UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION MAY 2012

TITLE OF PAPER:	**Fundamentals of Power Engineering**
COURSE CODE:	**EE 351**
TIME ALLOWED:	**THREE** HOURS

Student Name:	
Student Number:	

INSTRUCTIONS:
1. Answer all questions.
2. Give your answers on the question paper, and if more space is required, complete your answer on the back of the paper or in your answer book and mention about the place of your answer completion.
3. Put the question sheet inside the answer book upon submission of your exam paper.
   (DON'T FORGET TO SUBMIT BOTH OF THE ANSWER BOOK AND QUESTION PAPER)
4. Marks for different questions are indicated on the beginning of the question.
5. Rough work maybe done in the examination answer book and crossed through.

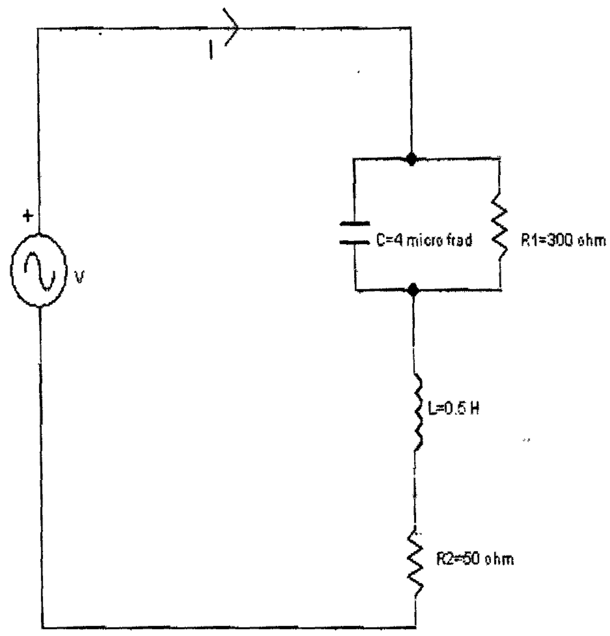
DO NOT OPEN THIS PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

This paper starts at page 1 and ends at page 15.

Question 1: Solve the following questions (36 marks):

a) In the following circuit, the source voltage $v = 400\sin(2\pi * 50t + 30°)$, the capacitor value C=$4\mu F$, the inductance value L=0.5 H, $R_1 = 300\Omega$, $R_2 = 50\Omega$. Calculate the total load impedance of the circuit, the input current in phasor and instantaneous forms and the active and reactive power absorbed by the total impedance in the circuit.

(Calculate: $Z_{tot}, I, i(t), P_{in}, Q_{in}$)



b) If the magnetic field intensity H is 100 AT/m, the current in the coil of N=150 Turns is 3 A, then the core mean path length l_c is

$l_c =$

c) The magnetic core mean path length $l_c = 2.5$ m, the core cross-section area A=0.2 m^2, the relative permeability of the core material $\mu_r = 3000$, and the relative permeability of the air $\mu_0 = 4\pi * 10^{-7}$. Calculate the reluctance R of the core.

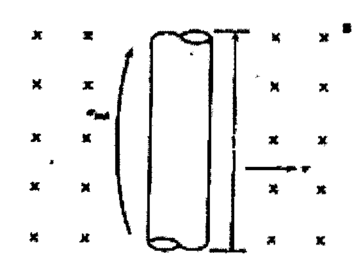
R=

d) A magnetic core has reluctance R= 30000 At/Wb and has 200 turns coil wrapped around the core. How much flux is produced when a 4 A current flows in the coil?

$\varphi =$

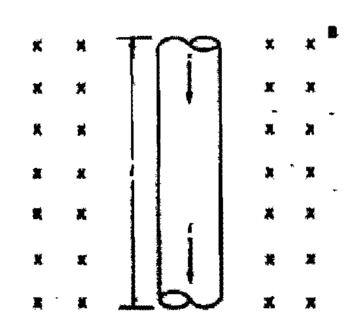
e) What is the magnitude and direction of induced voltage on a conductor moving with a velocity v=10 m/sec in uniform magnetic field density B=0.5T point to page, the wire length l=1.5 m? The direction should be shown in the following figure.

