[ESS35]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) MECHATRONICS (TOP-UP)

SEMESTER 1 EXAMINATION 2019/2020

ELECTRONIC ENGINEERING FOR MECHATRONICS

MODULE NO: MEC6005

Date: Thursday 16th January 2020 **Time: 2:00pm – 4:00pm**

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) A coil of copper wire has a resistance of 200 Ω, when its temperature is 0 °C. Determine its resistance at 100°C if the temperature coefficient of resistance (TCR) of copper at 0 °C is 0.0043/ °C.

[3 marks]

b) For the following circuit (Figure Q1b), using superposition theorem or otherwise, find out the current flowing through the 20Ω resistor.

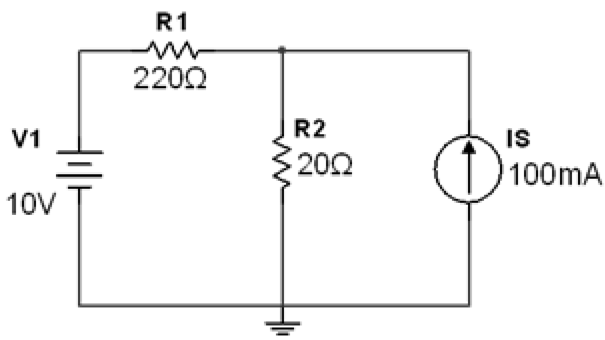

Figure Q1b

[10 marks]

c) For the following circuit (Figure Q1c), using nodal analysis or otherwise, find out the current flowing through the 120Ω resistor.

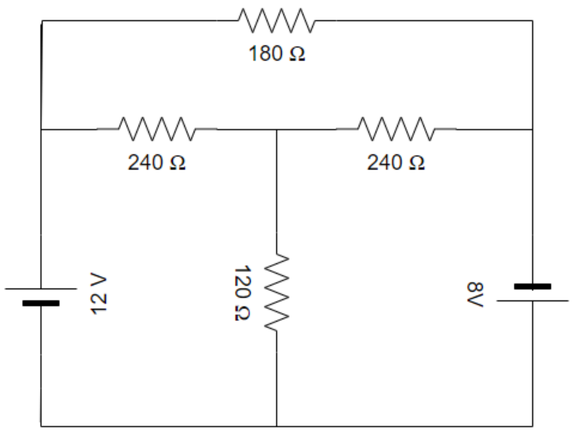

Figure Q1c

[12 marks]

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Total marks: 25
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Question 2:

a) For the circuit shown below (Figure Q2a), considering the RLoad as the load resistance

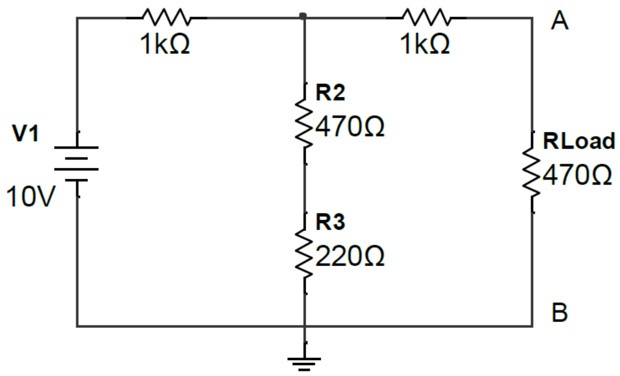

Figure Q2a

(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) Using mesh analysis or otherwise, for the circuit shown in Figure Q2b, find out the current flowing and power being dissipated through the 4Ω and 6Ω resistors.

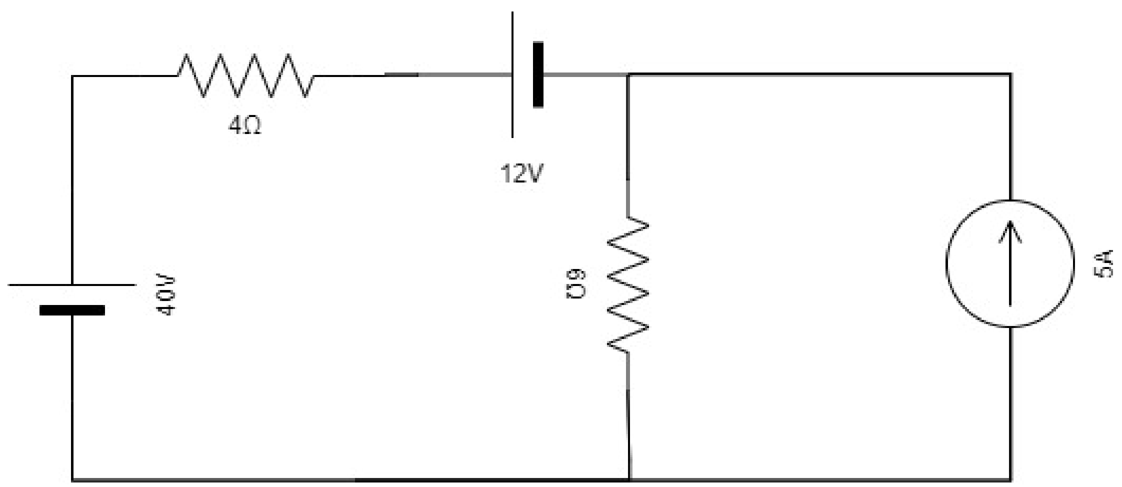

Figure Q2b

[10 marks]
Total Marks: 25
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Question 3

a) A 47 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]**

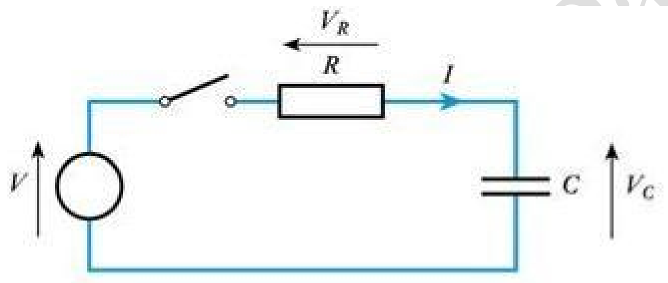

Figure Q3d; An initially uncharged capacitor being charged through a resistor.

