The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Foundation in Technology

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ECX2330 – Principles of Electricity
Final Examination 2007/2008

Date: 29th April 2008 Time: 09.30-12.30

This paper contains eight questions. Answer any **five** questions. All questions carry equal marks. Show your work clearly. Be sure to use proper units and significant figures.

Electric space constant $\varepsilon_o = 8.85\times10^{-12}\,Fm^{-1}$

Magnetic space constant $\mu_o = 4\pi\times10^{-7}\,Hm^{-1}$

1. (a) A circular loop of wire has resistance 20 Ω and at two points of the circumference a battery of internal resistance 0.4 Ω and of e.m.f. 4 V is connected by two wires of resistance 0.3 Ω each as shown in figure-Q1A.

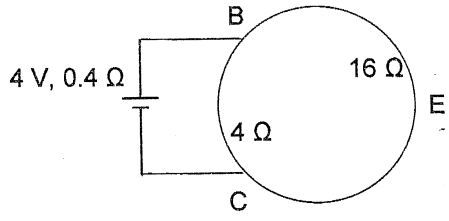


Figure - Q1A

(i) Find the current in the branch BC (4 Ω path).
(ii) Calculate the power dissipated by the branch BEC (16 Ω path).

(b)

(i) For the circuit shown in figure-Q1B, find the equivalent resistance with respect to the 2 V battery.

(ii) Calculate the current through the branch BC.

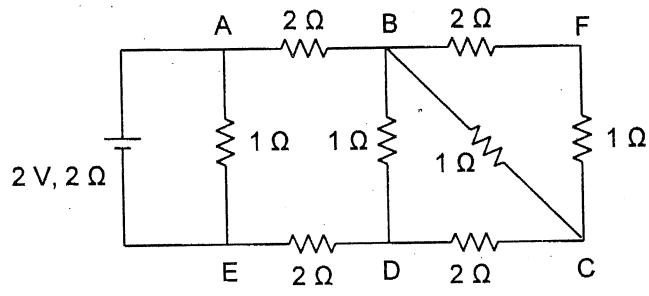


Figure – Q1B

(c) Use superposition theorem to find the current through each resistor of the circuit shown in figure-Q1C.

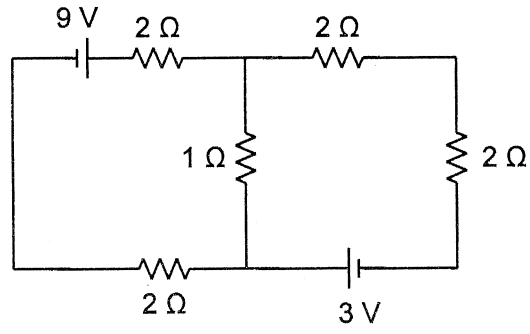


Figure – Q1C

2. An AC waveform is shown in figure-Q2A.

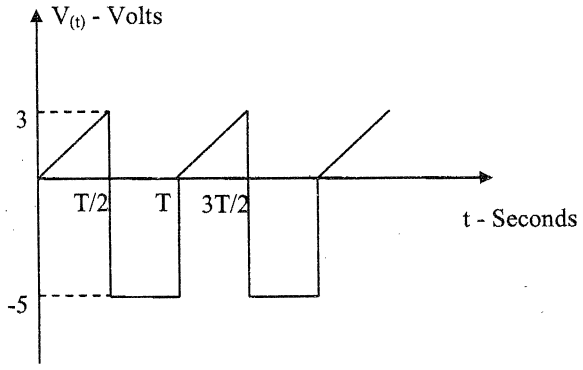


Figure – Q2A

(a) Calculate the average and rms values of the voltage waveform.
(b) An ac circuit is shown in figure-Q2B. The voltage drop across the resistor R is 12 V.

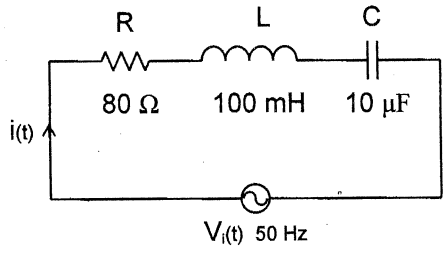


Figure-Q2B

(i) Find the total impedance Z of the circuit.
(ii) What is the rms value of the total current $i_{(t)}$?
(iii) Find the value of V_i(rms).

3.

(a) State the Gauss' theorem.

(b) An air filled coaxial cable shown in figure-Q3 consists of a metal wire of radius r surrounded by a thin metal sheath of radius R. When the inner wire carries a charge **q** per unit length, deduce expressions for the followings,

(i) Electric field strength $\mathbf{E}_{(r)}$ at a radial distance **r** from the central axis.

(ii) Electric potential at a radial distance $\mathbf{r}_1$ ($r < r_1 < R$) from the central axis.

(iii) Capacitance per unit length of the cable.

(c) If the voltage difference between inner metal wire and the metal sheath is 2 V and if **r** = 1 mm and **R** = 1 cm, find the energy stored in a piece of coaxial cable for 1 m length.

