UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG(HONS) ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTER 1 EXAMINATION 2023/24

INTRODUCTORY ELECTRICAL PRINCIPLES

MODULE NO: EEE4012

Date: **Time:**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions.

Answer ANY FOUR questions.

All questions carry equal marks.

Individual marks are shown within the question.

A formula sheet is given at the end of the paper.

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BEng (Hons) Electrical and Electronics Engineering
Semester 1 Examination 2023/24
Introductory Electrical Principles
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Question 1

a) Define the following terms (**1.5 marks for each definition**):

i. Frequency
ii. Period
iii. Phase angle
iv. Peak to peak value
v. RMS value
vi. Internal resistance
vii. Inductance
viii. capacitance

[12 marks]

b) An AC ammeter reads 22 A rms current through a resistive load, and a voltmeter reads 385 V rms drop across the load.

(i) What are the peak values and the average values of the alternating current and voltage**?** **[6 marks]**

(ii) Calculate the load resistance. **[2 marks]**

c) Find the Thevenin equivalent of the circuit given in Figure Q1 below. **[5 marks]**

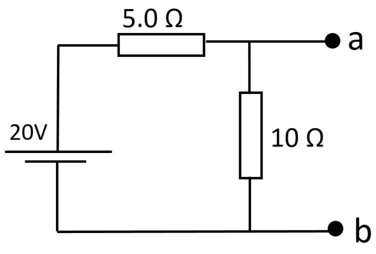

Fig.Q1c

Total Marks: 25
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Question 2

a) A coil of copper wire has a resistance of 150 Ω, when its temperature is 0 °C. Determine its resistance at 60°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 Q2b), using superposition theorem or otherwise, find out the current flowing through the 20 Ω resistor.

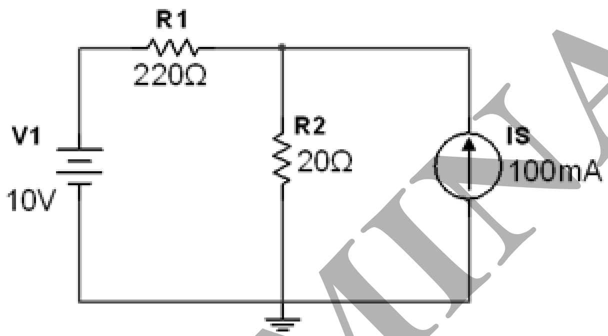

Figure Q2b

[10 marks]

c) For the circuit shown in Figure Q2c below, calculate:

(i) the voltage drop across the 4 kΩ resistor **[3 marks]**

(ii) the current through the 5 kΩ resistor **[3 marks]**

(iii) the power developed in the 1.5 kΩ resistor **[3 marks]**

(iv) the voltage at point X w.r.t. earth **[3 marks]**

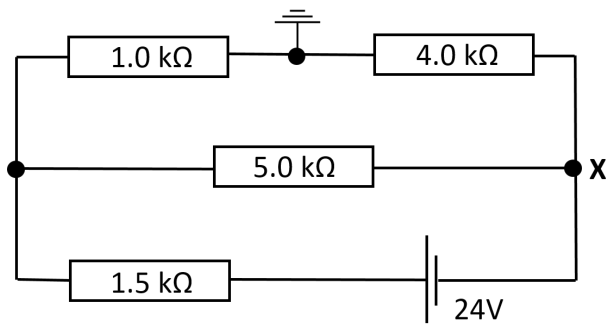

Figure Q2c

Total Marks: 25

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Question 3

a) A 4.7 μF capacitor has 12 V across it. What quantity of charge is stored in it? **[3 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? **[4 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. **[8 marks]**

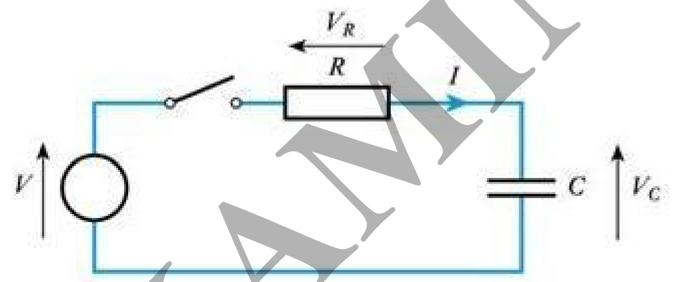

Figure Q3d An initially uncharged capacitor being charged through a resistor.

