UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: August 2015

Module Number: EE1301 Module Name: Introduction to Electrical Engineering

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1 a) i) Define Kirchhoff's Current Law.

ii) State the difference between linear and non-linear electrical circuits.

iii) When capacitors are connected in series and in parallel, how are the resultant capacitance affected?

[3.0 Marks]

b) i) Briefly describe the Reciprocity Theorem.

ii) Explain the use of the Maximum Power Transfer Theorem in Direct Current (DC) circuit analysis?

iii) Consider the circuit shown in Figure Q1 b). Calculate the current flowing through the 10 Ω resistor using the Superposition theorem.

[4.5 Marks]

c) A Wheatstone bridge with a galvanometer of 10 Ω internal resistance is connected across BD in the circuit given in Figure Q1 c). A voltage source of 20 V is connected across AC.

i) Use Thevenin's theorem to calculate the current flowing across the galvanometer.

ii) If the galvanometer is replaced by a load resistance of R Ω, calculate the maximum power that R receives from the circuit.
[Hint: You can assume any theorem to solve part ii).]

[2.5 Marks]

Q2 a) i) Explain the difference between the TT (Tera - Tera) earthing system and the TN (Tera - Neutral) earthing system.

ii) "Fuses are used as the earliest means of protection against over currents". Mention three types of fuses and describe one of them.

[2.5 Marks]

b) Consider the circuit given in Figure Q2 b). Calculate the current vector 'I' flowing across the 30 Ω resistor, if the operating frequency of the AC (Alternative Current) voltage source is 50 Hz.

[2.5 Marks]

c) i) Discuss the advantages of a three phase system compared to a single phase system in an electrical network.

ii) State the advantages of power factor improvement in an electrical installation.

[1.5 Marks]

d) Figure Q2 d) shows a three-phase power system with two loads. The Δ-connected generator is producing a line voltage of 480 V and the line impedance is 0.09 + j 0.16 Ω. Load 1 is Y connected with a phase impedance of $2.5\angle 36.87^0$ Ω and load 2 is Δ connected with a phase impedance of $5\angle -20^0$ Ω.

i) What is the line to line voltage across the two loads?

ii) What is the voltage drop in the transmission line?

iii) Calculate the real and reactive power supplied to each load.

iv) Calculate the real and reactive power losses in the transmission line.

[3.5 Marks]

Q3 a) i) Discuss the advantages of using transformers in electric power systems.

ii) What are the types of losses occurring in a single phase transformer supplying a single phase load?

[3.0 Marks]

b) Explain how open circuit and short circuit tests are conducted on a single phase transformer in order to obtain the necessary observations to determine its equivalent circuit parameters.

[2.0 Marks]

c) Open circuit and short circuit tests are performed on a single phase, 10 kVA, 2200/220 V, 50 Hz transformer and the results obtained are tabulated in Table Q3.

Table Q3: Open circuit and short circuit test data

	Open-Circuit Test (high-voltage side open)	Short-Circuit Test (Low-voltage side shorted)
Voltmeter	220 V	150 V
Ammeter	2.5 A	4.55 A
Wattmeter	100 W	215 W

i) Derive the parameters for the approximate equivalent circuits referred to the low-voltage side and the high-voltage side.

ii) Express the excitation current as a percentage of the rated current.

iii) Determine the power factor for the no-load and short-circuit tests.

[5.0 Marks]

Q4 a) i) Explain why a single phase induction motor cannot self-start, if it is not equipped with a special arrangement to create the initial starting torque.

ii) Explain the methods that can be employed to create an initial starting torque in a single phase induction motor.

[2.5 Marks]

b) i) Explain why a three phase induction motor can never rotate at its synchronous speed.

ii) What are the types of losses occurring in an induction motor? Discuss with the help of the power flow diagram of a three phase induction motor.

