UNIVERSITY OF SWAZILAND
MAIN EXAMINATION, DECEMBER 2012

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) A planar resistor of uniform thickness is made by cutting up squares of material from a slab of resistance material. Show that the resistance between any two opposite ends of the planar resistor is the same regardless of the size of the square cut. *(5 marks)*

(b) Determine the resistance of 1500 m of copper cable having a diameter of 12 mm, given that the resistivity of copper is 1.7×10^{-8} Ω-m. *(3 marks)*

(c) A Li-Ion battery for a digital camera is rated at 3.6 V, 2.4 W-h. When viewing a video taken by the camera 250 mA is taken from the battery. Estimate how long a fully charged battery can last if used for viewing videos. *(5 marks)*

(d) The Swaziland Electricity Company supplies residential premises with 230 V, 50 Hz mains and charges E0.84 for every kW-h of energy consumed. A student has used electricity on a typical day in his premises as follows:

Made 4 slices of toast using a 900W toaster which takes 2 min to toast each pair of slices

Boiled 4.5 litres of water using 1800 W, 1.5 litre capacity kettle which takes 5 min to boil a full kettle of water.

Used a 230 V, 60 W soldering iron for 24 min.

Used two 14 W energy saving bulbs for 6 h

Charged a cell phone for 1½ h using a 230 V, 200 mA charger.

Used a 1220 W steam iron for 24 min

Although the music system was not used, it was left on standby for 24 h. The system draws 20 mA from the 230 V mains while on standby.

Find the following:

(i) The total cost of electricity used. *(9 marks)*

(ii) The input current to the premises if all these appliances are switched on simultaneously and the overall power factor is 0.9 lagging. *(3 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)*

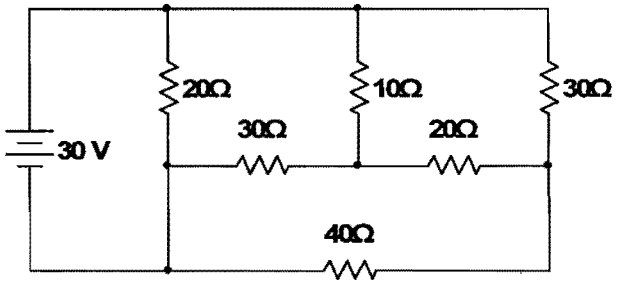
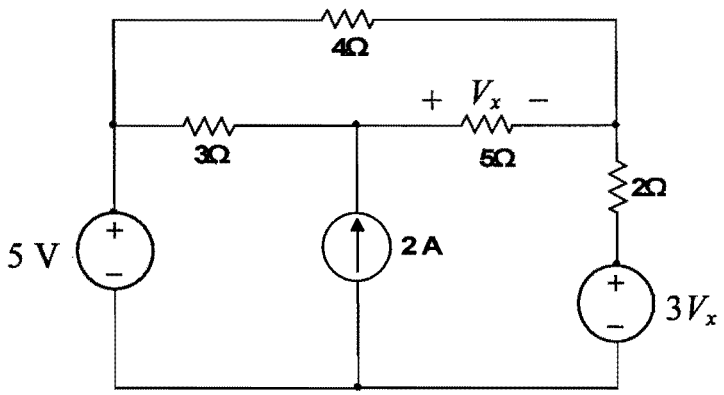


Fig. Q.2a

(b) Using the **mesh (loop) current** analysis method find the voltage across the current source shown in Fig.Q.2b. Note that the circuit has a voltage dependent voltage source, $3V_x$.



(15 marks)

Fig. Q.2b

QUESTION 3 *(25 marks)*

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

(i) Find the Thevenin equivalent of the circuit across the points **a** and **b**. *(8 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)*

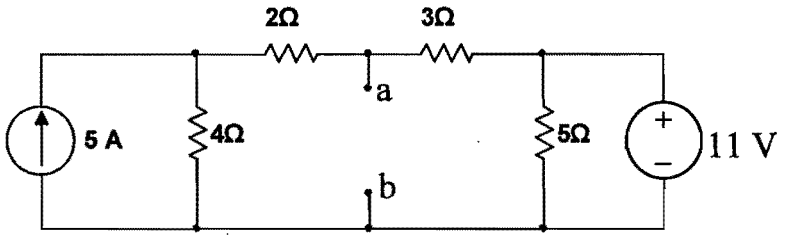


Fig. Q.3a

(b) Use **nodal analysis** to find the node voltages V_a, V_b and V_c shown in Fig.Q.3b. *(15 marks)*