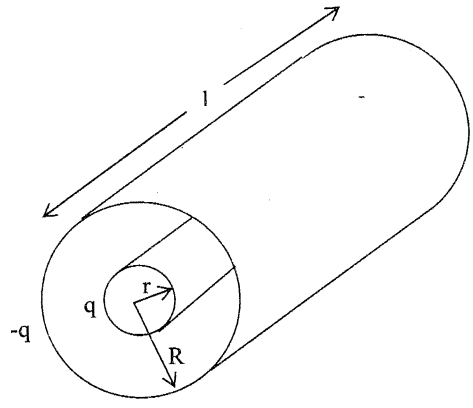


Figure – Q3

4.

(a) State the Faraday's law.

(b) Consider a conductor **AB** of length R which rotates about a metal axis **PQ** that is perpendicular to the plane of a static metal ring as shown in figure-Q4. The **AB** conductor is perpendicular to the axis **PQ** and there exists a magnetic field of uniform flux density of 0.1 T that is perpendicular to the plane of the ring. The conductor **AB** rotates with a constant angular velocity **ω**. The ends of the rotating conductor are always in contact with the static metal ring.

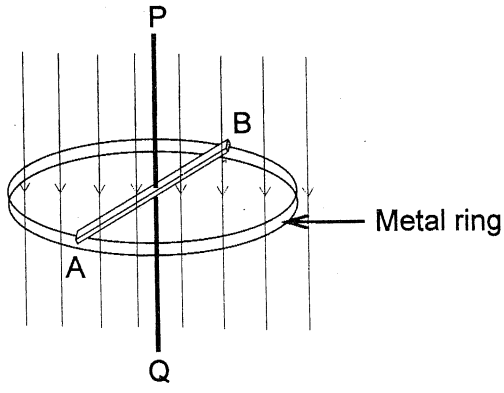


Figure-Q4

(i) Derive an expression for the emf induced across the metal axis **PQ** and the metal ring.

(ii) If R = 28 cm, $\omega = 200\pi$ rad/s and the resistance of the conductor AB is 0.4 Ω find the emf induced across the metal axis **PQ** and the metal ring. (Assume that the resistance of all other parts of the system is negligible)

(iii) If a 1 W, 1 V bulb glows properly when connected across the metal axis **PQ** and the metal ring, find the angular velocity ω of the conductor **AB** at that time.

5.

(a) Show that the self inductance of a coil is given by the equation $L = \frac{N^2 \mu A}{l}$.

(Assume that usual notation has been used.)

(b) (i) For the circuit shown in figure-Q5 write expressions for V_1 and V_2.

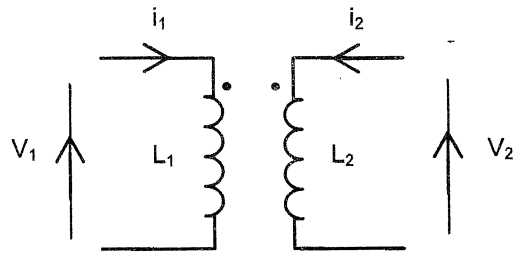


Figure – Q5

(ii) I0f the coefficient of mutual inductance is 0.8, determine the energy stored in the coils, given that

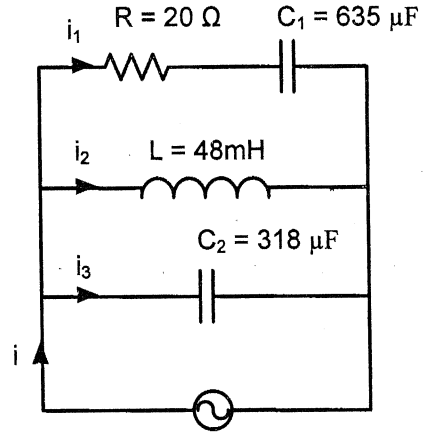
$L_1 = 10$ mH, $L_2 = 25$ mH, $i_1 = 1$ A and $i_2 = 1.5$ A.

(c) A toroid of circular cross section 20 cm^2 and magnetic length 80 cm is wound uniformly with 300 turns. Relative permeability of the core material is 900.

(i) If the current through the coil is 1A what will be the value of flux produced in the core?

(ii) If there is an air gap of length 0.5 mm present in the toroid, find the new current value to maintain the same value of flux (in the core) that you obtained in part (i). (Neglect the fringing effects at the air gap)

6.



V(t) = 10sin(100πt) V

Figure – Q6

In the AC circuit shown in figure-Q6,

(a) Determine the impedance of the circuit. (Use j notation)

(b) Find the rms values of the current in each branch (i_1, i_2, and i_3) and hence calculate the rms value of the total current i.

(c) Draw i, i_1, i_2 and i_3 in a single phasor diagram. Consider supply voltage V(t) as the reference.

(d) Determine the active power, reactive power and the apparent power of the circuit.

7.

