0450

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX3410 Introduction to Electrical Engineering**
Academic Year	: 2024/25
Date	: 29/01/2026
Time	: 0930 – 1230 hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Six (6)** questions in **Eight (8)** pages.
3. Answer any **Five (5)** questions, including **all** from Part A and **Two (2)** from Part B.
4. Answer for each question should commence from a new page.
5. Relevant values are provided.
6. This is a Closed Book Examination.
7. Answers should be in clear handwriting.
8. Clearly indicate all formula and calculations for full marks.
9. Do not use red colour pen.

PART A - Answer all the questions

Q1 **[25 marks]**

a) A straight conductor of length 50 mm carries a current of 1.4 A. The conductor experiences a force of 4.5×10^{-3} N when placed in a uniform magnetic field of magnetic induction 90 mT. Calculate the angle between the conductor and the direction of the magnetic field. (4 marks)

b) The Figure Q1a shows a metal axle that is free to roll on two parallel metal rails. The rails and the axle are in a uniform magnetic field. The direction of the magnetic field is out of the page as shown in Figure Q1b. The ends of the rails are connected to a 120 V power supply which can be switched ON and OFF.

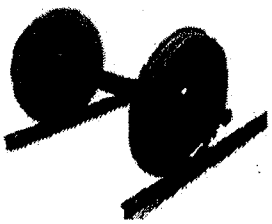


Figure Q1a

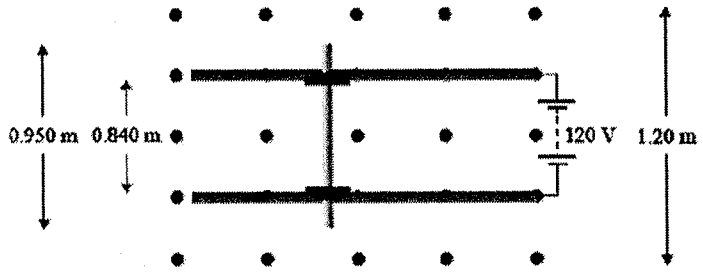


Figure Q1b

Strength of the magnetic field = 8.10×10^{-3} T
Length of the axle = 0.95 m
Distance between parallel metal rails = 0.84 m
Width of the magnetic field = 1.2 m
Total effective resistance = 42 Ω
Voltage of power supply = 120 V

i. Sketch the direction of the electromagnetic force with respect to the axle when the power supply is switched ON, (You may draw only the axle in your answer sheet to sketch the direction). State clearly whether the force is up, down, left, right, into page, out of page, or there is no force at all. (2 marks)

ii. Calculate the strength of the magnetic force on the axle when the power supply is turned ON. (2 marks)

iii. Briefly explain the electromagnetic laws underlying part i. above. (3 marks)

iv. The power supply is removed and the metal axle is pulled to move it towards the right at a constant speed of 3.10 ms^{-1} as shown in Figure Q1c.

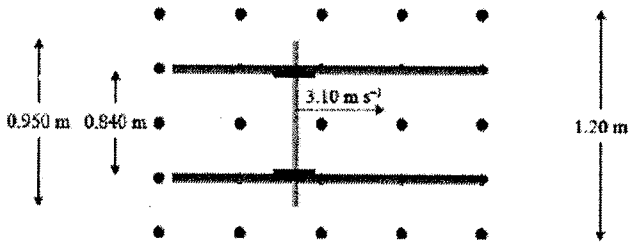


Figure Q1c

a. Calculate the voltage induced in the axle immediately after it is set moving. (2 marks)

b. Clearly mark the positive and negative ends on a sketch of axle. (2 marks)

v. With the power supply still disconnected, a wire is connected between the rails, and the axle is given a pull so that it starts moving to the right at a speed 3.10 ms^{-1} as shown in Figure Q1d.

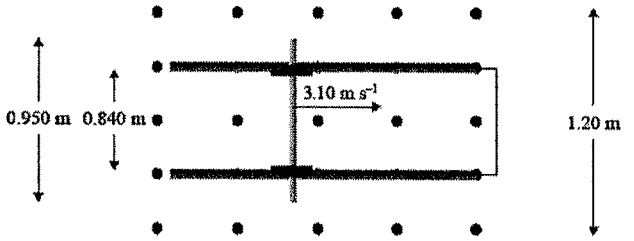


Figure Q1d

Describe How the speed of the axle changes after connecting the rails by the wire at the right end. Justify your answer using electromagnetism principles. (3 marks)

c) A simple AC generator consists of a rectangular coil rotating in a uniform magnetic field.

i. Briefly explain the principle of voltage generation in a rotating coil placed in a magnetic field. (3 marks)

ii. State two factors that affect the magnitude of the induced voltage in a simple generator. (4 marks)

Q2 **[30 marks]**

a)

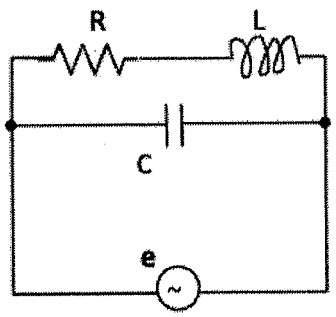


Figure Q2a

In the Circuit of Figure Q2a, it is given that L = 150 mH, C = 2.5 μF, and R = 400 Ω. The source delivers a sinusoidal output.

