UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, NOVEMBER 2013

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	**BASIC ELECTRICAL ENGINEERING**
COURSE NUMBER:	**EE251**
TIME ALLOWED:	**THREE HOURS**

INSTRUCTIONS:

1. There are five questions in this paper. **Answer any FOUR questions.**
2. Each question carries 25 marks.
3. Marks for different sections are shown on the right hand margin.
4. Show the steps clearly in all your calculations including any assumptions made.
5. A sheet containing useful formulae is attached at the end of the question paper.

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THIS PAPER HAS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION 1 ***(25 marks)***

(a) An aluminium wire and a copper wire both 10 m long are connected in parallel. When a current of 6 A is passed through the combination the current in the aluminium wire is measured to be 2 A.

(i) Explain why the wires carry different currents although they are the same length. *(1 mark)*

(ii) If the diameter of the aluminium wire is 1.0 mm, determin the diameter of the copper wire. The resistivity of copper is 1.72×10^{-8} Ω-m and that of aluminium is 2.8×10^{-8} Ω-m. *(10 marks)*

(b) An Uninterruptible Power Supply (UPS) consists of a battery which feeds into an electronic converter circuit which then runs a load. Measurements show that the UPS can run the load of 1 kW for only 20 mins. The electronic converter circuit loses 15% of its input power as heat. Calculate the W-h capacity of the battery.

(4 marks)

(c) A series RC circuit with R = 4 kΩ and C = 33 μF has a constant voltage 120 V applied at $t = 0$ and the capacitor has no initial charge. Find the expressions for $i(t)$, $v_R(t)$ and $v_C(t)$. Derive any equations used. *(10 marks)*

QUESTION 2 *(25 marks)*

(a) Use Delta-Star or Star-Delta transformation to evaluate the current supplied by the battery in Fig.Q.2a. *(10 marks)*

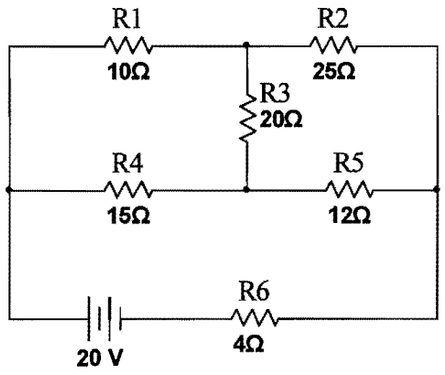

Fig. Q.2a

(b) In Fig. Q2b use the **mesh (loop) current** analysis method find

(i) the currents supplied by each voltage source. *(12 marks*

(ii) the voltage across the current source. *(3 marks*

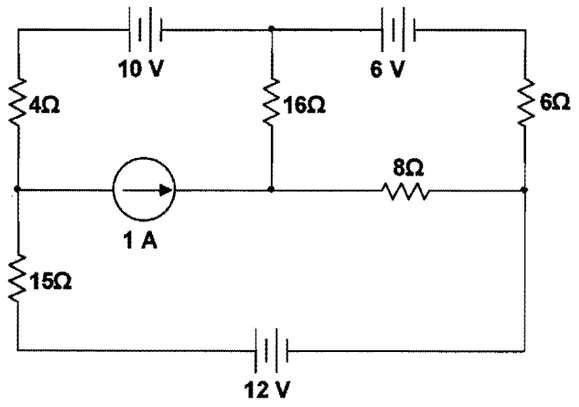

Fig. Q.2b

QUESTION 3 *(25 marks)*

(a) Consider the circuit shown in Fig. Q.3a.

(i) Find both the Thevenin and Norton equivalents of the circuit across the points **a** and **b**. *(10 marks)*

(ii) If a variable resistor were connected between the points **a** and **b**, what will be the maximum power dissipated in the variable resistor? *(2 marks)*

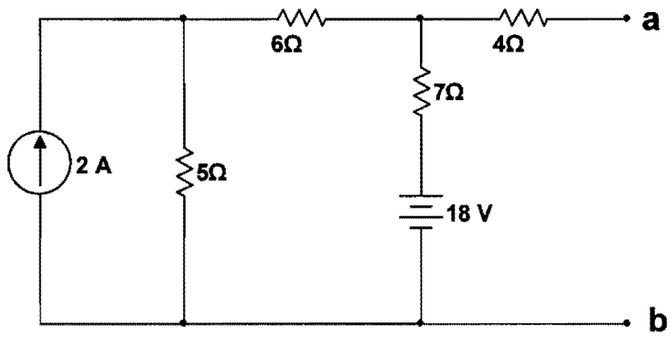

Fig. Q.3a

(b) Use **nodal analysis** to find the current through the resistor R_2 in the shown in Fig.Q.3b. *(13 marks)*

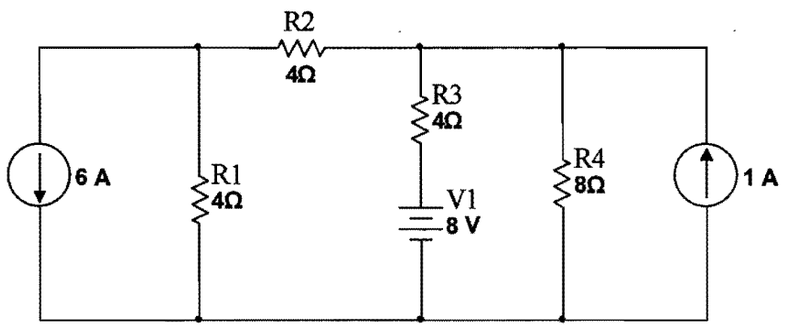

Fig. Q.3b

QUESTION 4 ***(25 marks)***

(a) The circuit shown in Fig. Q4a has two sources one of which is a dependent source.

