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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 2019/2020
Course Code and Title	**: EEX3510/ECX3210 Electro-techniques**
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 **Eight (8)** questions in **Five (5)** pages.
3. Answer any **Five (5)** questions only.
4. Answer for each question should commence from a new page.
5. Relevant charts / codes / values are provided.
6. This is a Closed Book Exam.
7. Answers should be in clear hand writing.
8. Do not use red colour pen.

Q1

a) What is the resistance range of a resistor displaying colour bands Violet, Green, Black, Gold?

b) The potential difference across the terminals of a battery is 8.4 V when there is a current of 1.5 A in the battery from the negative to the positive terminal. When the current is 3.5 A in the reverse direction, the potential difference becomes 9.4 V.

i. What is the internal resistance of the battery?

ii. What is the emf of the battery?

c) When two unknown resistors are connected in series with a battery, the battery delivers 225 W and carries a total current of 5 mA. For the same total current, 50 W is delivered when the resistors are connected in parallel. Determine the values of the two resistors.

Q2

a) Describe briefly the two Kirchhoff's Laws of electric circuits, indicating the underlying conservation laws.

b) In the circuit shown in Figure Q2, calculate using superposition principel,

i. the currents through the resistors, and

ii. the potential difference between points **x** and **y**.

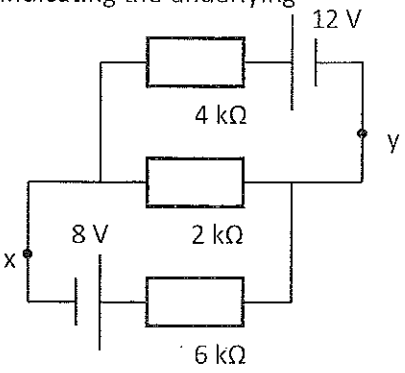

Figure Q2

Q3

a) State Gauss's Law.

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 Q3. The inner sphere has total charge +2q, and the outer shell has total charge -4q. Assume uniform charge distribution in insulating material.

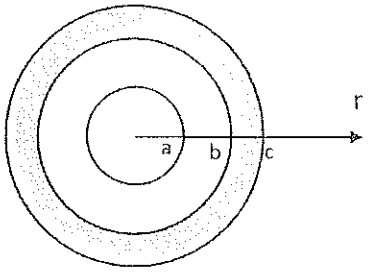

Figure Q3

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. $r > c$

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

c) Consider the situations when, for the same total charges,

vi. both sphere and shell are filled with conducting material

vii. both sphere and shell are filled with insulating material

Sketch a new graph each for the above scenarios.

Q4

a) A capacitor has vacuum in the space between the conductors. When you double the amount of charge on each conductor, what happens to the capacitance?

b) An isolated capacitor of unknown capacitance has been charged to a potential difference of 100 V. When the charged capacitor is then connected in parallel to an uncharged 10 μF capacitor, the voltage across the combination is 30 V. Calculate the unknown capacitance.

c) When a 360 nF air-filled capacitor is connected to a power supply, the energy stored in the capacitor is 1.85 $X10^{-5}$ J. While the capacitor is kept connected to the power supply, a slab of dielectric is inserted that completely fills the space between the plates. This increases the stored energy by 2.32 $X10^{-5}$ J.

i. What is the potential difference between the capacitor plates?

ii. What is the dielectric constant of the slab?

Q5

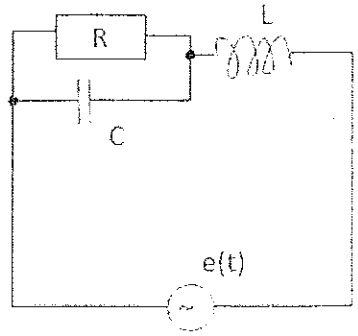

Figure Q5

In the Circuit of Figure Q5, 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.*

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

iii. Calculate i) power dissipated from the circuit and

ii) its power factor.

iv. Draw a phasor diagram for the circuit, using the above values, taking the voltage across the Capacitor as reference.

