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

ECX2330 – Principles of Electricity
Final Examination 2009/2010 **Closed book exam**

Date: 06th March 2010 Time: 1330-1630 hrs.

This paper contains eight questions. Answer any five questions. All questions carry equal marks. Marks will not be given unless your calculations are clearly shown. Be sure to use proper units and significant figures.

Gravitational acceleration	$g = 9.81\ ms^{-2}$
Electric space constant	$\varepsilon_0 = 8.85\times10^{-12}\ Fm^{-1}$
Magnetic space constant	$\mu_0 = 4\pi\times10^{-7}\ Hm^{-1}$
Charge of an electron	$e = -1.60\times10^{-19}\ C$
Rest mass of an electron	$m_e = 9.11\times10^{-31}\ kg$
Rest mass of a proton	$m_p = 1.67\times10^{-27}\ kg$

1. State Coulomb's law.

Two identical spheres are each attached to silk threads of length l = 0.500 m and hung from a common point. Each sphere has mass m = 8.00 g. The radius of each sphere is very small compared to the distance between the spheres, so they may be treated as point charges. One sphere is given positive charge q_1, and the other a different positive charge q_2. This causes the spheres to separate so that when the spheres are in equilibrium, each thread makes an angle θ = 20.0° with the vertical.

(a) Determine the magnitude of the electrostatic force that acts on each sphere, and determine the tension in each thread.

(b) Based on the information you have been given, what can you say about the magnitudes of q_1 and q_2? Explain your answers.

(c) A small wire is now connected between the spheres, allowing charge to be transferred from one sphere to the other until the two spheres have equal charges; the wire is then removed. Each thread now makes an angle of 30.0° with the vertical. Determine the original charges. *(Hint: The total charge on the pair of spheres is conserved)*

2. Describe how the physical dimensions influence the capacitance of a parallel plate capacitor.

Two capacitors C_1 = 9.0 μF, C_2 = 4.0 μF, are connected in parallel, and connected across a source V_S = 28 V. Suppose the charged capacitors are disconnected from the source and from each other, and then reconnected to each other with plates of opposite sign together. By how much does the energy of the system change?

3. Describe possible reasons for internal resistance of an electric cell.

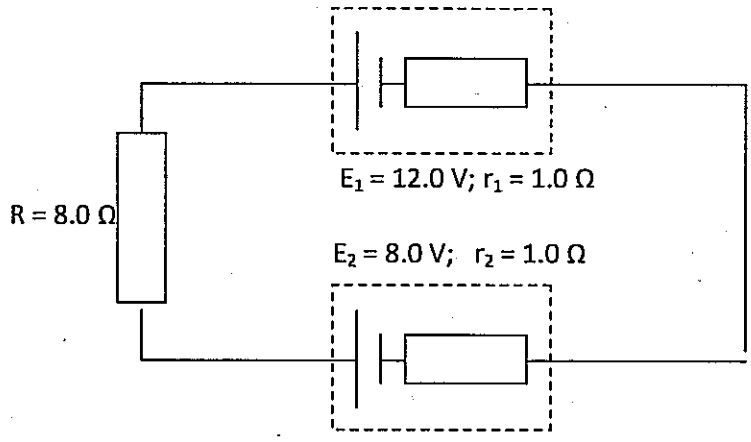

Figure Q3

The Fig. Q3 shows two rechargeable batteries E_1 and E_2 connected to the resistor R. Find

(a) the current through the 8.0 Ω resistor and

(b) the total rate of dissipation of electrical energy in the 8.0 Ω resistor and in the internal resistance of the batteries.

(c) In one of the batteries, chemical energy is being converted into electrical energy. In which one is this happening, and at what rate?

(d) In one of the batteries, electrical energy is being converted into chemical energy. In which one is this happening, and at what rate?

(e) Show that the overall rate of production of electrical energy equals the overall rate of consumption of electrical energy in the circuit.

4. What is the requirement for two resistors to be considered connected in series?

A 60 W, 120 V light bulb and a 200 W, 120 V light bulb are connected in series across a 240 V supply. Assume that the resistance of each bulb does not vary with current.

(a) Find the current through the bulbs.

(b) Find the power dissipated in each bulb.

(c) One bulb burns out very quickly. Which one? Why?

5. Describe the factors affecting a moving charge in a magnetic field.

(a) What is the speed of a beam of electrons when the simultaneous influence of an electric field of 1.56×10^4 V/m and a magnetic field of 4.62×10^{-3} T, with both fields normal to the beam and to each other, produces no deflection of the electrons?

(b) If the electric field is removed suddenly, what is the path of the electrons? Calculate its shape. (You may ignore gravitational effects)

6. What is the characteristic of a circuit at resonance?

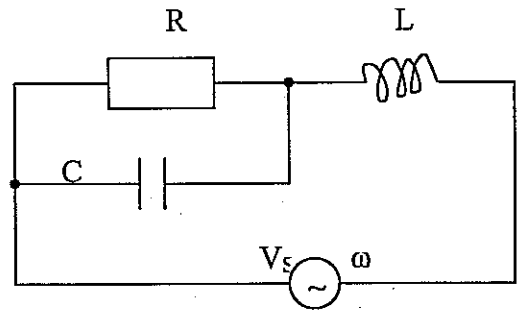

Figure Q6

$R = 500\ \Omega$
$C = 1.25\ \mu F$

$L = 250\ mH$

(a) Calculate currents through all elements of the circuit in Fig. Q6 when source voltage is given as $V_S = 34 \sin 2000t$ V.

(b) Draw the phasor diagram for the circuit at this input.

(c) Calculate the resonance frequency of the circuit.

(d) Calculate the currents through all elements when the circuit is at resonance, if the amplitude of the input voltage is unchanged.

7. Describe the effect of a magnetic field on a conductor moving within it.

A square loop of wire with side length **L** and resistance **R** is moved at constant speed **v** across a uniform magnetic field. Consider the field to be directed into the page, confined to a square region with sides parallel to the sides of the page. The lengths of the sides are twice the length of those of the square loop. The loop movement is from left-to-right along the page, so that the sides of the loop are perpendicular to the field and with its sides parallel to sides of the page. The loop is totally immersed in the field for some time, and remerges from the other side.
The x-axis is drawn in the direction of the motion. The coordinate x is measured from the centre of the magnetic-field region to the centre of the loop in the direction of the motion. It is negative when the centre of the loop is to the left of the centre of the magnetic-field region. Take positive force to be to the right.

(a) Graph the external force F needed to move the loop at constant speed as a function of the coordinate x from x = - 2L to x = +2L.

(b) Graph the induced current in the loop as a function of x for the same range. Take counter clockwise currents to be positive.

8. Describe how the zener stabiliser circuit functions.

(a) A 8.20 V / 0.5 W zener diode is used to stabilise a 500 Ω load. If the source voltage is known to fluctuate between 18.0 V and 22.0 V, what is a suitable value for the series resistor R_S of the circuit?

(b) The minimum zener current $I_{Z(min)}$ is indicated to be 600 μA. Dose this influence your solution from (a)?