UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BSC (HONS) MECHATRONICS

SEMESTER ONE EXAMINATION 2018/2019

ELECTRONIC ENGINEERING FOR MECHATRONICS

MODULE NO: MEC6005

Date: Thursday 17th January 2019 **Time: 14:00 – 16:00**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions.

Answer 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.

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) Using mesh analysis or otherwise, for the circuit shown in Fig. 1, find out the current flowing and power being dissipated through the 4Ω and 6Ω resistors.

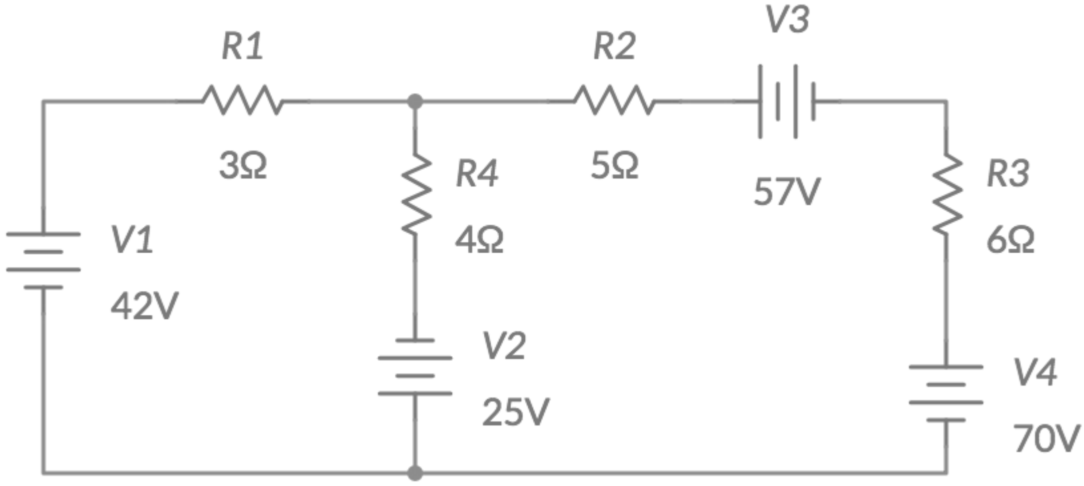

Fig. 1

[10 marks]

b) A straight wire carries a current of 0.75 A. What is the magnetic field strength H at a distance of 500 mm from the wire? **[3 marks]**

c) Design and draw a non-inverting amplifier with a gain of 125. You can choose any value of resistors in between 1-10 kΩ. **[5 marks]**

Question 1 continues over the page….

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Question 1 continued….

d) For the circuit shown below in Fig. 2, the values for capacitors are C1=60μF, C2=20 μF, C3=9 μF and C4=12 μF, respectively. If the potential difference between points "a" and "c" is V_{ac}= 120V, find the charge on the capacitor, C2.

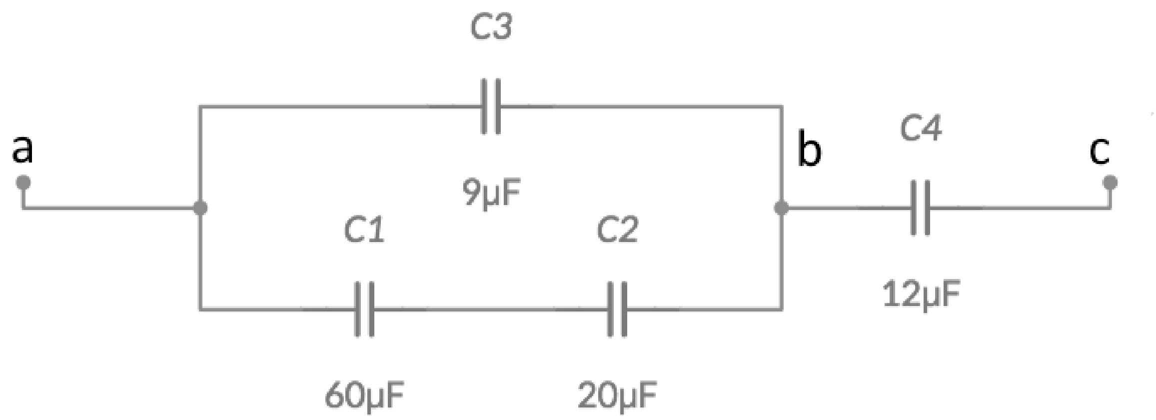

Fig. 2

[7 marks]

Total 25 marks

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Question 2.