The current and voltage of the Capacitor, as measured with an ideal multimeter at AC setting, read 60 mA and 12 V respectively.

i. Calculate the frequency of the circuit. [2 marks]

ii. Calculate currents and voltages of the other 2 passive components. *Consider the current through the Capacitor as reference.* [6 marks]

iii. Calculate the supply voltage, and express it in the time domain (in the form $e(t) = E_m \sin(\omega t \pm \phi)$). [2 marks]

iv. Calculate the power dissipated from the circuit, and its power factor. [4 marks]

v. Draw a phasor diagram for the circuit, using the above values, taking the current through the Capacitor as reference. [6 marks]

Draw the phasor diagram (approximately) to scale on a sperate page. They should match the values from i. Draw the reference horizontal to right.

b)

i. Describe the main characteristic of a circuit at resonance. [2 marks]

You are provided an inductor L = 100 mH, a capacitor C = 10 μF, a resistor R = 200 Ω, with ammeter A showing 20 mA, and a set of ideal AC voltmeters (V_1 .. V_5) connected as shown in Figure Q2b.

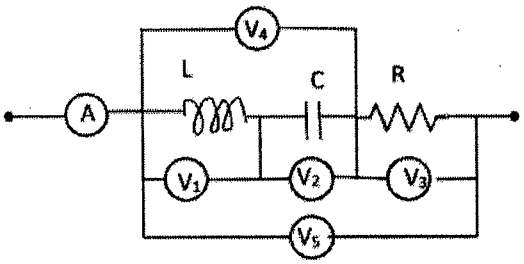


Figure Q2b

Give the circuit is tuned to its resonance, calculate

ii. the resonance frequency f_o

iii. V_1 reading iv. V_2 reading v. V_3 reading vi. V_4 reading vii. V_5 reading

viii. Draw to scale the phasor diagram for the circuit, using the source voltage as reference.

[8 marks]

Q3 **[15 marks]**

Figure Q3 shows a BJT amplifier circuit. Transistor is a Silicone transistor having β = 100. The parameters of the amplifier circuit are, $R_1 = 6.5\ k\Omega$, $R_2 = 5\ k\Omega$, $R_C = 500\ \Omega$, $R_E = 450\ \Omega$, $R_L = 5\ k\Omega, R_S = 200\ \Omega, V_{CC} = 5\ V$.

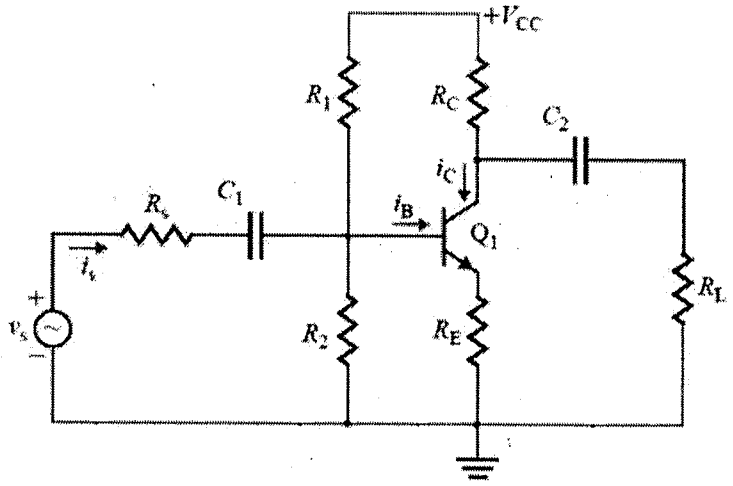


Figure Q3

a) What is the bias configuration of the amplifier? [1 Mark]

b) State the use of C_1 and C_2 capacitors? [2 marks]

c) Determine the base current (I_B) of the amplifier [3 marks]

d) Find expressions for the collector current (I_C) and the voltage across collector-emitter terminals (V_{CE}). [5 Marks]

e) Hence, draw the DC load line for the above amplifier and mark the Q point. [4 Marks]

Part B – Answer any two Questions

Q4 **[15 marks]**

a) The earth has a net electric charge that causes a field at points near its surface of about 150 N/C and directed in toward the centre of the earth.

i. What magnitude and sign of charge would a 60 kg human have to acquire to overcome his or her weight by the force exerted (generated) by the earth's electric field? [3 marks]

ii. What would be the force of repulsion between two people each with the charge calculated in part i. and separated by a distance of 100 m? [3 marks]

Consider $g = 9.8\ m/s^2$; $k = 9\times10^9\ Nm^2/C^2$

b) The capacitors in Fig. 4 are initially uncharged and are connected, as in Figure Q4, with switch S open. The capacitors are of values $C_1 = 3\ \mu F$ and $C_2 = 6\ \mu F$. A potential difference of $V_{ab} = 210$ V is applied between a and b.