(i) Find the voltage across the current source. *(8 marks)*

(ii) Find the power dissipated in each resistor *(3 marks)*

(iii) Find the total power supplied by the sources. *(2 marks)*

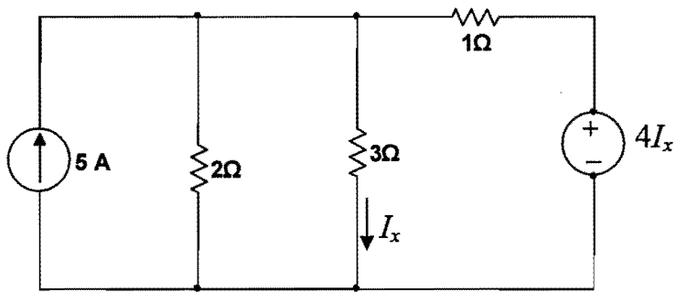

Fig. Q.4a

(b) For the circuit shown in Fig Q.4b

(i) Find the waveform expression for the current *i(t)*. *(6 marks)*

(ii) Find the phasor voltage across the capacitor. *(3 marks)*

(iii) Sketch the phasor diagram of all the currents in the circuit. *(3 marks)*

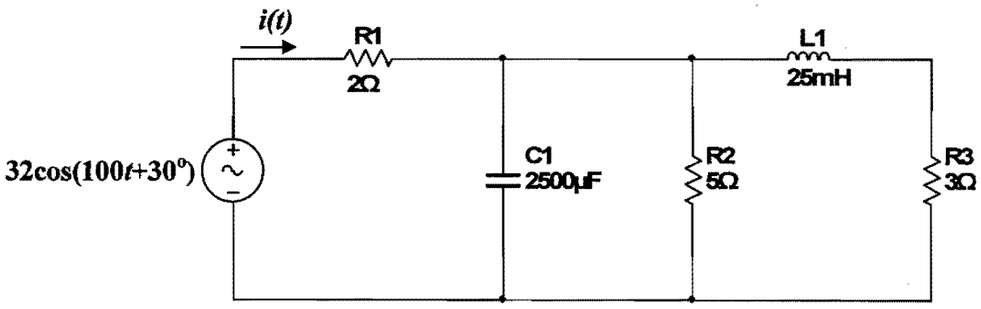

Fig. Q.4b

QUESTION 5 ***(25 marks)***

(a) A circuit consisting of a coil of inductance 150 μH and resistance 5 Ω, in series with a capacitor of 22 nF is connected to a variable frequency supply which has a constant voltage 20 V. Determine:

(i) the resonance frequency of the circuit. *(2 marks)*

(ii) the current in the circuit at resonance. *(2 marks)*

(iii) the voltages across the inductance and the capacitor at resonance. *(3 marks)*

(iv) the Q-factor of the circuit. *(3 marks)*

(b) A coil of inductance 80 mH and resistance 120 Ω is connected to a 230 V, 50 Hz supply. In parallel with it is a 60-μF capacitor in series with a 40 Ω resistor as shown in Fig. Q5b. Determine:

(i) The total impedance of the circuit, *(6 marks)*

(ii) The power factor of the combined circuit stating whether it is leading or lagging. *(3 marks)*

(iii) The total Active Power taken from the supply, *(2 marks)*

(iv) The total Reactive Power supplied, *(2 marks)*

(v) The Apparent Power supplied. *(2 marks)*

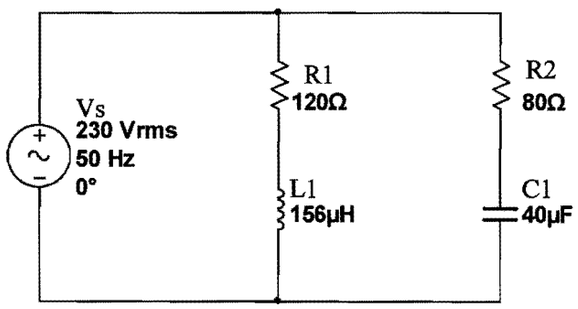

Fig. Q5b

========= *end of exam paper, attachment follows* ==========

SOME SELECTED FORMULAE

$$R = \rho \frac{l}{a}$$

$$P = V_{rms} I_{rms} \cos\phi, \qquad V_{rms} = \frac{V_m}{\sqrt{2}}, \qquad P^2 = Q^2 + R^2$$

$$Z = \frac{\vec{V}}{\vec{I}} = R + jX$$

$$R = \frac{V_R}{I_R}, \qquad X_L = \left|\frac{V_L}{I_L}\right| = \omega L, \qquad X_C = \left|\frac{V_C}{I_C}\right| = \frac{1}{\omega C}$$

$$W_L = \frac{1}{2} L I^2 \qquad W_C = \frac{1}{2} C V^2$$

$$\omega_o^2 = 1/LC, \qquad Q = \omega_o L / R$$

$$R_1 = \frac{R_B R_C}{R_A + R_B + R_C}, \qquad R_A = \frac{R_1 R_2 + R_2 R_3 + R_1 R_3}{R_1}$$

$$v_C(t) = V_s\left(1 - e^{-t/RC}\right), \qquad v_C(t) = V_i e^{-t/RC}$$