e) 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]

Total Marks: 25

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Question 4

An AC source of voltage 750cos(5000t+30°) is applied to a series RLC circuit as shown in Figure Q4 below.

i) Calculate the total impedance of the circuit, Z. **[5 marks]**

ii) Calculate the current and phase angle between the voltage and current.

[8 marks]

iii) Calculate the resonance frequency. **[5 marks]**

iv) Is the circuit inductive or capacitive? **[3 marks]**

v) Draw the phasor diagram. **[4 marks]**

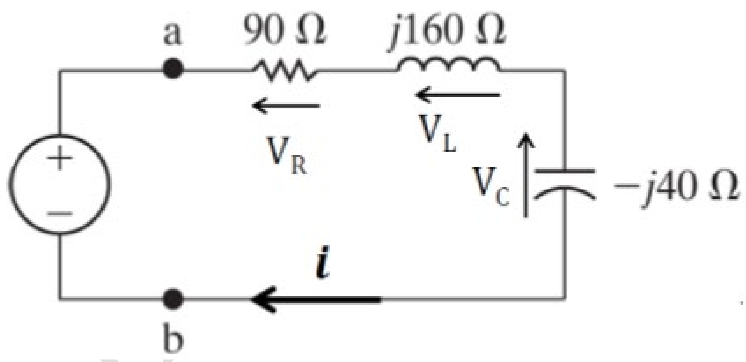

Figure Q4; An RLC series circuit

Total Marks: 25

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Question 5

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

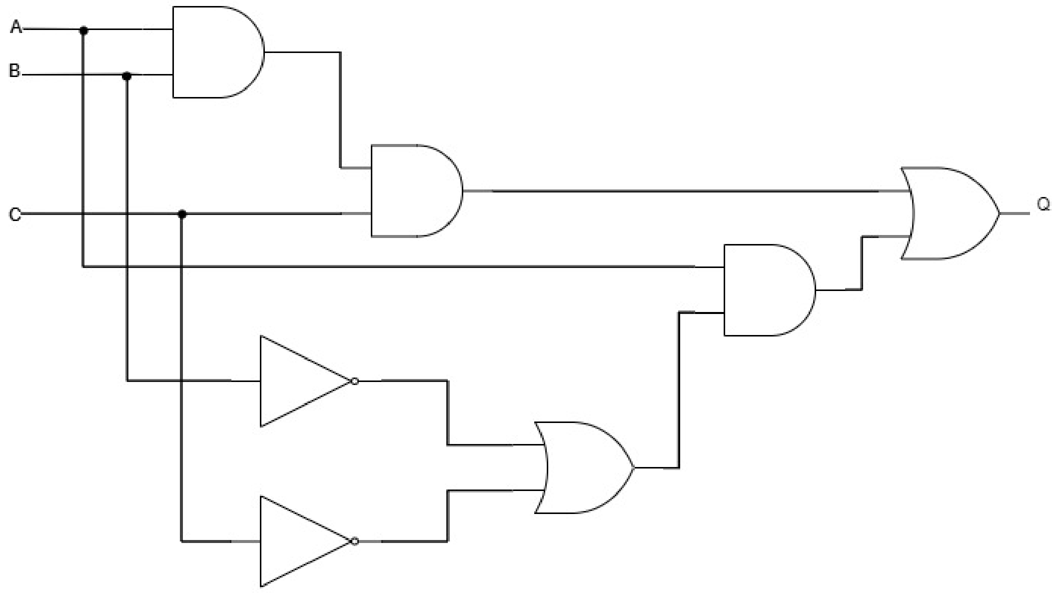

Figure Q5a: Digital Circuit

i) Find out the Boolean expressions at output Q. **[7 marks]**

ii) Complete the following 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) 101010_2 = $\_\_\_\_\_\_\_\__{10}$

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

iv) $\_\_\_\_\_\_\__{2}$ = 15_{10}

v) $\_\_\_\_\_\_\__{16}$ = 23_{10}

[5 marks]

Q5 continues over the page…

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Q5 continued…..

c) What does adding redundant information into numeric and alphabetic codes provide?

[3 marks]

Total Marks: 25

Question 6

a) Explain the purpose of Pseudocode in programming and its applications.

[5 marks]

b) Using an example, define what state machines are and explain their purpose.

[5 marks]

c) With the aid of state machines design techniques, design a state diagram showing a simple automated train ticket machine. Take into consideration the following requirements:

- Only 1 person can buy a train journey ticket each time.
- Each journey cost £5.00 and exact change is not needed.
- Accepts only the following currencies:

- Coins: £1, £2
- Note: £5 and £10.
- Refund of money from the machine is possible at any time.

[15 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 = $qvB\sin\theta$

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

$\mu_o = 4\pi X 10^{-7} H/m$, $\epsilon_o = 8.85 X 10^{-12} F/m$

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

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° $\theta = \arctan \frac{I_C}{I_R}$

END OF FORMULA SHEETS

END OF PAPER