THE INSTITUTION OF ENGINEERS, SRI LANKA

PART 1 EXAMINATION – APRIL 2006

ELECTROTECHNIQUES

This paper consists of ten questions. Answer any SIX questions. All questions carry equal marks.
Time allowed: 3 hours

Electric space constant $\varepsilon_o = 8.85 \times 10^{-12}$ Fm^{-1}
Magnetic space constant $\mu_o = 4\pi \times 10^{-7}$ Hm^{-1}

Q1. (a). Write expressions for electric potential and electric field strength on a conducting sphere.

(b). A long thin conducting wire connects two metallic spheres A and B. Radiuses of A and B are 0.75 m and 5 cm respectively. An electric charge of 10 μC is shared by these two spheres. The conducting wire is then removed.

(i). Determine the electric charges on spheres A and B.

(ii). Calculate the electric potential and electric field strength on the spheres A and B.

(iii). If the electric charge is increased by twice (by feeding electric charge using conducting wire and then wire is removed) determine whether the electric breakdown would be occurred or not? (Dry air can sustain maximum electric field strength of 3 MV/m)

Q2. (a). State Ampere's law.

(b). A coaxial cable consists of a solid inner conductor surrounded by hollow, very thin outer conductor. Both conductors carry equal current I but in opposite directions. The radius of inner conductor is R1 and outer radius of the cable is R2 (shown in figure Q2).

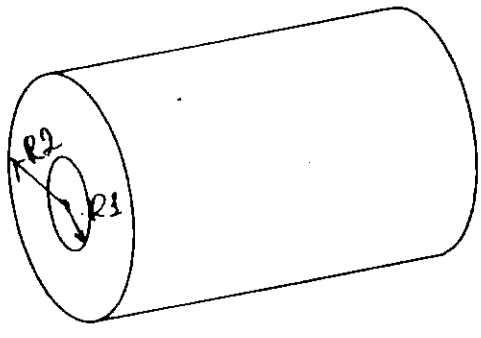

Figure Q2

(i). Derive expressions for the magnetic flux density (B) for the following positions:

within inner conductor, in the space between conductors and outside the cable.

(clearly state any assumption you made)

(ii). If R1=5 mm and R2=2 cm determine the self-inductance per unit length of the cable.

Q3. (a). Use Norton's theorem to determine the current through the 5 Ohms resistor of the circuit shown in figure Q3 (a).

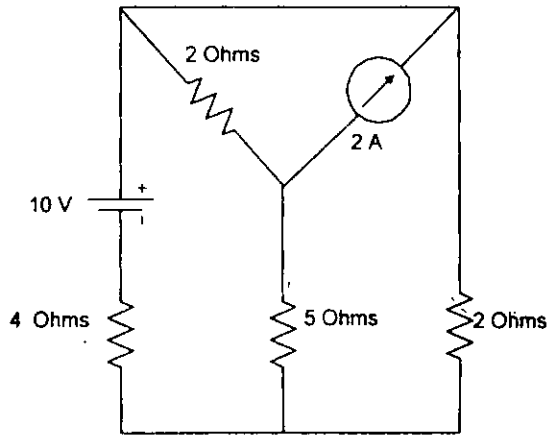

Figure Q3 (a).

(b). Use Thevenin's theorem to calculate current through the 6 ohms resistor of the circuit of figure Q3 (b).

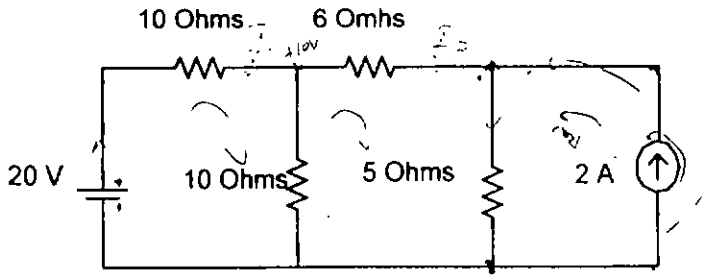

Figure Q3 (b).

Q4. A conducting coil bent into a semicircle of radius a is rotated with the angular velocity ω. The bent wire and its supports are placed in a uniform magnetic field B perpendicular to the plane of supports. At the time t=0, the semicircle rotates into the page as shown in figure Q4.

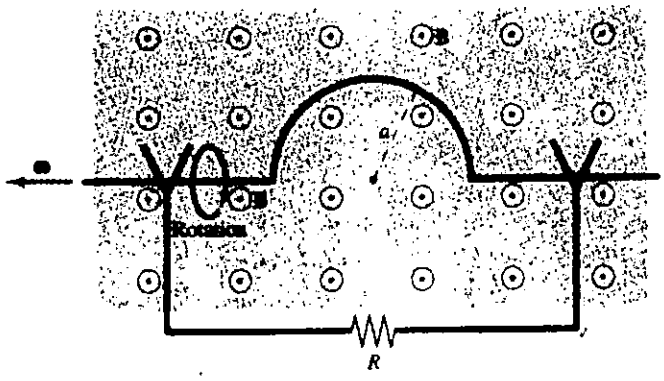

figure Q4.