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

Question 4

For the circuit shown in figure Q4 , calculate:

a) Currents I1, I2, and I3 **[9 marks]**
b) Voltages across R1, R2, and R3 **[6 marks]**
c) Powers P1, P2, and P3 **[3 marks]**
d) Draw the complete voltages and currents phasor diagram **[3 marks]**
e) The peak I3 current at resonance frequency **[4 marks]**

Where $v = 17cos314t$, $R_1 = R_2 = 2\Omega$, $R_3 = 4\Omega$, $X_{L2} = j2\Omega$, $X_{L3} = j6\Omega$, $X_C = -j4\Omega$

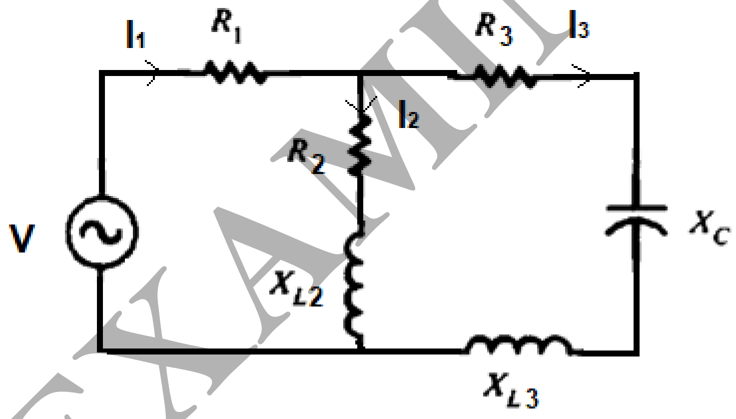

Figure Q4

Total Marks: 25

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Question 5

a) Explain why AC current through an inductor lags AC voltage across the inductor by 90 degrees, give the physical and mathematical interpretation for this phase difference.

[6 marks]

b) For a single-phase transformer of rated power of 250 V.A, what would be its secondary voltage and current if it has turns ratio ($\frac{N_1}{N_2}$) of 10:1(step down) when it is connected to a supply mains of 250 V, 50 Hz. **[5 marks]**

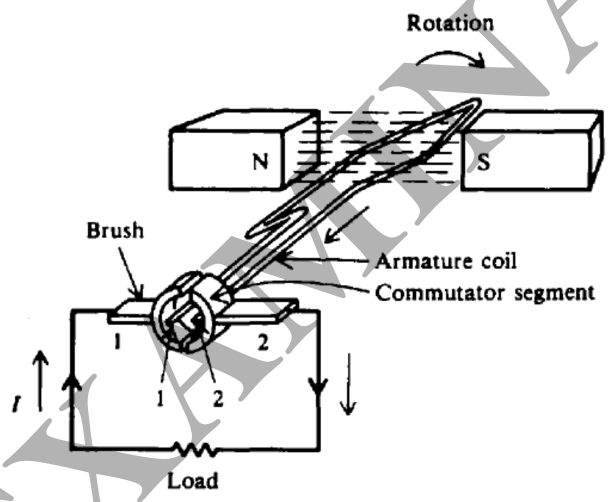

Fig.Q5c

c) If the DC generator shown above in Fig.Q5c generates 8 volts (peak value) across the brushes, what would be the rms current that flows in the 1- Ω load? **[3 marks]**

d) An AC motor is running at 1500 revolutions per minute when supplied from a 50 Hz supply mains, what would be its number of magnetic poles? **[4 marks]**

e) Design the clock signal frequency of a steps motor to rotate at 300 rpm +/- 10 rpm. Given that the stepper motor has the accuracy of 2.5 degree per step

[7 marks]

Total Marks: 25

END OF QUESTIONS PLEASE TURN PAGE FOR FORMULA SHEET

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

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

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

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

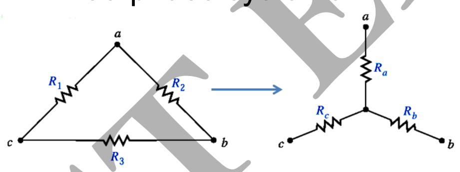
Summary Table for Series and Parallel *RC* Circuits

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

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

Three-phase systems:

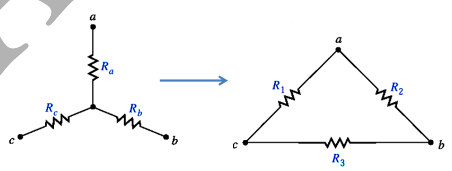


Delta to Star conversion:

$$R_a = \frac{R_1 R_2}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_3 R_1}{R_1 + R_2 + R_3}$$



Star to Delta conversion:

$$R_1 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b}$$

$$R_2 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$$

$$R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

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