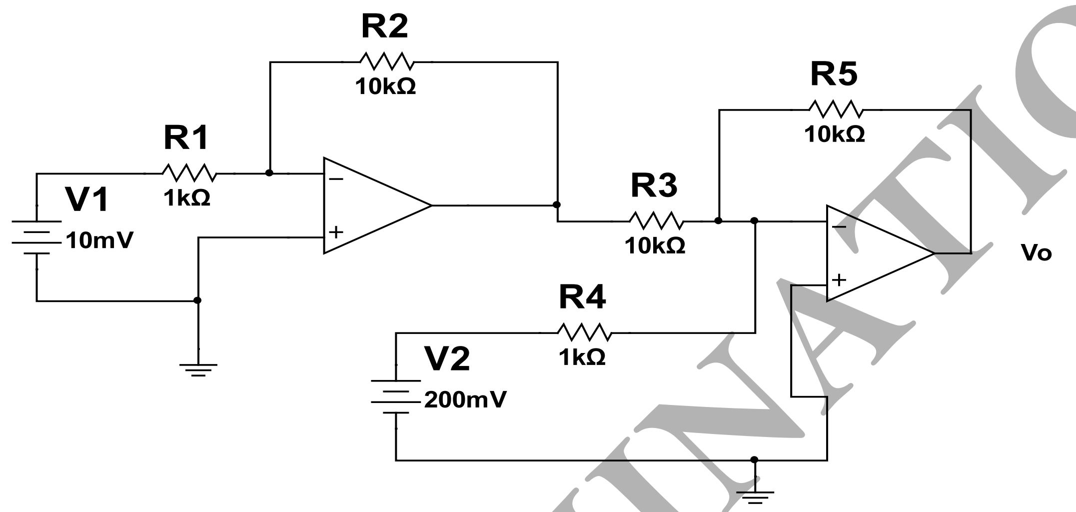

Fig 6a

(b) For the first order filter shown in Fig 6b , derive the transfer function.

[10 marks]

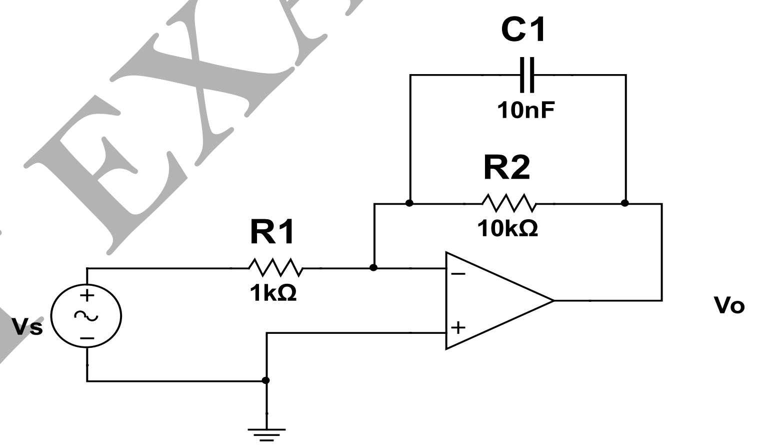

Fig 6b

(c) Calculate the corner frequency. **[5 marks]**

Total Marks: 25

END OF QUESTIONS

Formula Sheet continues over the page

Please turn the page….

School of Engineering
BSc(Hons) Mechatronics
Semester 1 Exam 2022-23
Electronic Engineering for Mechatronics
Module No. MEC6005

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: $E = Blv$

$f = pn/120$

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

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

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

Tangent function: tanA=opposite/adjacent

$\mu\_o = (4\pi X10^\wedge(-7)\ H)/m$, $\epsilon\_o = (8.85X10^\wedge(-12)\ F)/m$

$H = (N.I)/l$, $B=uH$

MMF=N.I

$L = (\mu\_o\ \mu\_r\ AN^\wedge 2)/l,$ $E = 1/2\ LI^\wedge 2$

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

$v\_L = L.(di\_L)/dt$

$i\_C = C\ (dv\_C)/dt$

$f = pn/120$

Transformer voltage ratio: ∠ , P=$V_1.I_1$=$V_2.I_2$

Please turn the page….

School of Engineering
BSc(Hons) Mechatronics
Semester 1 Exam 2022-23
Electronic Engineering for Mechatronics
Module No. MEC6005

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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