[2.5 Marks]

c) A 440 V, 50 Hz, six-pole induction motor has a slip of 6 percent when operating at its full-load conditions and draws 50 kW from the supply. At full-load conditions, the rotational losses are 300 W, the core losses are 600 W and the stator copper losses are estimated to be 1800 W. Stray losses can be neglected. Find the following values for full-load conditions.

i) The motor's speed in rev/min.

ii) The output power of the motor.

iii) The load torque.

iv) The induced torque of the motor.

[5.0 Marks]

Q5 a) i) What are the two modes of operation of a rotating electric machine? How are they defined?

ii) What are the basic functions of the following components of a DC motor?

(I) Brushes

(II) Commutator

(III) Field windings

iii) Explain why the armature core of a large DC electric machine is made of laminations.

[2.5 Marks]

b) i) Draw the dynamic equivalent circuit for a DC series motor. Hence, obtain the steady-state equivalent circuit for the DC series motor.

ii) In steady state, assuming that except for copper losses there are no other losses, obtain the relationship between the voltage constant and the torque constant of a DC series motor.

[2.0 Marks]

c) A DC series motor is connected to a 200 V constant DC supply. The motor shaft is mechanically coupled to a fan. The torque required by the fan is proportional to the square of the speed. The armature and the field resistances are 0.6 Ω and 0.4 Ω, respectively. At a certain operating point, the motor draws 25 A and runs at 400 revolutions per minute (rpm). Assume that except for copper losses there are no other losses in the motor.

i) Determine the power delivered to the fan and the torque developed by the motor at the above mentioned operating point.

ii) The speed is to be reduced to 300 rpm by inserting an additional resistance in the armature circuit of the DC series motor. Determine the value of this additional resistance.

[5.5 Marks]

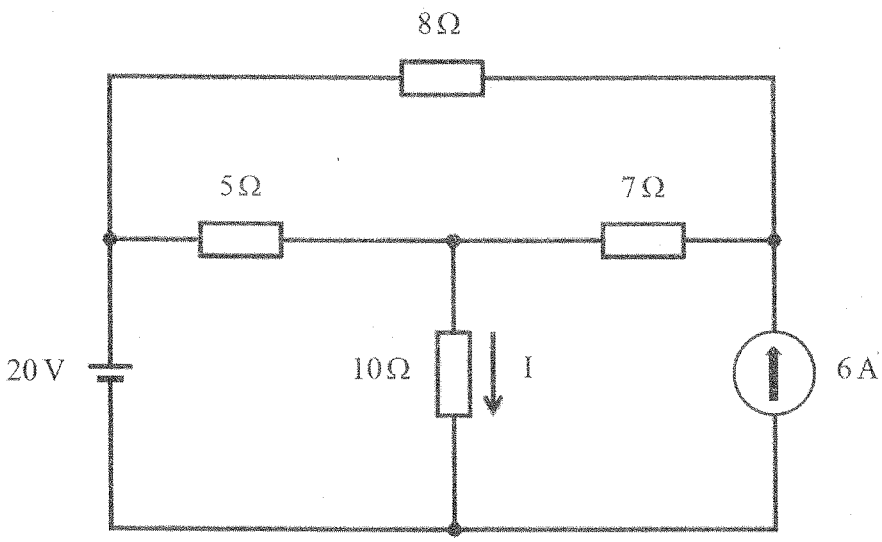

Figure Q1 b)

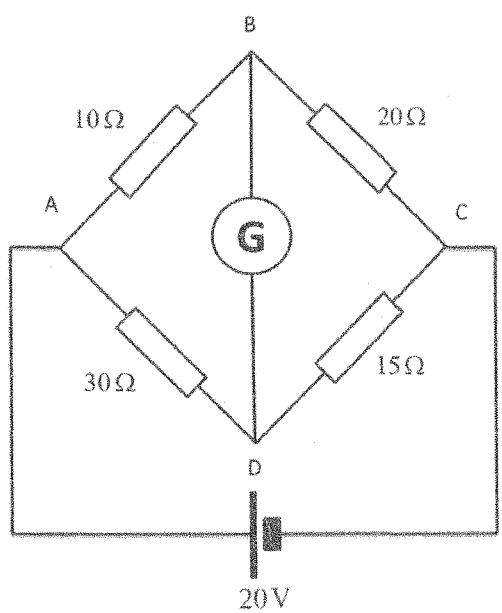

Figure Q1 c)

