THE INSTITUTION OF ENGINEERS, SRI LANKA

IESL ENGINEERING COURSE PART I EXAMINATION – 2008

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_0	$= 8.854 \times 10^{-12}\ Fm^{-1}$
Magnetic space constant	μ_0	$= 4\pi \times 10^{-7}\ Hm^{-1}$
Gravitational constant	**G**	$= 6.672 \times 10^{-11}\ Nm^2kg^{-2}$
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 Gauss' Law

(ii) There is a solid sphere of radius **R**, with uniform charge distribution. The total charge of the sphere is **Q**. Using Gauss' Law derivate an expression for the Electric Field;
  a) Inside the sphere and
  b) Outside the sphere
  Write all assumptions you make.

Q2. (i) State the formula for the Capacitance of a parallel-plate capacitor, and discuss briefly how a change in each value affects the capacitance.

(ii)

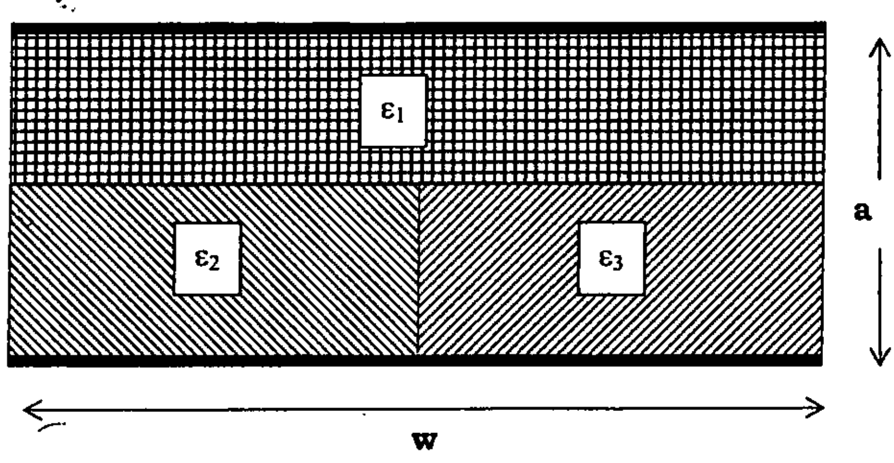

Figure Q2

Two rectangular conducting flat plates of length **l** and width **w** are k
distance **a** by filling the space between the two plates with three
dielectrics as shown in **Figure Q2**. Half the space is filled with a dielectric ε_1
other half is filled in equal amount with ε_2 and ε_3 material as shown.

a) If a voltage is to be applied across the two plates, write an expression for the total capacitance of the system in terms of **l, w, a,** ε_1, ε_2, and ε_3.
b) Calculate the total capacitance for values give below:
$l = 20cm \quad w = 10\ cm \quad a = 8mm$
relative dielectric constants $\varepsilon_1 = 4,\ \varepsilon_2 = 2,\ \varepsilon_3 = 3$.

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

(ii) Twelve 1Ω resistors are connected into a cube as shown in **Figure Q3** below.

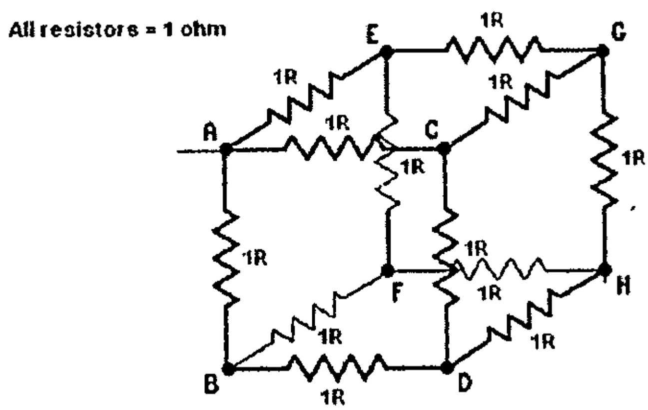

Figure Q3

Calculate the equivalent resistance of this cube, when measured between
a) points **A** and **H**, and b) points **A** and **B**.
Write all assumptions you make.

