UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION, JULY 2011

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

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

INSTRUCTIONS:

1. There are seven questions in this paper. Answer any FIVE questions.
2. Each question carries 20 marks.
3. A list of selected formulae which may be relevant is attached
4. If you think not enough data has been given in any question you may assume any reasonable values.

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THIS PAPER CONTAINS NINE (9) PAGES INCLUDING THIS PAGE

QUESTION ONE ***(20 marks)***

An experimenter building the voltage divider circuits shown in Fig. Q.1 predicted that varying the resistances $\mathbf{R_2}$ and $\mathbf{R_3}$ should give the results shown on the graphs below the circuits.

(i) Pair, giving your reasons, each voltage divider circuit (a) or (b) with its corresponding graph (c) or (d). Hence determine what the x-axis variables **X** and **Y** should be.

(8 marks)

(ii) Define the labeling of the graphs by working out, from the circuit variables, expressions for the voltages labeled **A, B, C, D** and **E**. *(12 marks)*

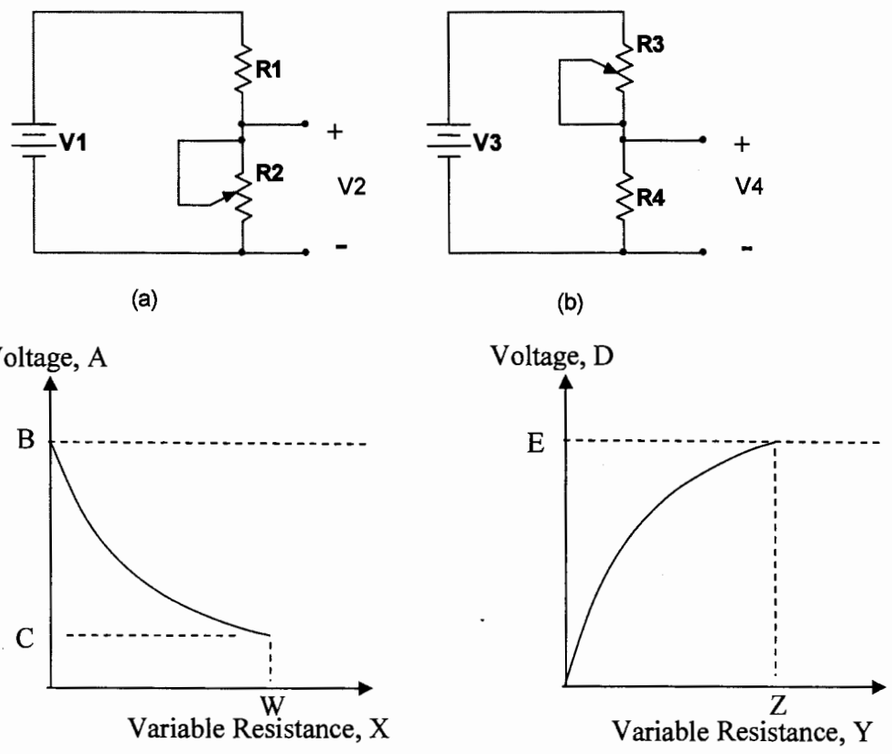


Fig. Q.1

QUESTION TWO ***(20 marks)***

(a) **(i)** By applying the $\Delta - Y$ transformation, find the resistance, R_{eq}, of the network shown in Fig Q.2a looking into the terminals A and B. *(8 marks)*

(ii) How else would you have found the result in (i) using an intuitive argument (i.e straight away without going into all the calculations)? *(2 marks)*

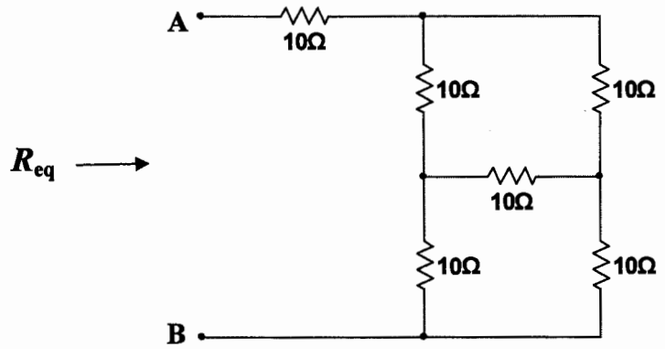


Fig. Q.2a

(b) Use the current divider formula to evaluate the currents I_1, I_2, I_3, I_4, and I_6 in Fig. Q2.b. You are given that $I_5 = 4$ A. *(10 marks)*

