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	: 2019/20
Date	: 26/09/2020
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 **Seven (7)** 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.
5. Relevant charts / codes / values are provided.
6. This is a Closed Book Examination.
7. Answers should be in clear handwriting.
8. Do not use red colour pen.

PART A - Answer all questions.

Q1 **[15 marks]**

a) Sketch the B-H loop of a ferromagnetic material and indicate the magnetic remanence and coercive force. What is the significance of the area of the loop? [4 marks]

b) A coil having 2000 number of turns is wound on a steel core as shown in figure Q1. Relative permeability of the steel is 250. Mean length l_Σ of the core excluding air gap is 160 cm. Air gap has a height of 25.5 cm. A square loop having 20 turns and side length of 25 cm is placed in the air gap. Initially (t=0), the loop is in a vertical position (loop area is perpendicular to the cross section of the air gap). The loop is then rotated at an angular velocity of 314 rad/s in anti-clockwise direction using an external force. The rotation axis of the loop goes at the mid points of two sides of the coil and perpendicular to the paper. When the coil is connected to a DC source, it is observed that an emf is induced in the loop.

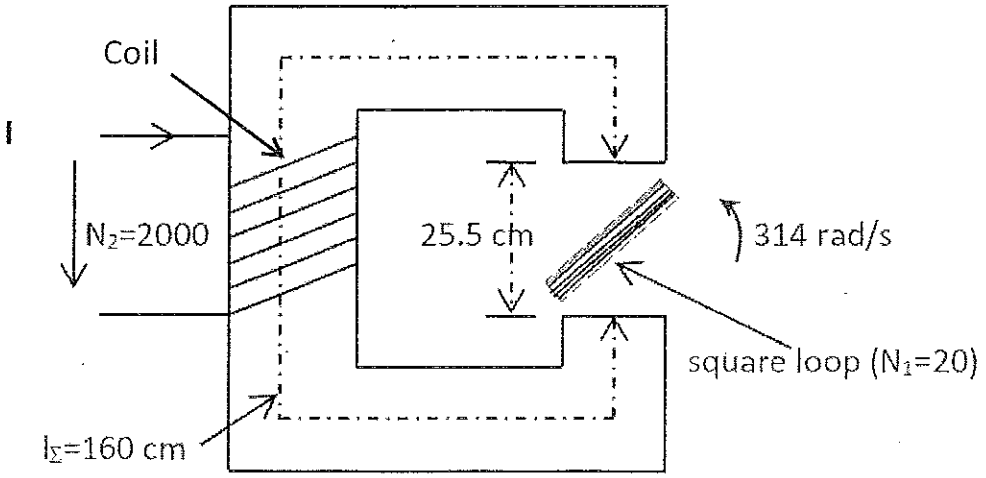

Figure Q1

i. Which is the law of electricity that helps you to explain the voltage induction in the loop? [1 mark]

ii. Sketch the voltage variation while the loop is going through its first cycle – starting from vertical. [2 marks]

iii. When the loop is at the vertical position, the voltage in the loop is found to be 23.55 V. Determine the flux density through the core. Assume that the flux in the air gap is same as the flux through the core. [3 marks]

iv. Calculate the current I in the coil. [5 marks]

Q2 [45 marks]

a)

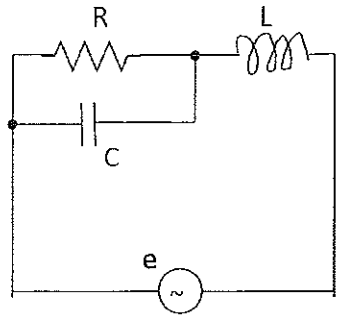

Figure Q2a

In the Circuit of Figure Q2a, it is given that L = 150 mH, C = 1.25 μF, and R = 300 Ω. The source delivers a sinusoidal output.

i. The current and voltage of the Capacitor, as measured with an ideal multimeter at AC setting, read 12 mA and 4.8 V respectively. Calculate the frequency, and currents through the R and L. *Consider the voltage across the Capacitor as reference.* (16 marks)

ii. 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)

iii. Calculate i) power dissipated from the circuit and
ii) its power factor. (4 marks)

iv. Draw a phasor diagram for the circuit, using the above values, taking the voltage across the Capacitor as reference (horizontal to right). (10 marks)

b) To investigate parallel resonance, you are provided an inductor L = 200 mH, a capacitor C = 1 μF, a resistor R = 200 Ω, a source of variable frequency E = 34 sin (ωt) V, and a selection of ideal AC ammeters (A) connected as shown in Figure Q2b.