$E_{ind} =$



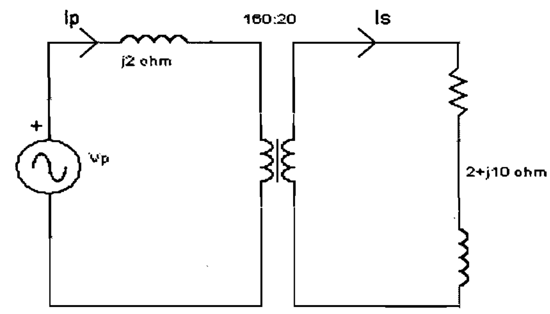
f) What is the magnitude and direction of induced force on a conductor of a length l= 2 m, carrying a current i=3 A from up to down and present in uniform magnetic field density B=0.7 T point to page? The direction should be shown in the following figure.

$F =$



g) A single phase transformer, has the number of turns in primary N_p=160 turns, number of turns in secondary N_s=20 turns, the primary source voltage $V_p = 230\angle 0$ with source impedance = j2.0 ohm and a load impedance in secondary= 2+j10 ohm. Calculate the transformer turns ratio, the primary and secondary currents and the load voltage.

(Calculate: a, I_p, I_s, V_{load})



h) In three-phase connected transformer, each of the three transformers has number of turns in primary $N_p = 120$ and number of turns in secondary $N_s = 80$. If the primary line-to-line voltage $V_{lp} = 415$, what will be the secondary line-to-line voltage V_{ls} in case of

1) $\Delta - \Delta$ Connected transformer.

2) $Y - \Delta$ Connected transformer.

i) Three phase $\Delta - Y$ connected transformer bank steps down the generator voltage from 11 KV (line-to-line) to 415 (line-to-line). Calculate the primary phase voltage, the secondary phase voltage and the transformer turns ratio.
(Calculate: $V_{\varphi p}$, $V_{\varphi s}$, a)

j) Draw a simple transmission-distribution system showing an example of the voltage levels at generation, transmission and distribution. What are the advantages of stepping up the voltage in the transmission network?

k) List three methods that can be used to decrease the voltage level in power systems when an over voltage is detected in the system.

Question 2: Solve the following questions (17 marks):

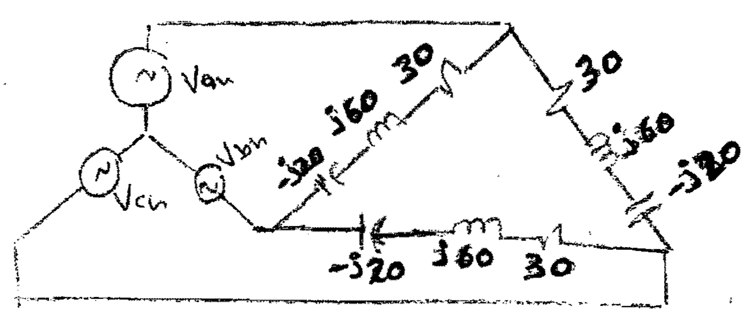
In the following Y-Δ connection between positive sequence sources and loads, given that

$V_{an} = 100\angle 10^\circ \quad V$

$V_{ab} = 173.2\angle 40^\circ \quad V$

$V_{bc} = 173.2\angle -80^\circ \quad V$

$Z_{\Delta} = 30 + j60 - j20 \quad \Omega$



Calculate the following:

a) The phase voltages V_{bn}, V_{cn}

b) The line-to-line voltage V_{ca}.

c) The current in each load branches I_{AB}, I_{BC}, I_{CA}.

d) The line current I_a.

e) The total three phase complex, active and reactive power supplied to load. (Calculate: $S_{3\varphi}, P_{3\phi}, Q_{3\varphi}$)