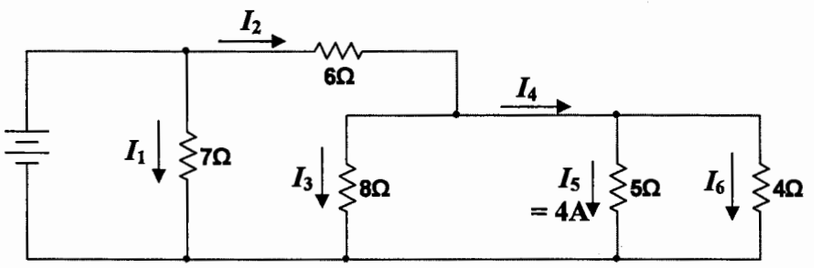


Fig. Q.2b

QUESTION THREE ***(20 marks)***

(a) **(i)** A current $i = I_m \sin(\omega t + \theta)$ is passed through an inductor L. Obtain a general expression for the voltage appearing across the inductor. *(2 marks)*

(ii) A current $i = 20\sin(2000\pi t + 45^\circ)$ A is passed through an inductor of 2 mH. Determine the expression for the voltage that will appear across the inductor. Sketch both the current and voltage waveforms on a common time axis. Show clearly the phase differences, if any. *(8 marks)*

(b) Impedances $Z_1 = 6 + j4$, $Z_2 = 5 - j3$, and $Z_3 = 2 - j7$ are connected in parallel. Evaluate the equivalent impedance of the three parallel impedances. *(10 marks)*

QUESTION FOUR ***(20 marks)***

(a) Use the superposition theorem to obtain the values of the currents I_1 and I_2 shown in Fig. Q.4a. Hence calculate the voltage, V_{AB}, across the current source. *(10 marks)*

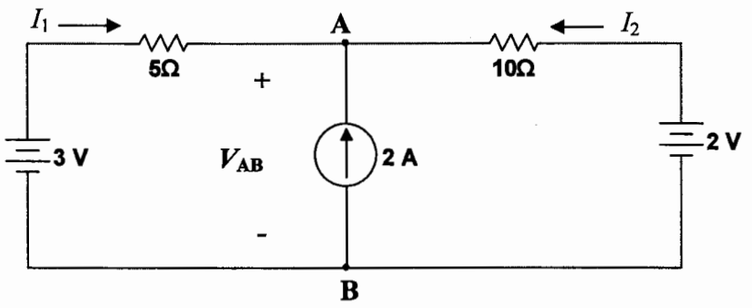


Fig. Q.4a

(b) In the circuit shown in Fig. Q.4b, write down the three equations for the mesh (loop) currents I_1, I_2 and I_3. Express your result in matrix form. You are not asked to solve the equations. *(8 marks)*

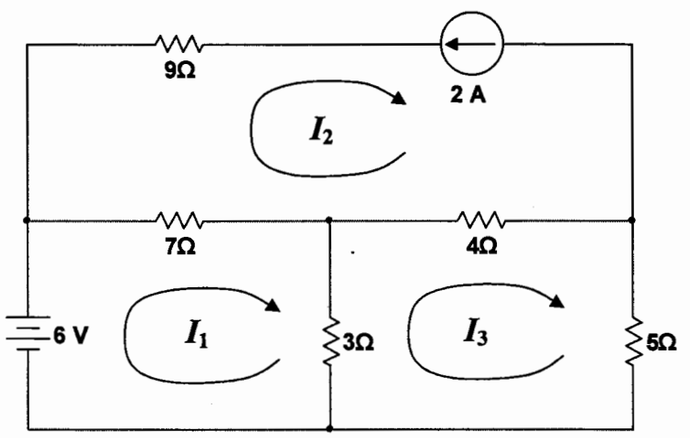


Fig. Q.4b

QUESTION FIVE ***(20 marks)***

(a) **(i)** Calculate the magnetomotive force (m.m.f) required to produce a flux of 2.7 mWb across an airgap 3 mm long with a rectangular cross-section 5 cm by 6 cm. *(7 marks)*

