ENG32

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

B.ENG (HONS) BIOMEDICAL ENGINEERING

SEMESTER 2 EXAMINATIONS - 2023/2024

MEDICAL SENSORY DEVICES & MEASUREMENT

MODULE NO: BME4004

Date: Thursday 16th May 2024 **Time: 2:00 – 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 10 A. What is the magnetic field strength H at a distance of 60 mm from the wire? **[5 marks]**

b) A 100 μC charge is available in a 20 V capacitor. What is its capacitance value in $\mu Farads$ **[5 marks]**

c) What is the capacitive reactance of a 100 μF capacitor working on 100 Hz? **[5 marks]**

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

i) What is the value of the magnetic motive force produced by this coil? **[4 marks]**

ii) What is the inductance of this coil with an air core? **[4 marks]**

iii) Calculate inductance of the coil for a relative permeability of 1000? **[2 marks]**

Hint:

Assume the ratio of coil area to its length is 4.

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]**

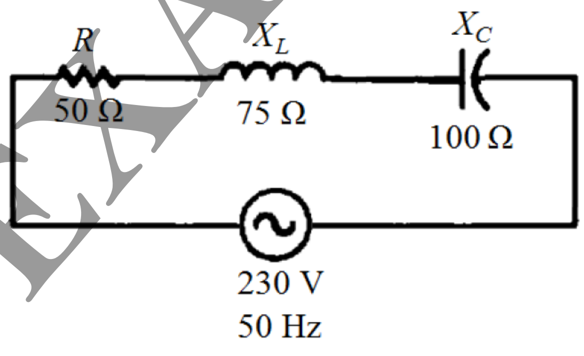

Fig.1 RLC series circuit **Total 25 marks**

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Question 3

a) A resistive circuit is shown in Fig.2

i) Explain Thevenin's and Norton's Theorems. **[4 marks]**

ii) Determine Thevenin's and Norton's equivalent circuits. **[6 marks]**

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

i) the voltage across R_{Load} using the superposition method. **[9 marks]**

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

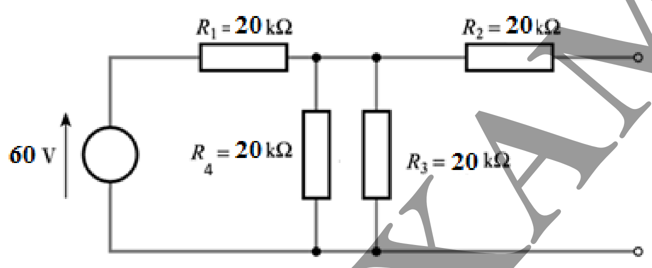

Fig.2

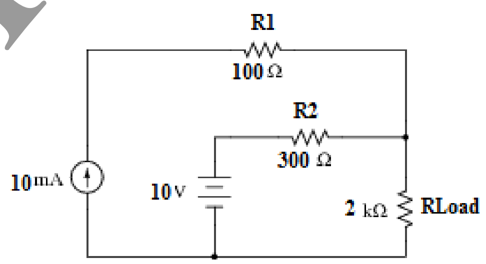

Fig.3

Total 25 marks

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Question 4

a) A single-phase transformer of rated power 200VA has a turns ratio (N1/N2) of 10:1 (step down) and is connected to a supply main of 200 V@50Hz, Determine

i) Its secondary voltage. **[3 marks]**
ii) Its primary and secondary currents. **[4 marks]**

b) The alternating voltage shown in Fig 3, is connected across a resistor of 10 kΩ. Calculate

i) the r.m.s. current, **[4 marks]**

ii) the frequency, **[5 marks]**

iii) the mean power dissipated in the resistor. **[5 marks]**

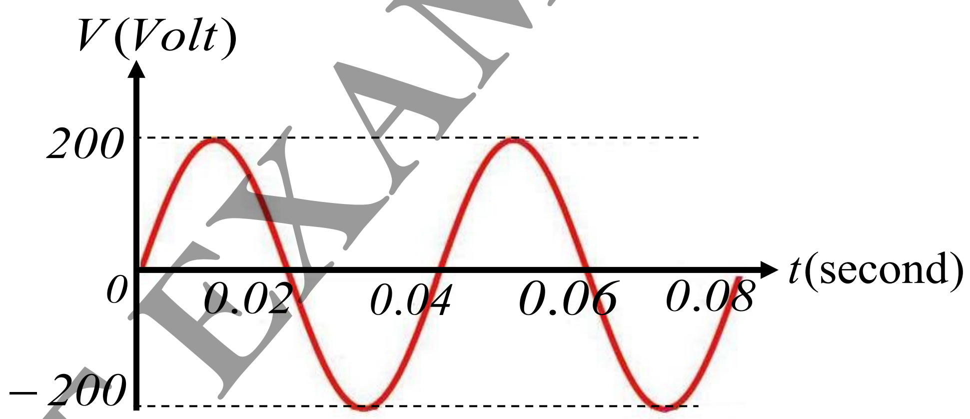

Fig 3.

c) Derive the instantaneous equation that predicts the waveform in Fig 3 and calculate the value when t = 1.25 ms. **[4 marks]**

Total 25 marks

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Question 5

a) Explain with the assistance of diagrams the operation of a Wheatstone bridge circuit as a resistive sensor **[6 marks]**

b) Describe the generalized medical instrumentation system. Illustrate your answer with the aids of diagrams **[7 marks]**

c) What are the main types of transducers used in biomedical instruments

[4 marks]

d) What are the basic components of a DC power supply used in biomedical equipment assuming the mains is AC power supply. What is the function of a bridge rectifier and how can we improve the quality of the DC output voltage?

Illustrate your answer with the aid of diagrams **[8 marks]**

Total 25 marks

END OF QUESTIONS

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Formula sheet

These equations are given to save short-term memorisation of details of derived equations and are given without any explanation or definition of symbols; the student is expected to know the meanings and usage.

Ohm's law: $V = IR$, Power: $P = IV$, Magnetic flux: $\Phi = BA$, Induced voltage: $V = N.\Delta\Phi/\Delta t$

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

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

$$L = \frac{\mu_o \mu_r A N^2}{l}$$

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

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

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

Transformer voltage ratio: $\frac{V_1}{V_2} = \frac{N_1}{N_2}$

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: $\tan\theta$=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

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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° $\theta = \arctan\frac{I_C}{I_R}$

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° $\theta = \arctan\left(-\frac{I_L}{I_R}\right)$

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