THE INSTITUTION OF ENGINEERS, SRI LANKA

IESL ENGINEERING COURSE PART I EXAMINATION – 2009

104 ELECTROTECHNIQUES

This paper consists of ten questions. Answer **any six (6)** questions.
All questions carry equal marks.
Time allowed : 3 hours

Electric space constant	ε_o	$= 8.854 \times 10^{-12}$ Fm^{-1}
Magnetic space constant	μ_o	$= 4\pi \times 10^{-7}$ Hm^{-1}
Gravitational constant	G	$= 6.672 \times 10^{-11}$ Nm^{2}kg^{-2}
Gravitational acceleration	g	$= 9.81$ ms^{-2}
Electron rest mass	m_e	$= 9.11 \times 10^{-31}$ kg
Electron charge	e	$= 1.602 \times 10^{-19}$ C

Q1. (i) State Coulomb's Law

(ii) A thin charged rod of length **L** is placed on the x-axis, with one end at the origin. The charge per unit length, λ, is constant. Determine the force on a positive point charge q_o, located at a position x = **a**, where

a) 0 > **a** > **L** b) **a** > **L** and c) **a** >> **L**

(iii) Calculate the force on a point charge of 5 μC, where L = 12 cm, a = 8 cm, and λ = 5 μC/cm.

Q2. (i) Describe the behaviour of capacitors connected in series and parallel.

(ii) A 1 μF capacitor and a 2 μF are connected in series across a 1200 V supply line.

a) Find the charge on each capacitor.
b) Find the voltage across each capacitor.

The charged capacitors are now disconnected from the supply line and each other, and re-connected to each other so that the terminals of like charges are together.

c) Find the final charge on each capacitor.
d) Find the change in electric energy of the system.

Q3. (i) State **the condition** for two elements to be connected in
a) series; b) parallel; in an electronic circuit.

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(ii) Twelve identical 1 Ω resistors are connected into a circuit as shown in Figure Q3.

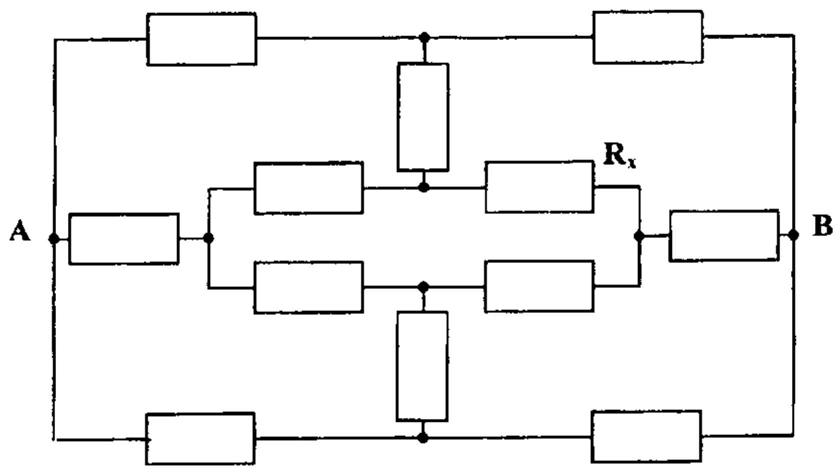

Figure Q3

Calculate the equivalent resistance of this circuit, when measured between points **A** and **B**. Write all assumptions you make.

(iii) What will be the current through the resistor $\mathbf{R_x}$ when a source of 36 V is connected across **AB**?

Q4. (i) Describe briefly the two Kirchhoff's Laws of electric circuits.

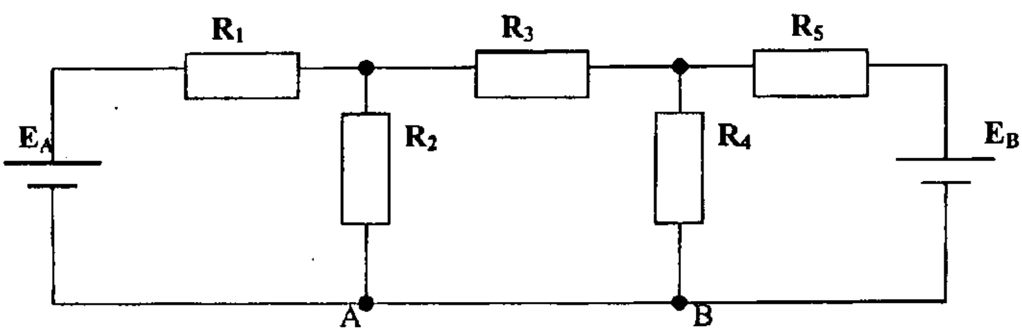

Figure Q4

(ii) Calculate the value of E_B in the circuit of **Figure Q4**, given that $\mathbf{R_1}$ = 12 kΩ; $\mathbf{R_2}$ = 6 kΩ; $\mathbf{R_3}$ = 2 kΩ; $\mathbf{R_4}$ = $\mathbf{R_5}$ = 10 kΩ and $\mathbf{E_A}$ = 12V, no current flow between points A and B.

Q5. (i) Describe Ampère's Law.