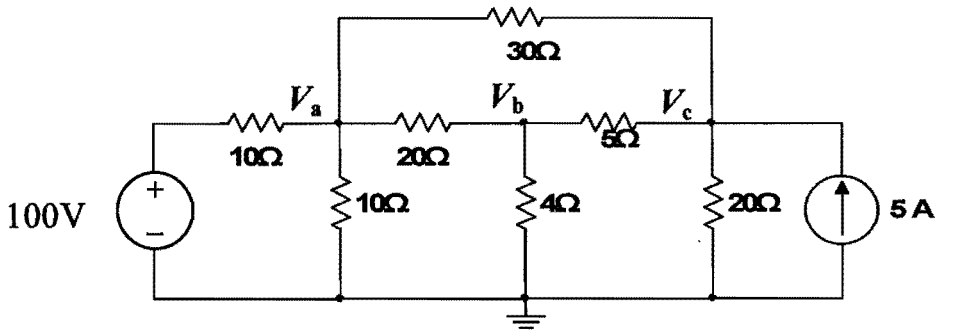


Fig. Q.3b

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

(a) A 500-μF capacitor connected in series with a 250-Ω resistor. The circuit is connected across a 50 V dc supply via a switch which is switched on at $t = 0$ s. Determine:

(i) the initial value of the current flowing. *(2 marks)*

(ii) the value of current in the circuit 100 ms after switching on. *(3 marks)*

(iii) the voltage across the capacitor, 50 ms after switching on. *(3 marks)*

(iv) the time at which the voltage across the resistor is 20 V. *(4 marks)*

(b) A power supply has a voltage $v_s = 308\sin(314t)$ volts. This supply supplies currents i_1 and i_2 to two parallel branches with complex impedances Z_1 and Z_2 as shown in Fig. Q4b where:

$$i_1 = 14.14\sin(314t + 45^o) \text{ A}$$
$$i_2 = 21.21\sin(314t - 60^o) \text{ A}$$

(i) Using phasors, or otherwise, derive a sinusoidal expression for the total current taken from the supply. *(6 marks)*

(ii) Determine the complex impedance connected to each branch. *(7 marks)*

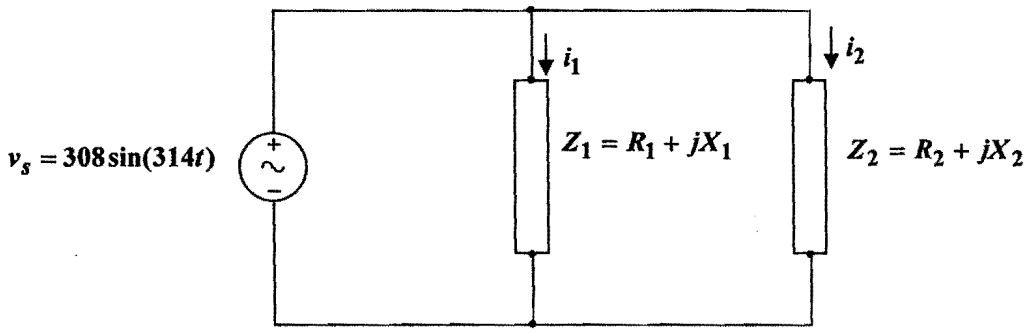


Fig. Q.4b

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

(a) A circuit consisting of a coil of inductance 0.15 H and resistance 12 Ω, in series with a capacitor of 12 μF is connected to a variable frequency supply which has a constant voltage 24 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)*

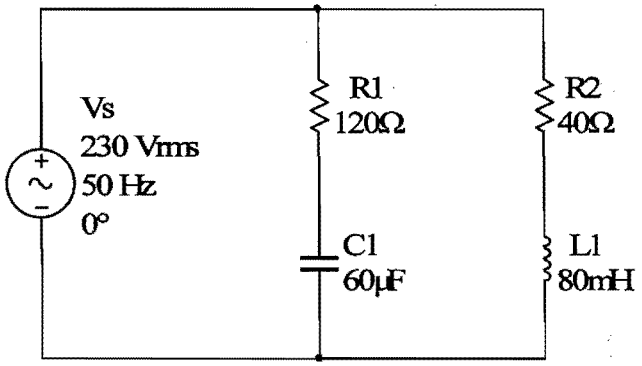


Fig. Q5b

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

SOME SELECTED FORMULAE

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

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

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

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

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

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

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

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