UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: July 2017

Module Number: EE1301 **Module Name: Introduction to Electrical Engineering**

[Three Hours]

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

Q1 a) i) State Thevenin's theorem related to an electric circuit.

ii) Find the Thevenin's equivalent circuit across points A and B in the circuit given in Figure Q1 (a).

iii) Hence or otherwise find the voltage v_0 across the 10 Ω resistor.

[4 Marks]

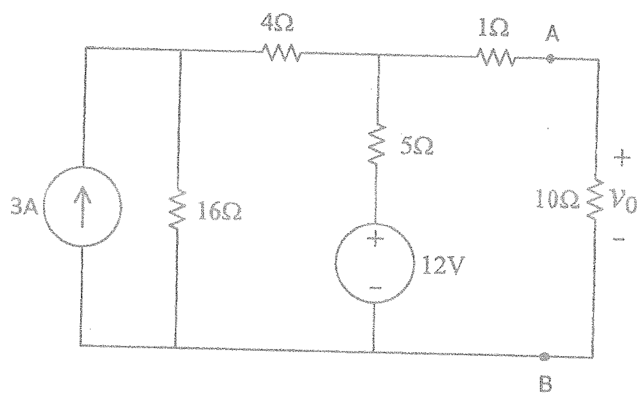

Figure Q1 (a)

b) i) Compare and contrast the use of Nodal analysis and Mesh analysis to solve an electric circuit.

ii) Using Mesh analysis or otherwise, find i_1, i_2 and i_3 shown in the circuit given in Figure Q1 (b).

[6 Marks]

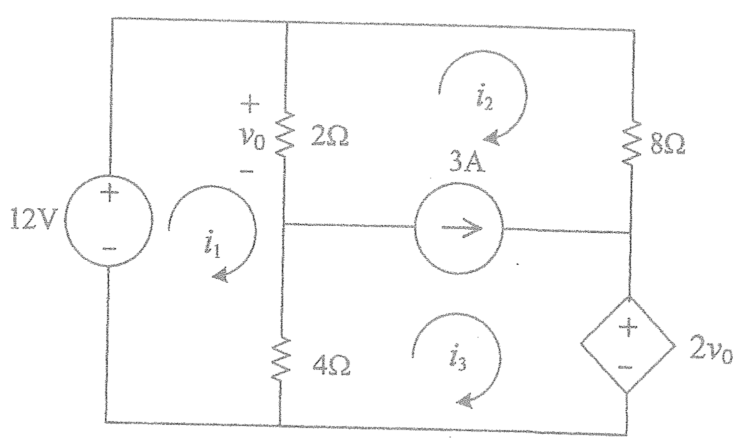

Figure Q1 (b)

Q2 a) i) A full wave rectified ac voltage waveform is shown in Figure Q2 (a)(i). Find the average value, rms value, form factor and the peak factor of the waveform.
Note: $cos2A = 1 - 2sin^2A$

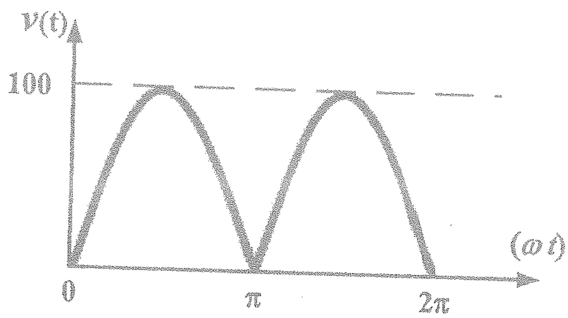

Figure Q2 (a)(i)

ii) With the appropriate notations, give the voltage-current relationship of a resistor, inductor and a capacitor in an ac circuit.

iii) A simple *RLC* circuit is shown in Figure Q2 (a)(iii). Assuming the inductive reactance to be larger than the capacitive reactance, draw the phasor diagram illustrating the voltages across the three circuit elements and the current flowing in the circuit.

[5 Marks]

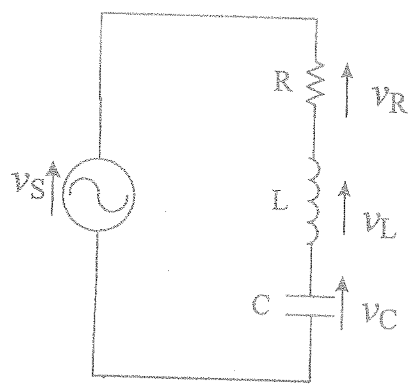

Figure Q2 (a)(iii)

b) Figure Q2 (b) shows a three-phase, star connected source connecting to a delta connected load through a transmission line. The phase voltage of the generator is 120 V, and the line impedance is 0.1 + j 0.15 Ω. The phase impedance of the load is 12- j 9 Ω.

i) Calculate the line to line voltage across the load.

ii) Calculate the voltage drop along the transmission line.

iii) Calculate the real and reactive power drawn by the load.

iv) Calculate the power factor of the load.