(a) Determine the currents I_1, I_2 and I_3 in the circuit shown in figure-Q7A. Assume that when diodes are forward biased, there exists a 0.7 V voltage between the anode and cathode of each diode.

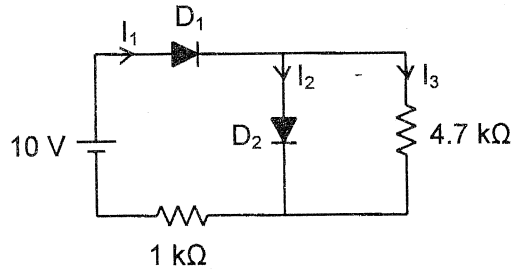


Figure – Q7A

(b) Output waveforms of the circuits shown in figure-Q7B and figure-Q7C are shown in figure-Q7D and figure-Q7E respectively. Draw input waveforms V_{S1} and V_{S2}. (Assume all diodes are ideal)

(i)

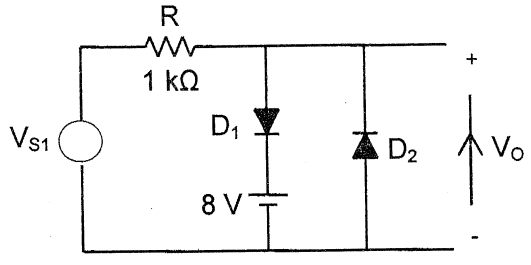


Figure – Q7B

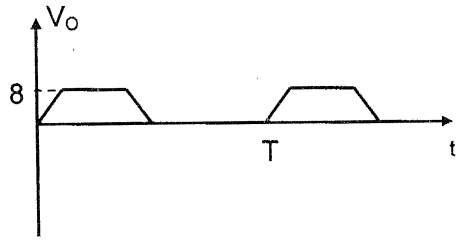


Figure – Q7D

(ii)

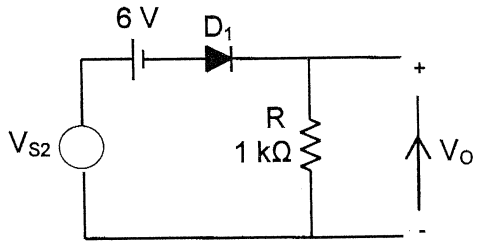


Figure – Q7C

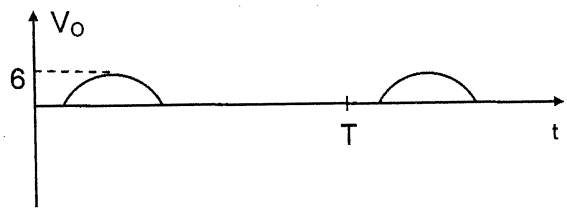


Figure – Q7E

(c) In the circuit shown in figure-Q7F the Galvanometer reading is zero.

(i) Find the value of V_1. Assume all diodes are ideal.

(ii) Then if we replace V_1 with a 15 V, 1 Ω battery find the new current value if I_1.

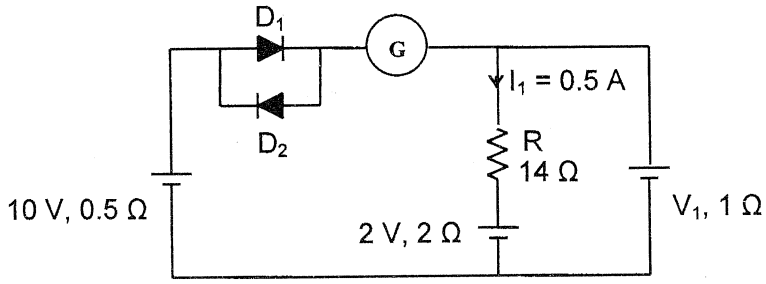


Figure – Q7F

8.

(a) A sinusoidal voltage source V_S is connected to the circuit shown in figure-Q8.The diodes D_1 and D_2 are assumed to be ideal. Draw the current waveforms across two resistors R_1 and R_2. Indicate the positive and negative peak values of above waveforms.

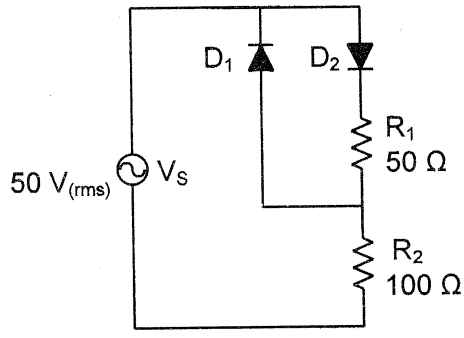


Figure – Q8

(b) A centre tapped transformer has a secondary voltage of 50 V(rms) and is used in a full wave rectifier circuit. Find the peak inverse voltage (PIV) rating for each diode.

(c) Four semiconductor diodes used in a bridge rectifier circuit have forward resistance which can be considered constant as 0.1 Ω and infinite reverse resistances. They supply a mean current of 10 A to a resistive load from a sinusoidally varying alternating supply of 20 Vrms. Determine the resistance of the load.