UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATION, JULY 2014

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. **When a particular method of solving a problem is specified, you must use that method to arrive at your answer; otherwise zero marks will be awarded even if your answer is correct.**
5. Show the steps clearly in all your calculations. This is because marks may be awarded for method and understanding, even if a final answer is incorrect.
6. If you think not enough data has been given in any questions you may assume reasonable values and state those assumptions.
7. A sheet containing useful formulae and other information is attached at the end.

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER HAS SEVEN (7) PAGES INCLUDING THIS PAGE

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

(a) You are to build an electromagnet with 0.643-mm diameter copper wire. To create the required magnetic field, the current in the coil must be 2 A. The electromagnet is powered from a 12-V dc source and the resistivity of copper is 1.723×10^{-8} Ω-m. How many meters of wire do you need to wind the coil? *(5 marks)*

(b) A Li-Ion battery for a digital camera is rated at 7.2 V, 6 W-h. Another Li-Ion battery for a cell phone is rated at 3.6 V, 2100 mA-h. Which of the two batteries stores more energy than the other? Include a justification for your answer. *(5 marks)*

(c) In a factory two air-conditioning machines each delivering 30 kW are used on average for 9.2 h/day for 296 days per year. One machine is older and has only 75% energy efficiency while the other machine is newer and has 89% energy efficiency. Calculate the difference in cost per year of operating the two air-conditioning machines assuming that energy consumed is charged at E1.06 per kW-h. *(5 marks)*

(d) In the circuit shown in Fig.Q.1d,

(i) Find the voltage across the capacitor when switch S has been **closed** for a long time and when S has been **open** for a long time. *(2 marks)*

(ii) If the switch S has been closed for a long time and then opened at time $t = 0$ s, find the voltage across the capacitor when time $t = 2RC$. *(8 marks)*

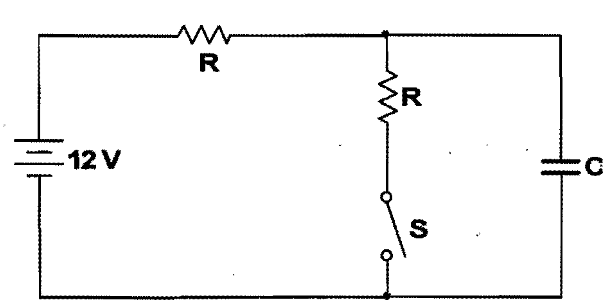

Fig. Q1d

QUESTION 2 ***(25 marks)***

(a) In Fig. Q2a use the **mesh (loop) current** analysis method find the **magnitude and direction** of the currents in the following components:

(i) The resistor R_2. *(5 marks)*

(ii) The resistor R_1. *(3 marks)*

(iii) The voltage source. *(2 marks)*

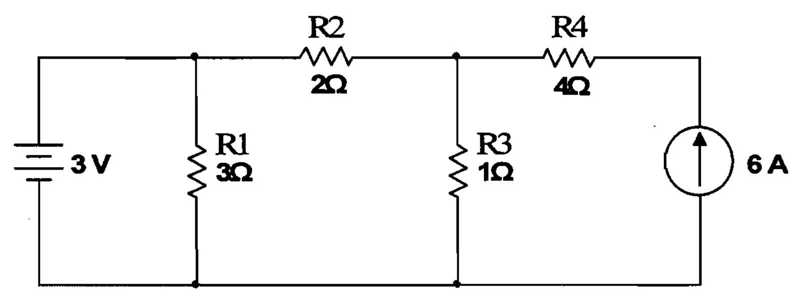

Fig. Q.2a

(b) Obtain the **Norton's equivalent** across the terminals A and B of the circuit shown in Q.2b. *(9 marks)*

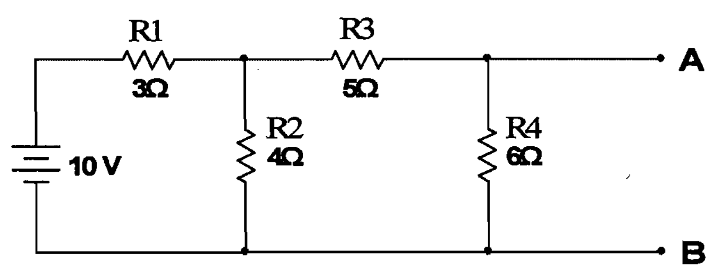

Fig. Q.2b

(c) Obtain the **Thevenin's equivalent** across the terminals X and Y of the circuit shown in Q.2c. *(6 marks)*

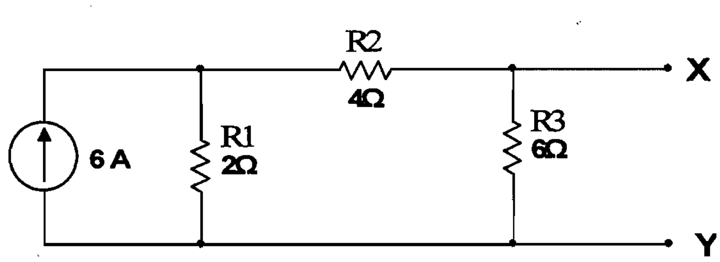

Fig. Q.2c

QUESTION 3 ***(25 marks)***

(a) Use **Delta-Star or Star-Delta** transformation to evaluate the current supplied by the voltage source in Fig.Q.3a. *(10 marks)*