a) For the circuit shown below in Fig. 3, assuming the 2Ω resistor as the load resistance, find out the:

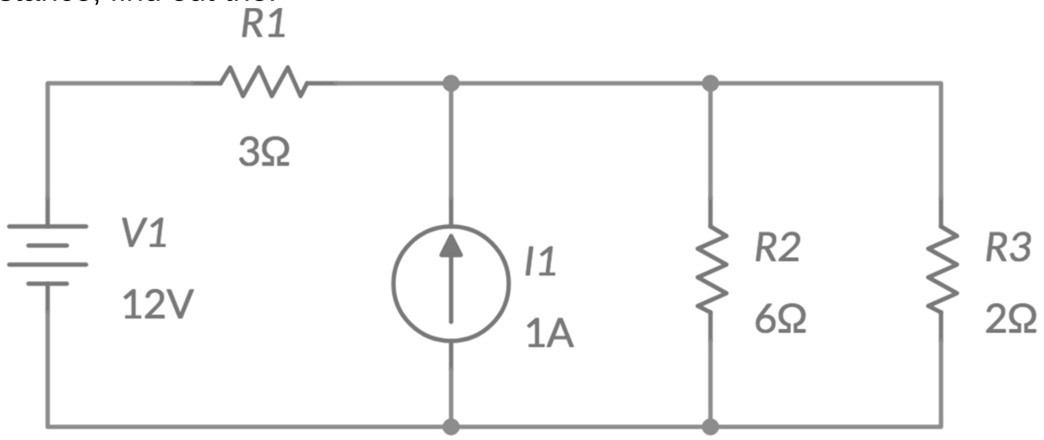

Fig. 3

(i) Equivalent Thevenin circuit. **[10 marks]**
(ii) Convert the equivalent Thevenin circuit to Norton circuit **[2.5 marks]**
(iii) Power dissipated in the load resistance **[5 marks]**

b) A rectangular coil measuring 200mm x 100mm is mounted in such a manner that it can be rotated around the midpoint of the 100 mm side. The axis of rotation is at right angle to a magnetic field of uniform flux density 0.1T. Calculate the flux in the coil for the following conditions:

(i) Maximum flux through the coil and the position at which it will occur **[2.5 marks]**

(ii) Flux through the coil when 100 mm side is inclined at 45^o to direction of the flux. **[2.5 marks]**

c) A steady state direct current of 4A passes through a solenoid coil of 0.5H. What would be the back emf voltage induced in the coil if the switch in this circuit were opened for 10 milliseconds and the current flowing through the coil dropped to 0A. **[2.5 marks]**

Total 25 marks

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Question 3

a) Using node analysis or otherwise, calculate the value of current "*I*" marked out with arrow in the circuit shown in Fig. 4:

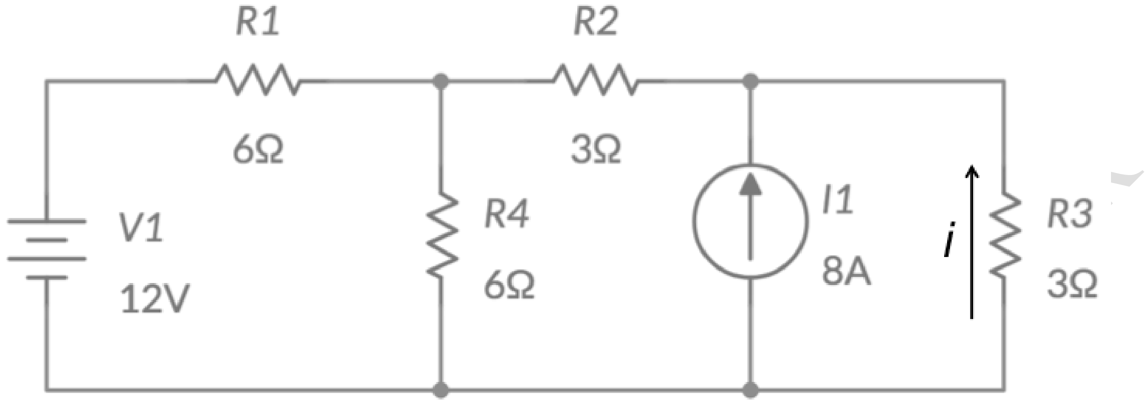

Fig. 4

[15 marks]

b) For an ideal operational amplifier, write down its three main characteristics.