Q6

a) What is the **characteristic of a circuit** at resonance? Give the primary characteristic only. *Incorrect answers may be awarded negative marks.*

b) A circuit similar to that in Figure Q5, with component values L = 300 mH, C = 2.25 μF, and R = 500 Ω, is constructed brought to resonance. The amplitude of the input voltage is fixed at 34 V.

i. Write an expression for total impedance Z of the circuit, in terms of L, C and R.

ii. Using the above, calculate the resonance frequency of the circuit using the component values.

iii. Calculate the currents through the components. Take the source voltage as the reference.

Q7

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?

b) A coil having 2000 number of turns is wound on a steel core as shown in figure Q7. Relative permeability of the steel is 250. Mean length l_χ 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.

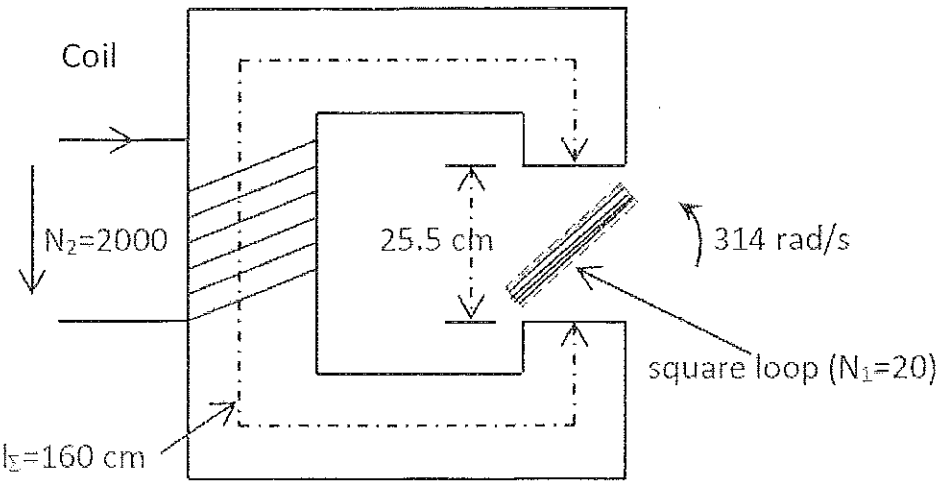

Figure Q7

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

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

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.

iv. Calculate the current in the coil.

Q8

a) Sketch and describe behaviour of an ideal diode in a circuit using I-V curve.

b) Sketch the design for a diode-clipper circuit that clips the input of sinusoidal 12 V maximum, at 6 V in the positive half and 8 V in the negative half. Assume use of ideal diodes. Show all relevant calculated values on the sketch.

c) The source in the circuit of Figure Q8 provides an input e(t) = 8 sin 400t V and the source E is a variable DC source

i. 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.

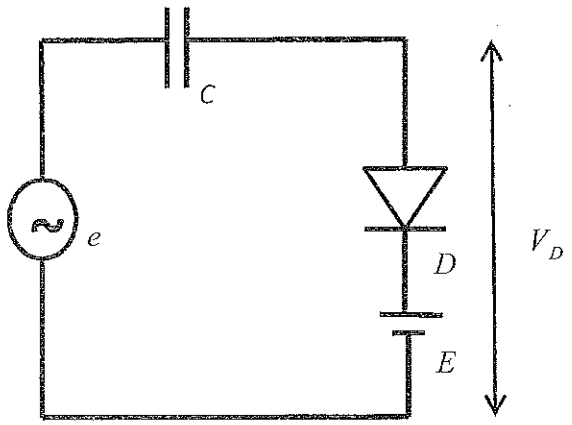

Figure Q8

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

ii. 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 the same manner as in i.

Follow the same instructions when drawing the sketch.