(ii) A coaxial cable consists of an inner solid conductor of radius **a**, and an outer concentric (pipe like) conductor of inner radius $\mathbf{b_i}$ and outer radius $\mathbf{b_o}$. The inner conductor carries a current **I** in the opposite direction to the current flow of the outer conductor, which also carries the same **I** amount of current. Assume that the current density within a conductor is uniform. Calculate the magnetic field for the regions

a) $r < a$; b) $a < r < b_i$; c) $b_i < r < b_o$; and d) $b_o < r$

(iii) For I = 10 A, a = 10 mm, b_i = 16 mm and b_o = 20 mm, calculate magn[etic] field density at
a) r = 5 mm and b) r = 18mm

Q6. An electron is projected into a uniform electric field of 5000 N/C, directed vertically upward. The initial velocity of the electron is 10^7 m/s, at an angle of 30^0 above the horizontal.

a) Find the maximum distance the electron rises vertically above the initial elevation.
b) After what horizontal distance dose the electron return to the original elevation?

Q7. (i) Describe briefly the behaviour of
a) a capacitor
b) an inductor in a sinusoidal circuit.

(ii)

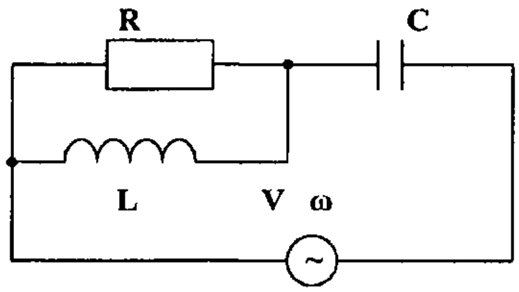

Figure Q7

In the above circuit rms value of V is 10 V. Given **R** = 300 Ω, **L** = 400 mH, **C** = 2.5 μF and ω = 1000 rad/s;

a) Calculate the currents through all components.
b) Draw the phasor diagram to show all currents and voltages of the circuit.

Q8. (i) Describe **the characteristic** of a resonant circuit.

(ii)

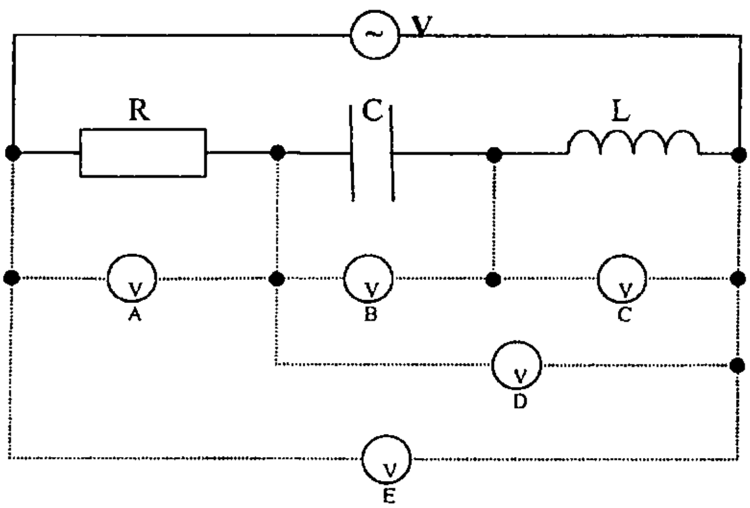

Figure Q8

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The circuit in figure Q8 is tuned to resonance, and five AC voltmeters V_A-V_E a connected to it as shown. Give the **reading of each voltmeter**, if R=300 Ω, L=400 mH, C=3 μF, $v(t)=12 \sin \omega_0 t$ V, where ω_0 is the angular velocity at resonance.

Q9. (i) Real ammeters and voltmeters may present problems when measuring very large, or very small loads. Show, and describe briefly how best to connect an ammeter and a voltmeter to accurately measure

a) Voltage across a very large load
b) Current through a very small load.

(ii)

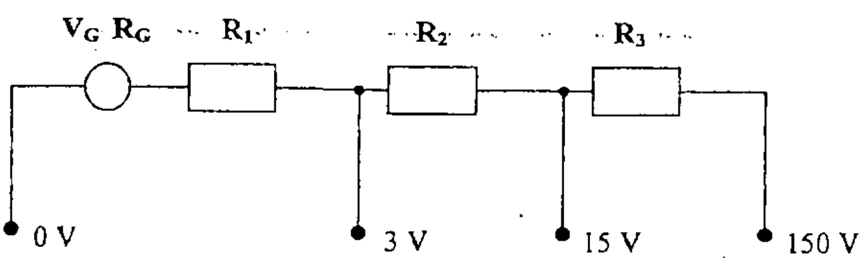

Figure Q9

In Figure Q9 the internal wiring of a 3-scale moving-coil voltmeter is shown with scales of +3 V, +15 V and + 150 V. The resistance of the moving coil $\mathbf{R_G}$ = 15 Ω, and a current of 1 mA causes it to deflect full-scale. Find the values of $\mathbf{R_1}$, $\mathbf{R_2}$, and $\mathbf{R_3}$.

Q10. (i) Devise a 2-input NAND gate, using only the minimum number of 2-input NOR gates.

(ii) The Boolean function F is defined as

$$F = \overline{ABCD} + \overline{A}B\overline{CD} + \overline{AB}C\overline{D} + \overline{ABCD} + \overline{A}BC\overline{D} + \overline{A}B\overline{C}D + ABC\overline{D}$$

a) Construct the truth table for function F.
b) Simplify function F using Boolean Algebra.
c) Find a simple equivalent expression for (original) function F using a suitable Karnaugh-map.