[3 marks]

c) Fig. 5 shows the diagram of an inverting summing amplifier/ voltage adder circuit; with voltage inputs of V_1, V_2 and V_3 and an output voltage V

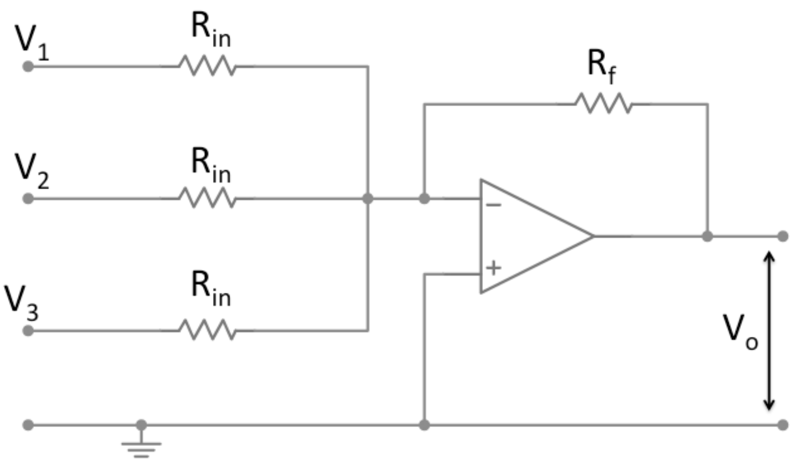

Fig. 5

(i) Find out the transfer function V_o/V_i of this amplifier circuit.

[5 marks]

(ii) If the values of V_1, V_2 and V_3 for such a circuit are 2mV, 5mV, 7mV with values of Rin being 1kΩ throughout and Rf of 10kΩ, what would be the value of Vo?

[2 marks]

Total 25 marks

Question 4.

a) Consider a series RLC circuit containing a resistor of 12Ω, an inductor of 0.15H and a capacitor of 100µF connected to an AC source of 100V, 50 Hz supply, as shown in Fig. 6. For this circuit, calculate the following:

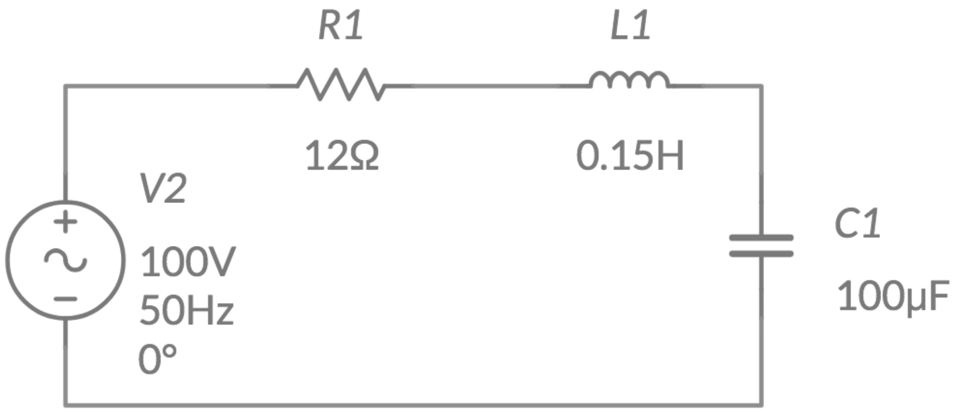

Fig. 6

(i) Total impedance, Z provided by the circuit **[5 marks]**
(ii) Current flowing in the circuit **[2 marks]**
(iii) Voltage drop across resistance, inductor and the capacitor **[3 marks]**
(iii) Draw the voltage phasor diagram and deduce the phase angle **[5 marks]**
(iv) Is the circuit inductive or capacitive? **[2 marks]**
(v) Series resonant frequency? **[3 marks]**

b) X, Y and Z are three sine AC voltage waveforms of the same frequency. The sine-wave X leads the sine-wave Y by a phase angle of 60° and lags the sine-wave Z by 70°.

(i) What is the phase angle between wave Y and wave Z? **[3 marks]**
(ii) Which wave is leading? **[2 marks]**

Total 25 marks

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Question 5.

a) For the combinational digital circuit shown below in Fig. 7:

