00333

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

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX3410 Introduction to Electrical Engineering**
Academic Year	: 2021/22
Date	: 01/02/2022
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 **Six (6)** pages.
3. Answer any **Five (5)** questions only, including **all** from Part A and **Two (2)** from Part B.
4. Answer for each question should commence from a new page. Indicate the question number clearly on each page.
5. Relevant charts / codes / values are provided where required.
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 questions

Q1 **[25 marks]**

A L-shaped conductor is fixed in a uniform magnetic field with a flux density (B) of 0.25 T as shown in the Figure Q1. A second L-shaped conductor is moving away from the fixed conductor while touching each other forming a loop. The second L-shaped conductor has constant velocity (v) of 15 ms^{-1} and makes an angle (θ) of 30° with horizontal axis. The magnetic field is perpendicular to the both L-shaped conductors as indicated in the figure. Initially (before the second L-shaped conductor starts moving), the points of O and O' of these two conductors were overlapped so that the enclosed area becomes zero. You can assume both L-shaped conductors are identical and made of the same material.

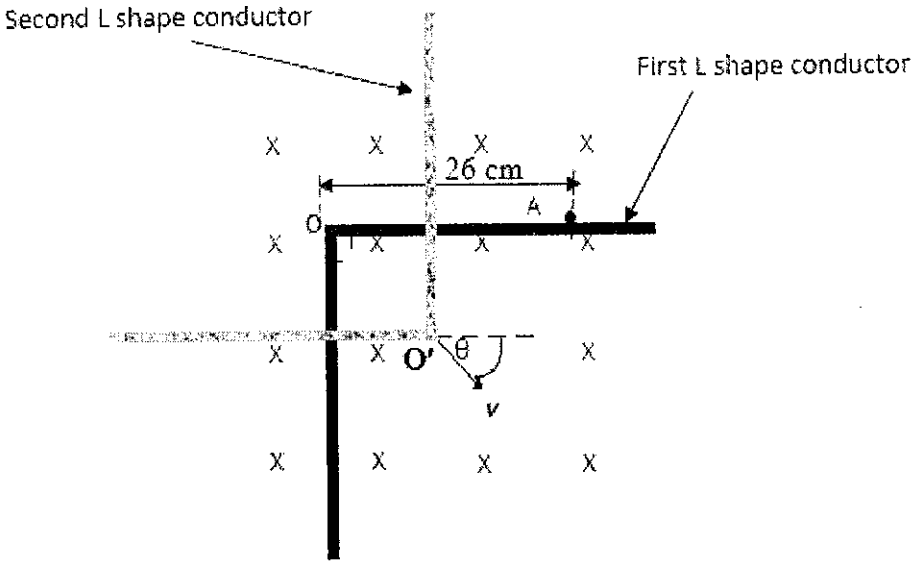


Figure Q1

a) What is the direction of the induced current through the loop formed by two conductors, when the second conductor is moving in the direction as shown in the Figure Q1? [2]

b) State and define the rule that helps you to determine the direction of induced current in a). [3]

c) Calculate induced emf in the conductor when the moving conductor's horizontal position - point **A** - is 26 cm away from the point O. [10]

d) Analytically show that the current through the loop is constant. [6]

e) After reaching to the point A, the second conductor moves back to the initial position at the same speed in opposite direction and this forward-backward process continues infinitely. Draw the variations of voltage and current as a function of time. [4]

Q2 **[30 marks]**

a)

In the circuit of Figure Q2, 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 Inductor, as measured with an ideal multimeter at AC setting, read 40 mA and 12 V respectively.

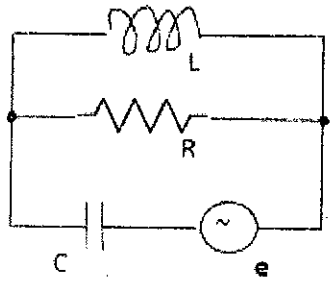


Figure Q2

i. Calculate the frequency, currents, and voltages of the other two passive components.