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

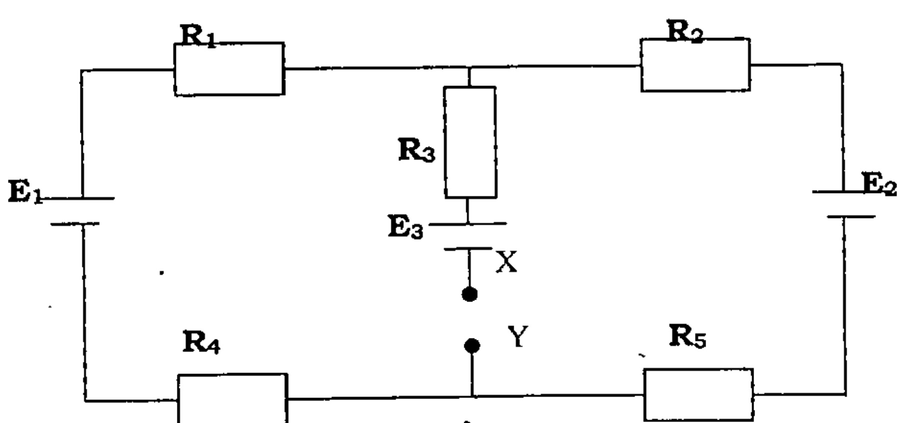

Figure Q4

(25)

(ii) Calculate the potential difference between terminals X and Y in Fig[...] given that
$R_1 = 12\Omega$; $R_2 = 22\Omega$; $R_3 = 36\Omega$; $R_4 = 20\Omega$; $R_5 = 46\Omega$; $E_1 = 12V$; $E_2 = 48$[...] and $E_3 = 24V$.

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 b_i and outer radius 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) $b_o < r$

Q6. (i) Describe Lenz's Law of induction.

(ii) A thin metal strip is allowed to slide down frictionless parallel rails of negligible resistance. The rails are connected at the bottom end, and elevated at an angle **θ** above the horizontal. A uniform magnetic field **B** is directed vertically upward throughout the region. The strip has a mass **m**, and a resistance **R.** The minimum distance between the rails is **d**.

a) Derive an expression for the terminal speed v_t of the strip in terms of **m, B, θ, R,** and **d**.
b) Calculate v_t, given that $m = 35g$, $B = 1.5T$, $\theta = 30°$, $R = 20\Omega$, and $d = 30cm$.

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

(ii)

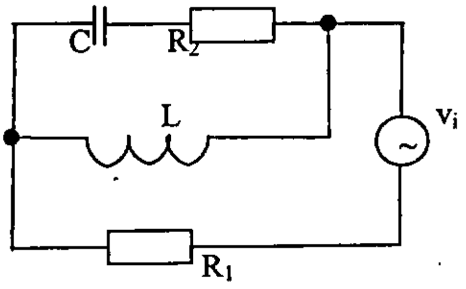

Figure Q7

In the above circuit v_i is described as $v_i = 17 \sin(1000t)$ V. Given $R_1 = 500\Omega$, $R_2 = 3002\mu F$, $L = 400mH$, and $C = 2\mu F$;
a) calculate the currents through all elements.
b) Draw the phasor diagram for the circuit.

Q8. (i) A resistor **R**, a capacitor **C**, and an inductor **L** are connected in one another. A power source of variable frequency is connected in to this circuit. When the source frequency is set to the resonance frequ f_o, a current I_o flows from the source. The elements are then replaced those of twice the value, **2R**, **2C** and **2L** respectively.

a) What is the new resonance frequency in terms of f_o?
b) What is the new current drawn from the source at resonance in terms of I_o?

(ii) A simple choke can be modelled as an ideal inductor connected in series with an ohmic resistor. A capacitor is connected in parallel to such a simple choke. Given **C** = 20μF; **L**= 50mH and R_L = 10Ω, calculate the resonance frequency for the circuit.

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) A simple permanent-magnet galvanometer shows full-scale deflection at 100mV and 1mA. How can this be used to construct a metre able to measure up to
a) 100V and
b) 20A

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

(ii) A simple display is to be constructed to help small children to identify prime numbers. Buttons carrying integers between 0 and 9 are given, so that only one button can be pressed at a time. The lamp lights up only when a button with a primary number is pressed.
Use a Karnaugh-map to find a simplified logical expression for the above display.