[5 Marks]

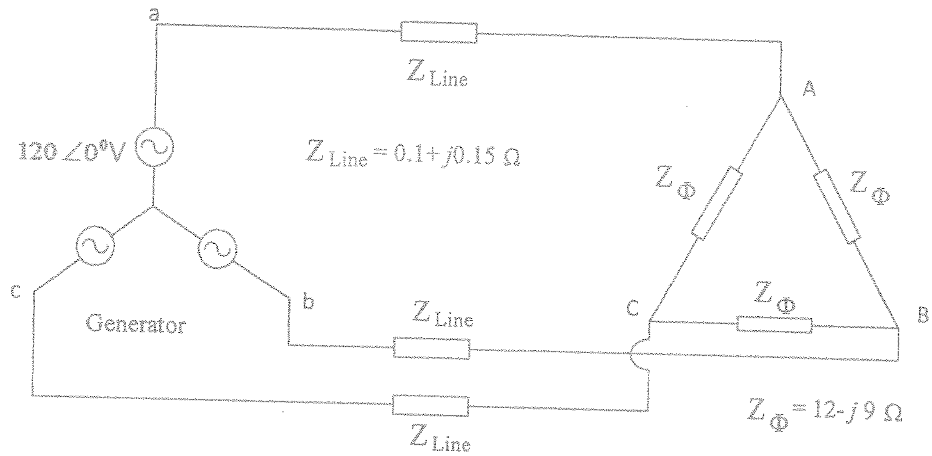

Figure Q2(b)

Q3 a) i) State Faraday's law of electromagnetic induction.

ii) Figure Q3 (a) shows a coil wound on a circular ferromagnetic core. If the flux within the core varies in a sinusoidal fashion and is given by $\emptyset(t) = \emptyset_{max} sin\omega t$, evaluate an expression for the effective voltage induced in the coil.

[2.5 Marks]

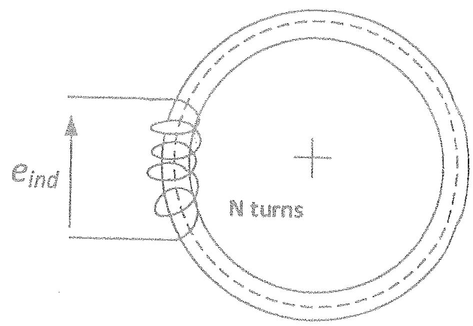

Figure Q3 (a)

b) i) What are the advantages of transformers in an electric circuit?

ii) Draw the equivalent circuit of a single phase transformer indicating and defining all the major elements in the circuit.

[2.5 Marks]

c) A 24-kVA, 7200/480-V single phase distribution transformer has the following resistances and reactances with their usual notations:

$R_1 = 32\Omega$	$X_1 = 45\Omega$	$R_C = 250k\Omega$
$R_2 = 0.05\Omega$	$X_2 = 0.06\Omega$	$X_m = 30k\Omega$

The excitation branch impedances are given referred to the high-voltage side of the transformer.

i) Find the equivalent circuit of this transformer referred to the high-voltage side.

ii) Assume that the transformer is supplying rated load at 480 V and 0.8 power factor lagging. Calculate the input voltage of the transformer and its voltage regulation.

iii) Calculate the efficiency of the transformer under the conditions of part c)(ii).

[5 Marks]

Q4 a) i) Briefly describe the types of three-phase induction motors available in industry.

ii) Draw the typical torque-speed characteristics of a three phase induction motor indicating its salient features.

iii) Explain why an induction motor can never rotate at its synchronous speed.

[2.5 Marks]

b) A three-phase. 60-Hz induction motor runs at 890 r/min at no load and at 840 r/min at full load.

i) Estimate the number of poles of this motor.

ii) Calculate the slip at rated load.

iii) Calculate the speed at one-quarter of the rated load.

[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 stator copper losses are estimated to be 1800 W. You may neglect the stray losses of the machine. Find the following values for full load conditions:

i) The shaft speed.

ii) The output power.

iii) The load torque.

iv) The induced torque.

[5 Marks]

Q5 a) i) Define a rotating electric machine?

ii) Define the two modes of operation of a rotating electric machine.

iii) State the types of dc electric machines in terms of electrical connection of armature windings and field windings. Explain your answer using suitable diagrams.

[2.5 Marks]

b) i) Draw the dynamic equivalent circuit for the dc shunt motor. Hence, obtain the steady-state equivalent circuit for the dc shunt motor.

ii) A dc shunt motor is supplied by a 100 V constant dc supply. It has an armature resistance of 2 Ω and a field resistance of 50 Ω. At a certain operating point the rotor speed is 1000 rpm and the input power is 500 W. Assuming that except for copper losses that there are no other losses, calculate the armature produced torque and the efficiency of the motor at the operating point.

[4 Marks]

c) The field circuit of a separately excited dc motor is connected to a constant dc source. A constant 100 V dc supply is applied to the armature terminals. The resistance of the armature circuit is 0.5 Ω. It is observed that the motor produces a 5 Nm torque for an armature current of 5 A. If the torque is increased to 15 Nm, calculate the speed reduction expected in the motor. Assume that except for copper losses, there are no other losses in the motor.

[3.5 Marks]