ENG04

UNIVERSITY OF BOLTON

ENGINEERING, SPORTS AND SCIENCES ACADEMIC GROUP

B.ENG (HONS) BIOMEDICAL ENGINEERING

SEMESTER 2 EXAMINATIONS - 2022/2023

MEDICAL SENSORY DEVICES & MEASUREMENT

MODULE NO: BME4004

Date: Tuesday 9th May 2023 **Time: 2:00pm – 4:00pm**

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.

Electronic calculators may be used provided that data and program storage memory is cleared prior to the examination.

CANDIDATES REQUIRE:

Formula Sheet (attached).

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Question 1

a) A straight wire carries a current of 5 A. What is the magnetic field strength H at a distance of 56 mm from the wire? **[5 marks]**

b) A 300 μC charge is available in a 20V capacitor. What is its capacitance value in $\mu Farads$? **[5 marks]**

c) What is the capacitive reactance of a 20 μF working on 500 Hz? **[5 marks]**

d) A 5 A. current flows through a 100-turns coil.

i) What is the value of the magnetic motive force produced by this coil?

[4 marks]

ii) What is the reactance of a 1mH coil operating at 1kHz **[4 marks]**

iii) What is its inductance permability.

[2 marks]

Total 25 marks

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Question 2

Fig.1 shows an RLC series circuit.

(a) Determine the values of:

i. The circuit impedance Z **[5 marks]**

ii. The circuit current I **[3 marks]**

iii. The phase difference between the supply voltage and the circuit current **[3 marks]**

(b) Is the circuit inductive or capacitive using the voltage phasor diagram **[5 marks]**

(c) Calculate the resonant frequency of the circuit and the peak current flowing in the circuit at the resonant frequency **[9 marks]**

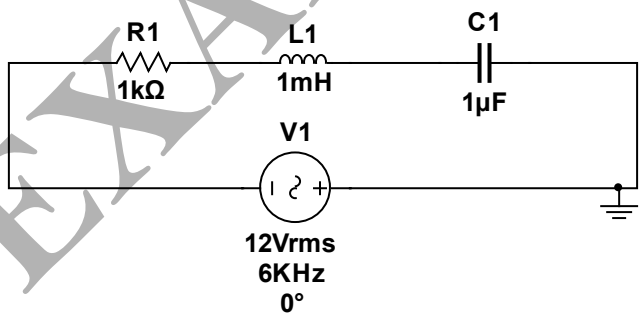

Fig.1 RLC series circuit **Total 25 marks**

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Question 3

(a) A resistive circuit is shown in Fig.2

(i) Explain the Thévenin's and Norton's Theorems and draw their equivalent circuit respectively. **[4 marks]**

(ii) Determine Thévenin and Norton equivalent circuits of the circuit in Fig.2 **[6 marks]**

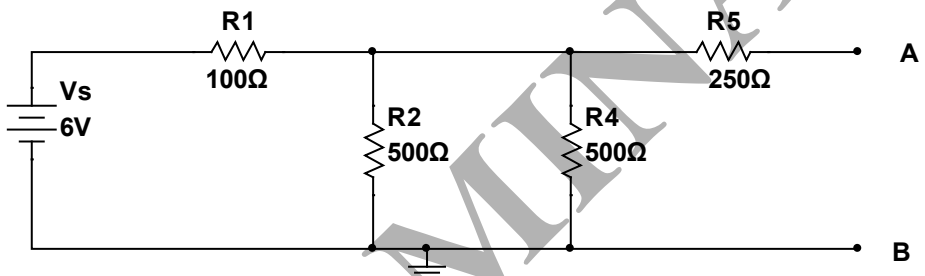

Fig.2

(b) For the circuit shown in Fig.3 below, Find:

(i) the voltage across R_1 using the superposition method **[9 marks]**

(ii) the current flowing through the R_2 resistor **[6 marks]**

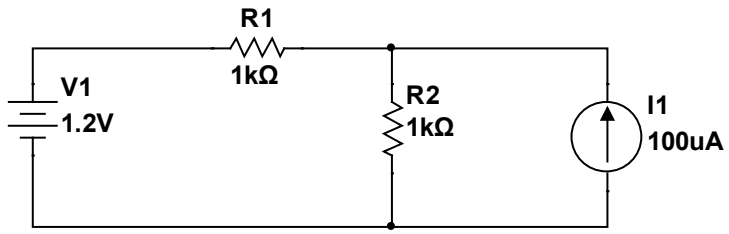

Fig.3

Total 25 marks

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Question 4

(a) For a single-phase transformer of rated power of 200 V.A, what would be:
(i) its secondary voltage **[3 marks]**
(ii) its primary and secondary currents **[4 marks]**

If it has a turns ratio ($\frac{N_1}{N_2}$) of 25:1(step down) and when it is connected to a supply mains of 240 V, 50 Hz.

(b) For the circuit shown in Fig 4, sketch the input waveform. **[3 marks]**
(c) Calculate the time constant in Fig 4. **[5 marks]**
(d) If a stepped voltage is applied to Fig 4, sketch the output wave- form and indicate the time when the capacitor has charged fully. **[10 marks]**

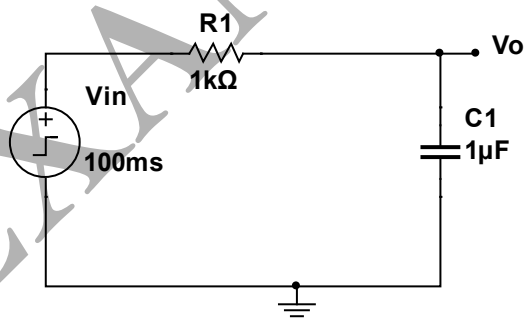

Fig 4

Total 25 marks

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Question 5

(a) An A.C. waveform is described by the equation, $V(t) = 100mV \sin(1000t)$ Calculate the peak, the angular velocity, and the period, sketch the waveform. **[5 marks]**

(b) Calculate the instantaneous value for the waveform in part (a) when the time is 1ms. **[4 marks]**

(c) If the waveform in part(a) is applied to 1kΩ calculate the average power and energy after 2 seconds. **[4 marks]**

(d) In a displacement capacitive sensor the circuit connected to it measures the capacitance where $C = \frac{\epsilon A}{x}$, define each parameter in this formula and find the sensitivity of this sensor with respect to the displacement. **[7 marks]**

(e) What are the main types of transducers used in biomedical instruments **[5 marks]**

Total 25 marks

END OF QUESTIONS

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Formula sheet

Tangent function: tanθ=opposite/adjacent

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 *RC* Circuits

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

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

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