Consider the current through the Inductor as reference. [12]

ii. Calculate the supply voltage, and express it in the time domain (in the form $e(t) = E_m \sin(\omega t \pm \phi)$). [1]

iii. Calculate the power dissipated from the circuit, and its power factor. [2]

iv. Draw a phasor diagram for the circuit, using the above values, taking the current through the Inductor as reference. [10]

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

i. State the primary characteristic of a circuit at resonance. [1]

Select the primary characteristic only! Multiple answers will not be considered.

ii. Starting from the basic formula, derive an expression for the resonance frequency of the circuit in Figure Q2 in terms of **R**, **C** and **L**. [4]

Q3 **[15 marks]**

a) Describe the two terms intrinsic and extrinsic semiconductors. [2]

b) Consider the bipolar junction transistor (BJT) circuit shown in Figure Q3 A. [6]

i. Identify the type of BJT used in the circuit.

ii. Identify the bias configuration of the circuit.

iii. Draw the transfer characteristic for the circuit.

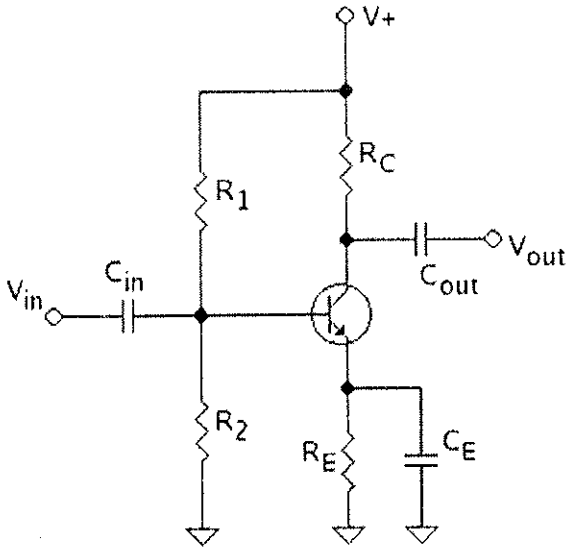


Figure Q3 A

c) Calculate the voltages across R_1 and R_2 in Figure Q3 B (a) and (b) considering the

i. ideal diode model and

ii. practical diode model - given that 1N4004 is a Silicon diode. [7]

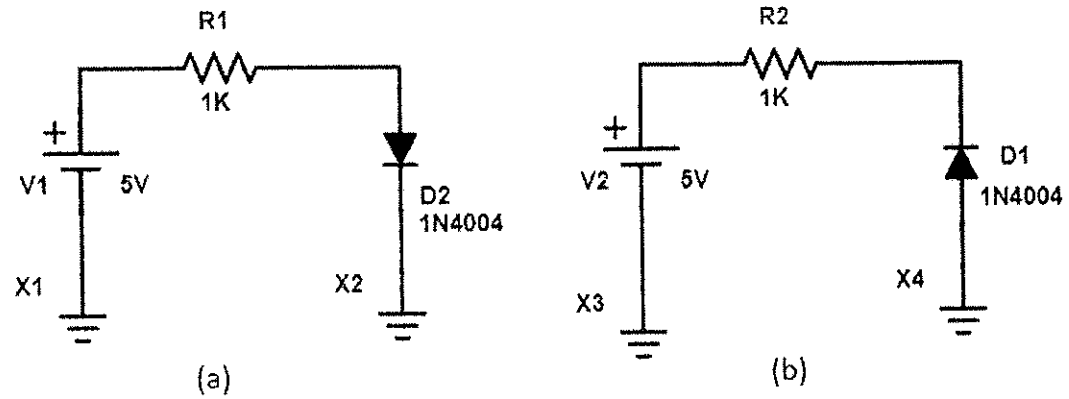


Figure Q3 B

Part B – Answer any two Questions

Q4 [15 marks]

a) A parallel-plate capacitor, with plate area **A** and plate separation **d**, has the space between the plates filled with two slabs of dielectric, one with constant $\mathbf{K_1}$ and the other with constant $\mathbf{K_2}$. Each slab has thickness **d/2**, and area shape identical to that of the capacitor plates.

i. Derive a formula for the capacitance **C** of this capacitor.

ii. Calculate the factor by which the energy of the capacitor has increased, relative to the value before the dielectric slabs were introduced. [6]

b) A small insulating sphere of radius **a** is concentric with a larger conducting spherical shell with inner radius **b** and outer radius **c** as in figure Q4. The inner sphere has total charge +2**q**, and the outer shell has total charge -4**q**. Assume uniform charge distribution in insulating material.