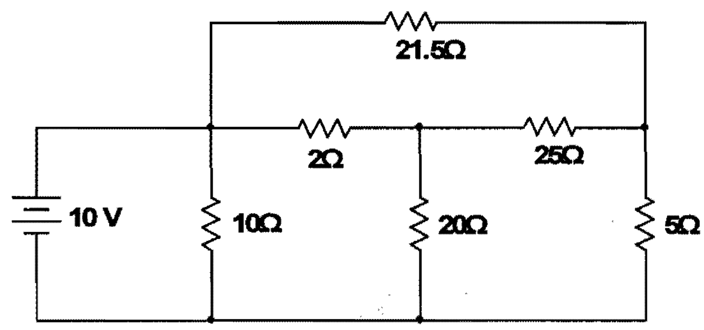

Fig. Q.3a

(b) Consider the circuit shown in Fig. Q.3b. Use **loop (mesh)** analysis to find the voltage across the 5-A current source. *(15 marks)*

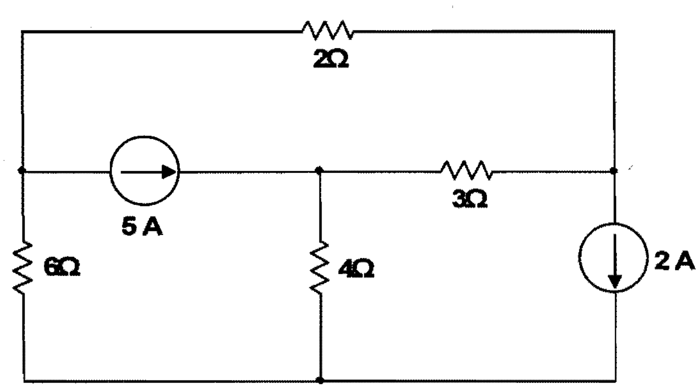

Fig. Q.3b

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

(a) Use **the superposition principle** to find the currents I_1 and I_2 in the circuit shown in Fig.Q.4a *(10 marks)*

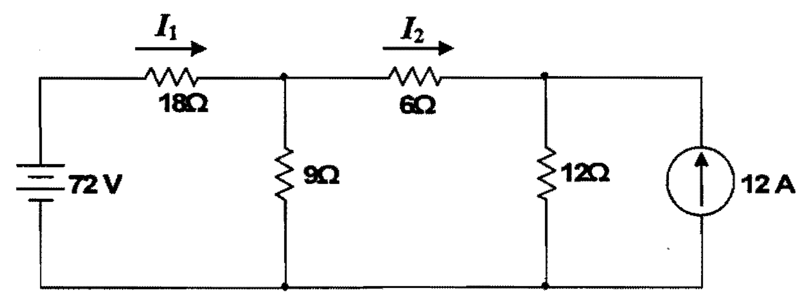

Fig. Q.4a

(b) Use **Nodal Analysis** in Fig.Q.4b to find the current in the 8-V voltage source.

(15 marks)

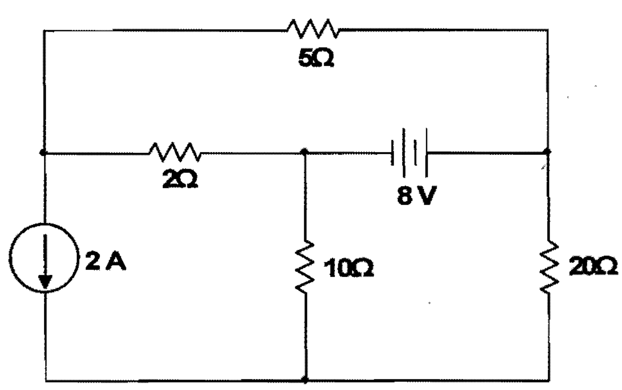

Fig. Q.4b

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

(a) A series RLC circuit with $L = 8\ \mu H$, $R = 0.5\ \Omega$ and $C = 100$ nF is connected to a variable frequency sinusoidal a.c. source which has a voltage of constant peak amplitude $3\sqrt{2}$ V. Determine:

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

(ii) the power dissipated by the circuit at resonance. *(3 marks)*

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

(iv) the quality factor of the circuit. *(2 mark)*

(b) For the a.c. circuit is shown in Fig. Q5b. Determine:

(i) The total impedance of the circuit as seen from the supply. *(6 marks)*

(ii) The power factor seen by the supply, stating whether it is leading or lagging. *(3 marks)*

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

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

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

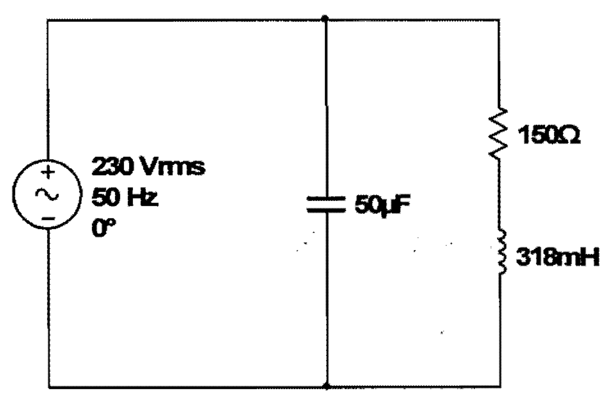

Fig. Q5b

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

SOME SELECTED FORMULAE

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

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

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

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

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

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

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

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