(a). What is the direction of current immediately after the time t=0?
(b). Derive an expression for the current through the resistor R as a function of time (ignore the self-inductance of the coil).
(c). Calculate the average power needed to maintain the rotation of semicircle over a long period of time.

Q5. Instantaneous currents $i_1(t)$ and $i_2(t)$ of the circuit shown in figure Q5 are

$i_1(t)=1.13\ \text{Sin}314t$ amperes,

$i_2(t) =0.848\ \text{Sin}(314t-50^0)$ amperes

R1=25 Ohms and L=0.05 H.

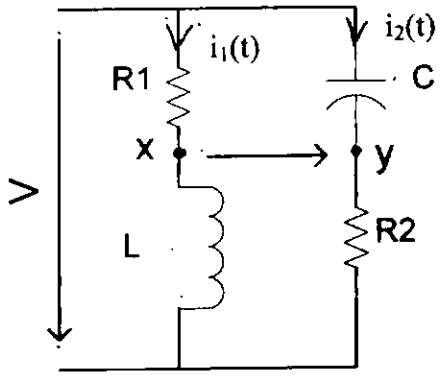

Figure Q5

(i). Determine the frequency and rms values of the currents i_1 and i_2.
(ii). Calculate the values of C and R2.
(iii). What is the supply voltage V?
(iv). Determine the potential difference between points X and Y.

Q6. (a). Briefly explain the losses in a power transformer.
(b). A certain 10 kVA, 2200 V/220 V single-phase transformer is connected to a 2200 V supply without having any load at secondary side. Electrical power

consumed by the transformer is 250 W and a current of 1 A flows through the primary windings at this situation. Resistances of primary and secondary windings are 2.2 Ohms and 0.18 Ohms respectively.

(i). Calculate the efficiency of the transformer when the rated load at power factor 0.85 is connected to the secondary side of the transformer.
(ii). If the load is reduced by half (power factor remains constant) what is the new efficiency?
(iii). If the secondary side voltage is maintained at 220 V calculate the approximate value of voltage at the primary side (leakage reactances and core loss can be neglected).

Q7. A three-phase balanced star connected load is supplied by a 400 V (line voltage) supply. Equivalent per phase resistance of the load is 0.81 Ohms and power factor is 0.62 lag (voltage drop due to connecting wires can be neglected).
(a). Calculate the line currents.
(b). A star connected set of capacitors is connected in parallel with this load in order to improve the power factor up to 0.92.
(i). What is the required value of per phase capacitive reactance?
(ii). Calculate the new line current.
(iii). How line currents would be changed if both loads were connected in delta?

Q8. (a). With help of suitable diagram explain briefly dynamometer type moving coil instrument and show that its deflection is proportional to the square of current.
(b). Explain why permanent magnet moving coil meters cannot be used for ac measurement?
(c). A certain moving coil instrument has a coil resistance of 500 Ohms and gives full scale deflection of 1 mA.
(i). What is the full-scale deflection if this instrument is used for measurement of voltages.
(ii). It is needed to convert this voltmeter to a multirange voltmeter with full scale of 1000V, 100V, 10V and 1 V. Draw a possible circuit arrangement using four resistors R1, R2, R3 and R4 and calculate values of them.

Q9. (a). With help of suitable graphs and diagrams explain the operating principles of Residual Current Circuit Breaker (RCCB) and Miniature Circuit Breaker (MCB)
(b). What is the purpose of earthing in an electric installation? Notes types of earthing systems that you know? What is the earting system that is used in Sri Lanka?
(c) A sub circuit consists of six lamps. Out of these six, three are to be operated form 3- gang switch, two from 2- gang switch. The rest one operated under a single switch. Draw a possible circuit arrangement using "loop-in-method".

Q10 (a). For the truth table given bellow create Karnaugh map and derive the sum product expression.

A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

(b). For the digital circuit given in figure Q10 find the Boolean expression.

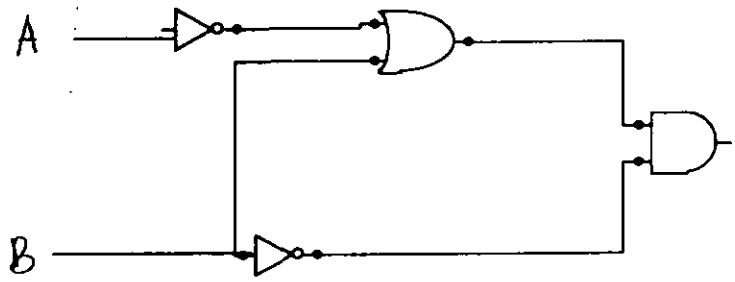

Figure Q10

(c). Simplify the following expression.

$$A+\overline{B}+C+\overline{AB}$$