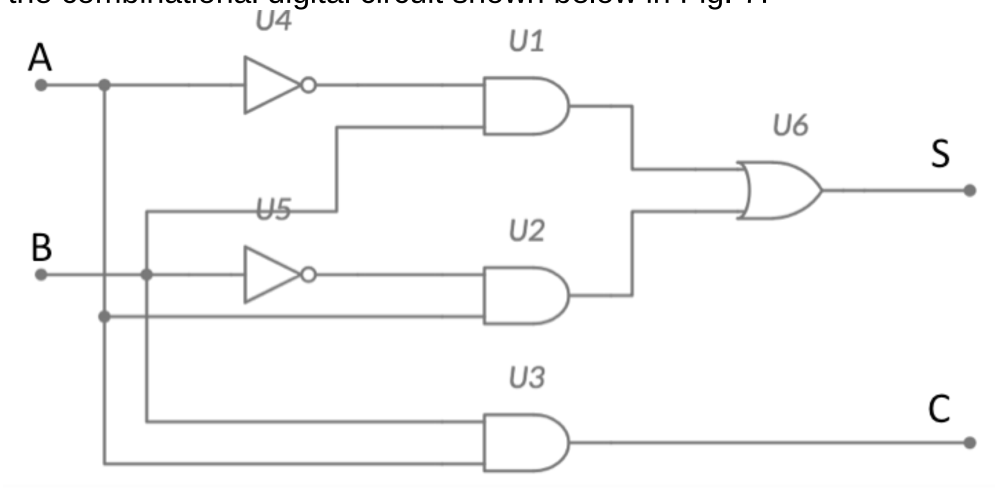

Fig. 7

(i) Find out the Boolean expressions at outputs S and C. **[5 marks]**

(ii) Complete the following truth table for this digital circuit: **[5 marks]**

Inputs				Outputs	
A	B	$\overline{A}$	$\overline{B}$	S	C

b) Show the operation of a J-K Flip Flop using a truth table

[5 marks]

Question 5 continues over the page….

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Question 5 continued….

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

(i) 10000_2 = $\_\_\_\_\_\_\_\__{10}$
(ii) 101010_2 = $\_\_\_\_\_\_\_\__{10}$
(iii) 101110_2 = $\_\_\_\_\_\_\_\__{10}$
(iv) $\_\_\_\_\_\_\__2$ = 11_{10}
(v) $\_\_\_\_\_\_\__2$ = 14_{10}

[5 marks]

d) Implement the following Boolean expression using appropriate logic gates:

$$Q=AB + BC(B+C)$$

[5 marks]

Total 25 marks

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Question 6.

Fig. 8 shows the diagram of a power supply consisting of an alternating current supply V, a transformer and circuit components. The circuit of electronic components consists of a bridge rectifier, a resistor, a capacitor and a Zener diode.

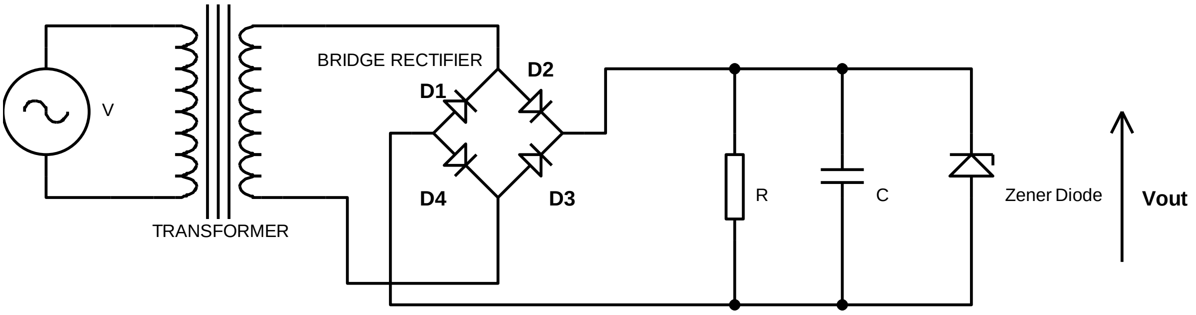

Fig. 8

(i)

Describe how the bridge rectifier functions together with resistor R. In your description draw the bridge circuit and show the direction of the current for each half cycle of the voltage supply.

[12 marks]

(ii) Describe how the capacitor C provides smoothing of the full-wave rectified voltage across the resistor R. As part of your description draw a diagram of the smoothed waveform across the resistor R and the half-cycle unsmoothed waveform on the same axis. Refer in your description to the charging and discharging time constants of the resistor and capacitor combination.

[8 marks]

(iii) Briefly describe how the Zener diode functions in the circuit.

[5 marks]

Total 25 marks

END OF QUESTIONS

Formula sheets 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: $V = \Delta\Phi/\Delta t$

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

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

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

Tangent function: tan A=opposite/adjacent

$\mu_o = 4\pi X 10^{-7} H/m$, $\epsilon_o = 8.85X10^{-12} F/m$

$H = \frac{N.I}{l}$

MMF=N.I

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

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

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

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

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

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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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