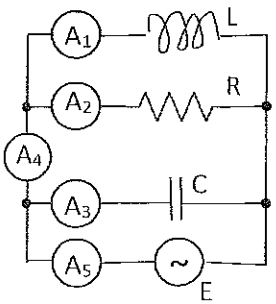

Figure Q2b

i. Write an expression for the total admittance Y of the circuit. (Admittance Y is the reciprocal of impedance Z)

You tune the source E to the parallel resonance angular frequency ω_{PO}. Based on your knowledge of resonance calculate /deduce the following values and meter readings:

ii. ω_{PO} iii. A_1 reading iv. A_2 reading v. A_3 reading vi. A_4 reading vii. A_5 reading

viii. Draw to scale the phasor diagram for the circuit.

(13 marks)

Q3 [10 marks]

a)

i. Sketch and identify the behaviour of an ideal diode in a circuit using the I-V characteristic curve. [1 Mark]

ii. The source in the circuit of Figure Q3a provides an input e(t) = 8 sin 400t V and the source E is a variable DC source.

Sketch, relative to the input the graphs of voltage V_D when the DC source E is not providing an input voltage (E = 0). The diode D is to be considered as ideal, and the DC source acts as an ideal conductor. [2 Marks]

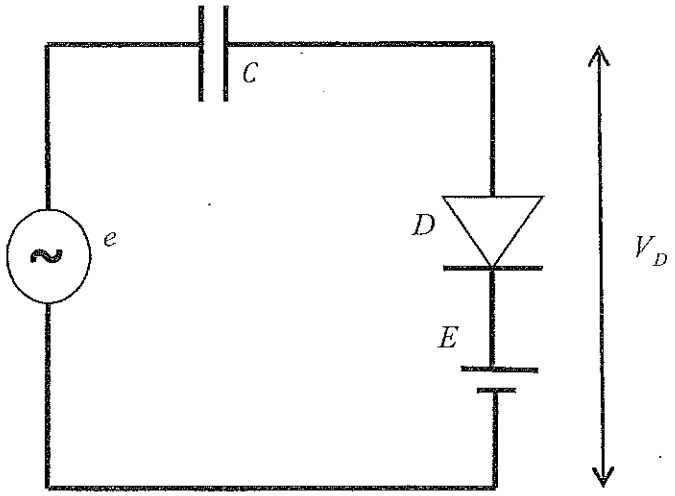

Figure Q3a

Instructions: Show both input and output in the same sketch, show the input using a dotted line. Indicate the values on both axes.

iii. Now the ideal DC source E is turned up to provide a voltage of E = 6 V. For this configuration, sketch, relative to the input the graphs of voltage V_D. All the other elements behave in exactly the same manner as in ii. [2 Marks]

Follow the same instructions as above when drawing the sketch.

b) A transistor amplifier circuit is shown in Fig. Q3b (i). The output characteristics of the transistor are shown in Fig. Q3 b) (ii). The d.c. load line of the transistor is also shown in Fig. Q3 b) (ii).

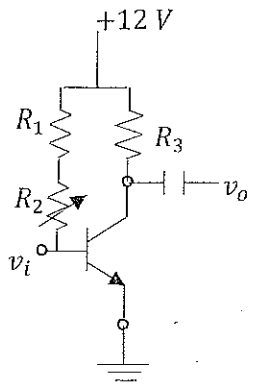

Figure Q3b (i)