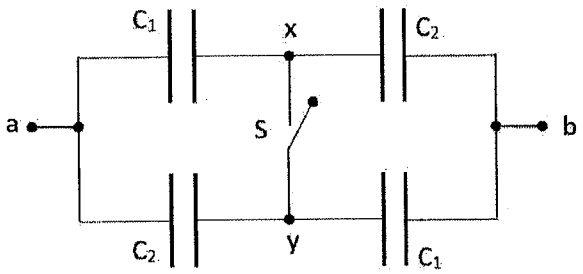


Figure Q4

i. What is the potential difference V_{xy}? [3 marks]

ii. What is the potential difference across each capacitor after switch S is closed? [3 marks]

iii. How much charge flowed through the switch after it was closed? [3 marks]

Q5 **[15 marks]**

A moving coil type indicating instrument requires 50 μA DC current for the full-scale deflection. The resistance of the instrument is 200 Ω. This instrument needs to be configured as a voltmeter of 50 V DC full scale deviation by connecting an external resistance.

a) Draw the circuit diagram of the meter configuration with external resistance connected to the meter. [3 marks]

b) Calculate the value of external resistance. [3 marks]

c) If the voltmeter is used to measure the voltage between the points **A** and **B** in the circuit shown in **Figure Q5**, calculate the voltage reading. Assume that the voltage source is ideal. [6 marks]

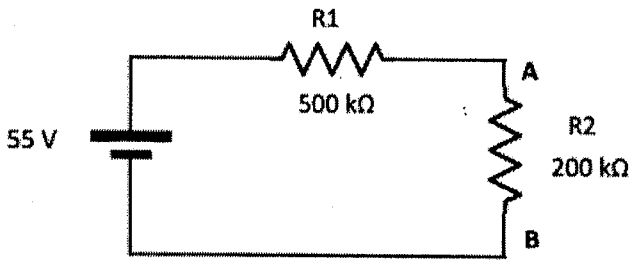


Figure Q5

d) Calculate the percentage error of the meter reading you have calculated in c). [3 marks]

Q6 **[15 marks]**

a) Briefly discuss three conventional methods of electricity generation, clearly describing the advantages and disadvantages of each method. [3 marks]

b) Suggest two alternative renewable energy sources that can be used to reduce environmental pollution and briefly explain how they contribute to environmental protection. [3 marks]

c) The single-line diagram represents a 400 m long, DC ring main distribution network fed at point A, where at point C it connects to a 210 m long radial distributor. The network supplies loads at points B, D, E, F and G as shown in the Figure Q6. The supply voltage at point A is 230 V, and the resistance of the distributor is 0.008 Ω/m.

i. Determine the currents in each section (AB, BC, CD, DA, CE, EF and FG) [4 marks]

ii. Calculate the voltages at points B, C, E, F and D. [3 marks]

iii. Describe briefly how the ring-main system improves voltage regulation compared with a radial system. [2 marks]

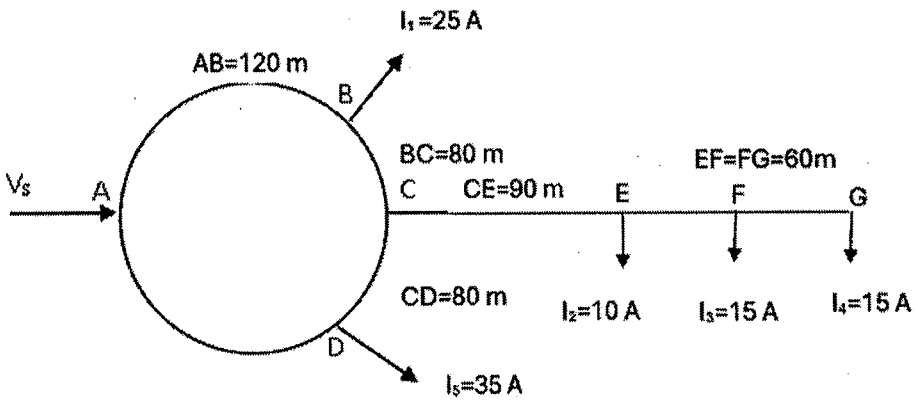


Figure Q6