(ii) The flux referred to in (i) is produced by winding a coil of 500 turns around an iron ring with relative permeabilbity $\mu_r = 1000$. How much current will be needed to produce the flux? Assume that the total length of the magnetic path is much greater than the length of the airgap. *(3 marks)*

(b) A transformer to be used at 50 Hz has a core of uniform cross-section 20 mm by 20 mm. The transformer is designed to step down voltage from 230 V a.c. to 20 V a.c. The flux density in the core is not to exceed 0.8 Tesla. Determine the number of turns in each of the two windings of the transformer. Note that the number of turns must be a whole number. *(10 marks)*

QUESTION SIX ***(20 marks)***

(a) (i) By means of suitable illustrations distinguish between the connections of the armature and field windings in each of the following machines:

Series d.c. generator

Shunt d.c. generator

Compound d.c. generator

(9 marks)

(ii) Describe the starting of a d.c. shunt generator. *(3 marks)*

(b) A four-pole wave connected armature with 39 slots is required to generate 230 volts when driven at 1000 r.p.m. If the useful flux per pole is 30 mWb, calculate the required approximate number of conductors per slot. *(8 marks)*

QUESTION SEVEN ***(20 marks)***

(a) The armature of a d.c. machine has a resistance of 0.15 Ω and is connected to a 230 V supply. Calculate the e.m.f. generated when it is running as

(i) a generator giving 100 A, and

(ii) a motor taking 60 A

(6 marks)

(b) A 460 V supply is connected to a 4-pole shunt motor which has its armature wave-wound with 888 conductors. The useful flux per pole is 20 mWb and the resistance of the armature circuit is 0.7 Ω. If the armature current is 40 A, calculate:

(i) the speed of the motor. *(8 marks)*

(ii) the torque developed by the armature. *(6 marks)*

EE251 LIST OF SELECTED FORMULAE WHICH MAY BE RELEVANT

$$F = BlI\sin\theta$$

$$E = Blv$$

$$H = \frac{NI}{l}$$

$$B = \mu_o \mu_r H$$

$$\mu_o = 4\pi \times 10^{-7} \text{ H/m}$$

$$E = 2\frac{Z}{c} \times \frac{Np}{60} \times \Phi$$

$$E = 4.44Nf\Phi$$

$$\text{Flux} = \frac{\text{MMF}}{\text{Reluctance}} \quad \text{i.e. } \Phi = \frac{NI}{\Re} = BA$$

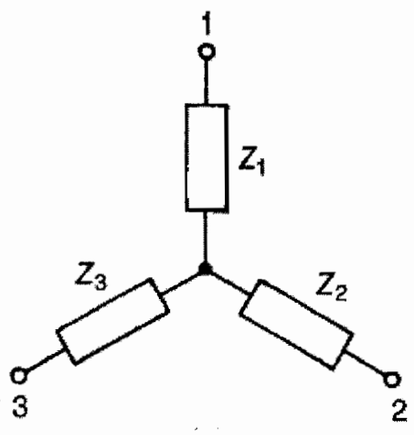
$$E = V - I_a R_a$$

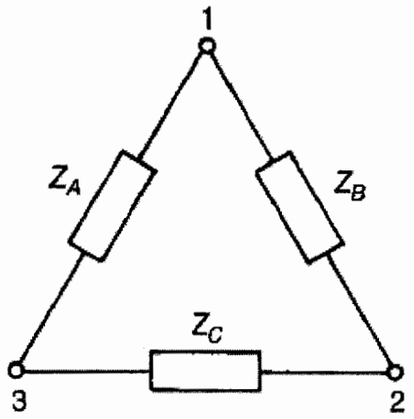
$$E' = V + I_a R_a$$

$$N = \frac{V - I_a R_a}{k\Phi} \simeq \frac{V}{k\Phi}$$

$$T = k\Phi I_a$$

$$P = T\omega, \quad \omega = \frac{2\pi N}{60}$$





$$Z_1 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$$

$$Z_A = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}{Z_2}$$