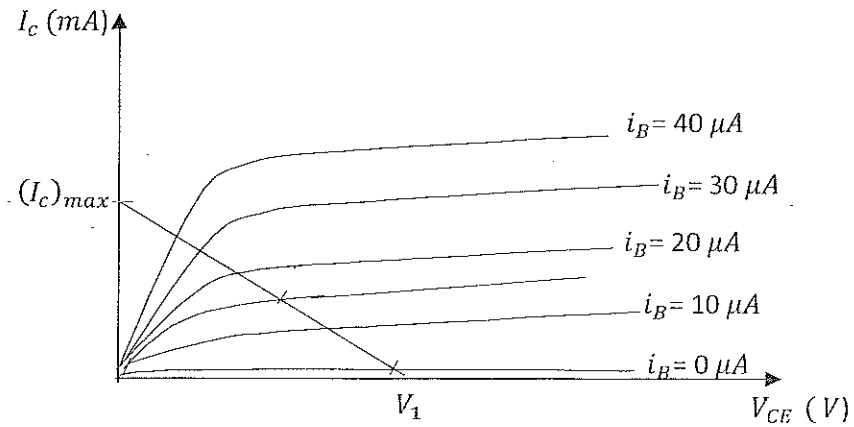

Figure Q3b (ii)

i. Derive the equation of the d.c. load line.

ii. Find the value of $(I_c)_{max}$, when R_3 = 4 kΩ.

iii. How would you decide a suitable operating point for the amplifier using Fig. Q3b (ii)?

[5 Marks]

Part B – Answer any two Questions

Q4 [15 marks]

a) Two identical small spheres, each of mass 2 g, are suspended in a vacuum by light strings 10 cm in length as shown in Fig Q4. The spheres have charges equal to $+4\times10^{-8}$ C and $+8\times10^{-8}$ C.

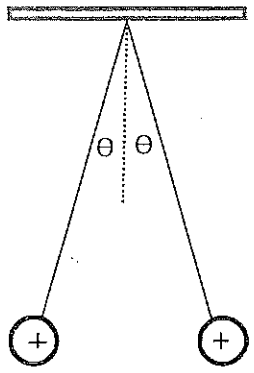

Figure Q4

i. Determine the value of angle Θ that the spheres to be in equilibrium (5 marks)

[Use $g = 9.8\ m/s^2$, $1/4\pi\varepsilon_o = 9\times10^9\ Nm^2/C^2$]

ii. Now the two spheres are briefly connected through a conductor, and then released again. Calculate the new value of angle Θ_n that the spheres to be in equilibrium. (2 marks)

b) Two parallel-plate capacitors $C_1 = 6\ \mu F$ and $C_2 = 4\ \mu F$ are placed in a vacuum and charged as a parallel combination across a 250 V ideal battery.

i. Calculate the resulting charge on each capacitor. (3 marks)

The capacitors are disconnected from the battery and from each other. They are then reconnected in series to one another and reconnected to the same battery.

ii. By how much does the total energy of the system change? (3 marks)

In this series configuration, the capacitor C_2 is filled with a dielectric material with relative permeability $\varepsilon_r = 2$.

iii. Calculate the charge on each capacitor. (2 marks)

Q5 **[15 marks]**

a) State whether each measuring instrument listed below can be used for the measurement of both ac and dc quantities or only one of them. Briefly give reason for each.

- Permanent magnet type instrument
- Dynamometer type instrument [2 marks]

b) A measuring instrument has internal resistance of 500 Ω and at the current of 1 mA the instrument gives full deflection. The instrument is used to design a multi-range voltmeter with three ranges: 1 V, 10 V, 50 V.

I. Sketch two possible circuit arrangements to design this multi-range voltmeter.

II. Determine the values of resistors of one of these arrangements. [6 marks]

c) Two coils (fixed and moving) of a dynamometer type moving coil ammeter are connected in series. When 8 A is measured the pointer deflects an angle of 100°. The same coils are now connected in parallel: the fixed coil is connected with a shunt resistance of 10 Ω and a moving coil with a 100 Ω resistance. What would be the deflection angle when the measured current is 22 A? [7 marks]

Q6 **[15 marks]**

a) "Electricity is more useful than other forms of energy". Justify the above statement by giving four reasons. [2 marks]

b) Draw energy conversion diagram for the coal power plants. [2 marks]

c) Describe the two methods that are used to convert solar irradiation into electricity. [2 marks]

d) Briefly explain why electricity is transmitted at high voltages. [2 marks]

e) Is it convenient to increase the transmission voltage as high as possible? Justify your answer. [2 marks]

f) A two-wire distributor of length 100 m is fed at one end. The feeding point potential is 220 V. Loads if 10 A, 20 A, 10 A and 5 A connected at distances 25 m, 50 m, 75 m and 100 m respectively from the feeding point. If the conductor resistance is 0.001 /m calculate the voltage at each node and the total voltage drop in the system. [5 marks]