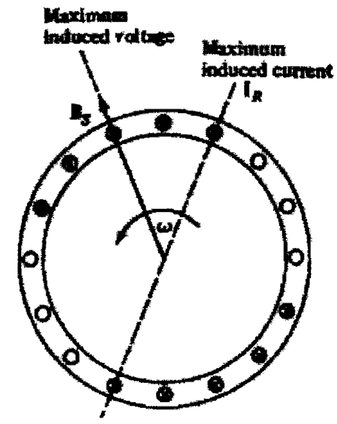
f) The active and reactive power absorbed in the resistor in branch AB. (Calculate: P_R, Q_R)

g) The active and reactive power absorbed/supplied in the inductor in branch AB. (Calculate: P_L, Q_L)

h) The active and reactive power absorbed/supplied in the capacitor in branch AB. (Calculate: P_C, Q_C)

Question 3 (15 marks):

a) Explain briefly the principle of operation of three-phase induction motor.



b) What is the effect of increasing mechanical load torque on the induction motor?

c) Explain how you can control the induction motor speed.

Question 4 (32 marks):

A 415V (line to line voltage), 25 hp, 50 Hz, two poles, Y connected induction motor, has the following impedances in ohms per phase referred to stator circuit.

$R_1 = 0.7\Omega$

$R_2 = 0.4\Omega$

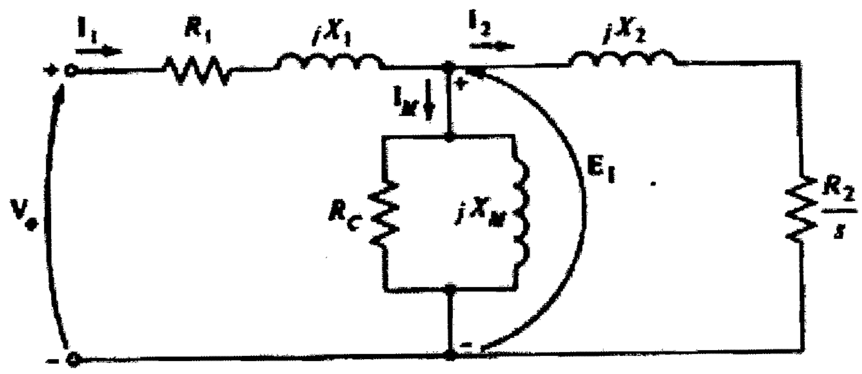
$X_1 = 1.4\Omega$

$X_2 = 0.5\Omega$

$X_M = 60\Omega$

$s = 0.05$

The total rotational losses are 1000W. The motor slip is 0.05 at rated voltage and rated frequency.



a) Calculate the synchronous speed in rpm (n_{sync}) and rad per sec (ω_{sync}).

b) Calculate the motor speed in rpm (n_m) and rad/sec (ω_m).

c) Calculate the rotor current frequency f_r.

d) Calculate the total impedance of the circuit Z_{tot}.

e) Calculate the stator phase voltage and current.

$V_\varphi =$

$I_1 =$

f) Calculate the motor power factor.

$P_f =$

g) Calculate the motor input power.

$P_{in} =$

h) Calculate the motor stator copper losses.

$P_{scl} =$

i) Calculate the air gap power.

$P_{ag} =$

j) Calculate the rotor copper losses.

$P_{rcl} =$

k) Calculate the power converted from electrical to mechanical.

$P_{conv} =$

l) Calculate the motor output power.

$P_{out} =$

m) Calculate the induced torque.

$T_{ind} =$

n) Calculate the load torque.

$T_{load} =$

o) Calculate the motor efficiency ς.

$\varsigma =$

p) Calculate the equivalent thevenin voltage as seen from two points where the rotor circuit connects.

$V_{th} =$

q) Calculate the equivalent thevenin resistance and thevenin reactance as seen from two points where the rotor circuit connects.
(Calculate: R_{th}, X_{th})

r) Calculate the rotor current referred to stator I_2.

s) Calculate the slip at which the maximum torque occurs and the corresponding speed in rpm.

$$s_{max} = \frac{R_2}{\sqrt{R_{th}^2 + (X_{th} + X_2)^2}}$$

$n_{max} =$

t) Given the main equation for T_{max}, calculate the maximum induced torque.

$$T_{max} = \frac{3V_{th}^2}{2\omega_{syn}\left[R_{th} + \sqrt{R_{th}^2 + (X_{th} + X_2)^2}\right]}$$