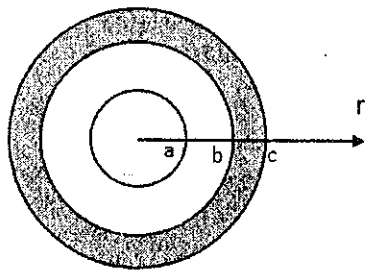


Figure Q4

State the electric field (magnitude and direction) in terms of **q** and the distance r from the common centre for

i. $r < a$; ii. $a < r < b$; iii. $b < r < c$; iv. $r > c$

You may use Gauss's Law to find the expressions.

v. Show your results in a graph of the radial component of **E** as a function of r. [9]

Q5 [15 marks]

An ammeter of 2 mA scale was designed with a moving coil type indicating instrument and a 333 Ω shunt resistor. The moving coil instrument requires 499.6 μA DC current for the full-scale deflection.

i. Draw the circuit diagram of the 2 mA ammeter setup. [2]

ii. Calculate the new shunt resistor (that replace 333 Ω shunt) required to design a 0.5 A ammeter using the same moving coil instrument. [5]

iii. Can a 0.5 W resistor be used as the shunt resistor in 0.5 A ammeter? Justify your answer. [2]

iv. If the instrument is required to be used as a voltmeter of 20 V DC (full scale) range, calculate the series resistance that you need to connect. [3]

v. If the voltmeter prepared in 'iv' 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 24 V voltage source is ideal. [3]

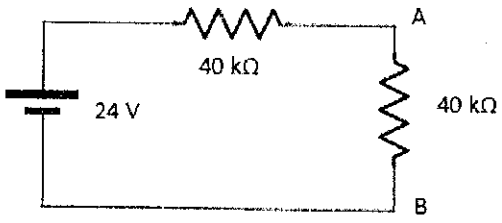


Figure Q5

Q6 **[15 marks]**

a) Electrical energy is the most superior form of energy for most humans use. Convenient form is one of the major advantages of electrical energy that validates above statement. Write three reasons why the electrical energy is considered the most convenient form of energy. [2]

b) Briefly explain the term **'non-renewable energy'** in your words. List two types of non-renewable energy sources that are used for electricity generation. [2]

c) Briefly explain the way of turning light energy into electrical energy in solar panels. [2]

d) What are the transmission voltages of Sri Lanka? Briefly explain why the high voltage transmission is used for bulk power transmission over long distances. [3]

e) What is the major drawback of radial distribution systems? [1]

f) A 2-wire DC distributor (AB) is shown in the figure Q6 A. Length of the AB distributer is 900 m, and it is fed at the point A at 400 V and loads of 50 A, 100 A and 150 A are tapped off from C, D and E which are at a distance of 200 m, 500 m, and 800 m from the point A respectively. The distributor is also loaded uniformly at the rate of 0.5 A/m. If the resistance of distributor per meter (forward and return) is 0.0001 Ω, calculate the voltages at point B. [5]

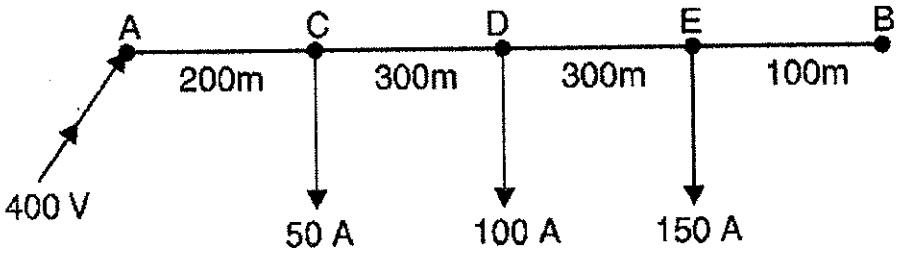


Figure Q6 A

Hint

*The voltage drop **due to the uniform loading** (V_d) in the distributor up to the point C, which is located 'x' distance away from the point A (see Figure Q6 B) is given by the following equation,*

$$V_d = \int_0^x ir(l-x)dx = ir[lx - \frac{x^2}{2}]$$

where 'l' is the total length of the feeder and 'r' is the forward and return resistance of distributer per meter.

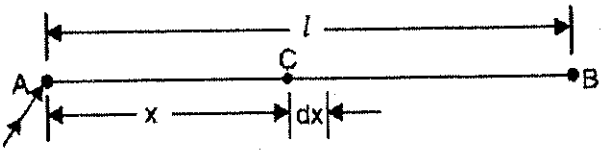


Figure Q6 B