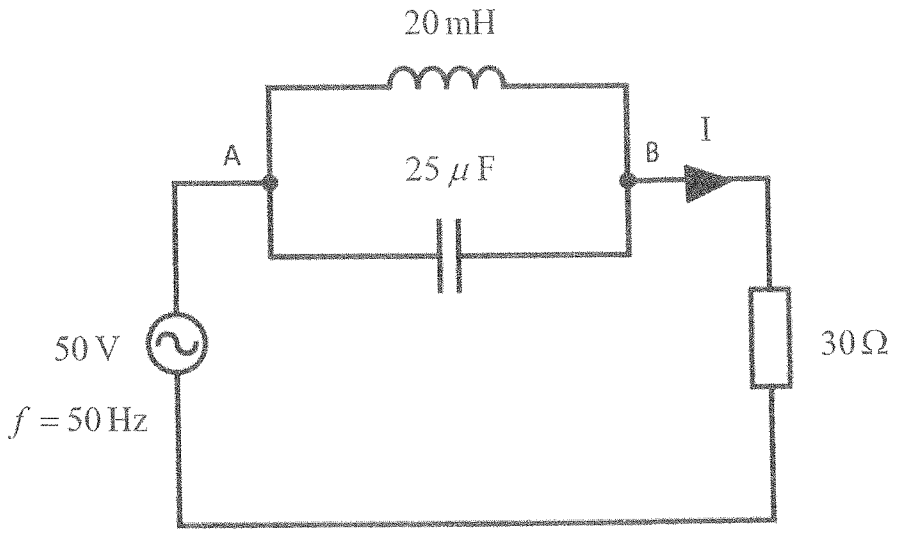

Figure Q2 b)

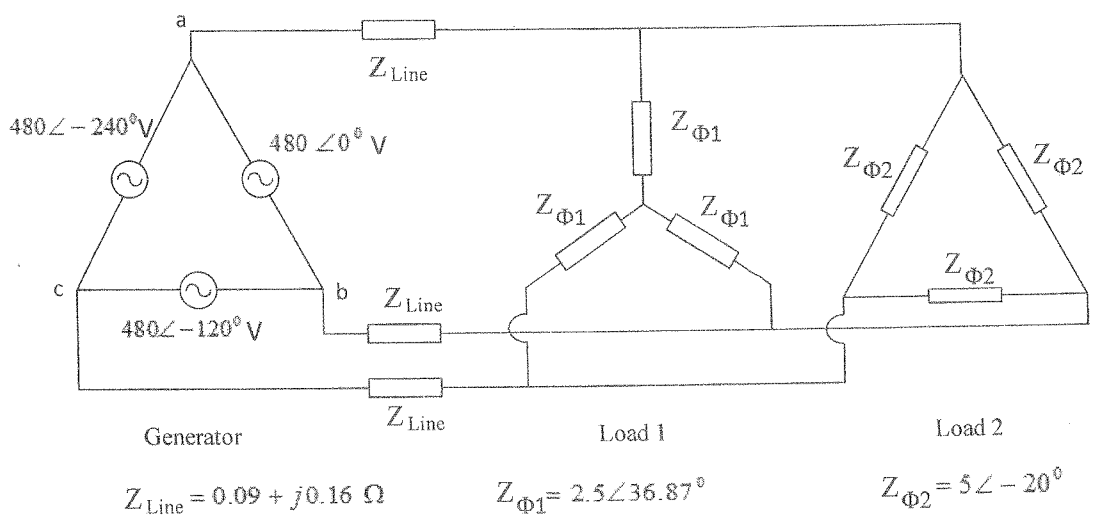

Figure Q2 d)