UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION DECEMBER 2012

TITLE OF PAPER: **ELECTRICAL MACHINES**

COURSE CODE: **EE 451**

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 (21 marks)

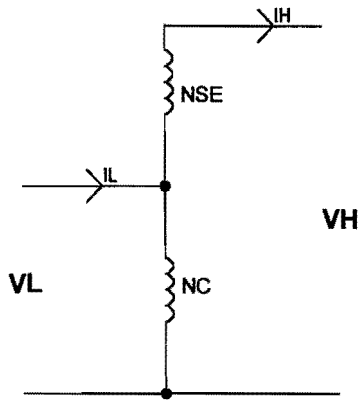
a) The equivalent circuit impedances of a 25 kVA, 2400V/240V, 50 Hz transformer to be determined. The open circuit test and short circuit test were performed and the following data were found. Calculate the impedances of approximate equivalent circuit referred to primary.
(Calculate: $R_C, X_M, R_{eqp}, X_{eqp}$ **)**

Open circuit results	Short circuit results
$V_{oc} = 2400V$	$V_{sc} = 80V$
$I_{oc} = 0.4A$	$I_{sc} = 9A$
$P_{oc} = 60W$	$P_{sc} = 200W$

b) 50 KVA, three phase, 400V/22000V (line to line), $Y-\Delta$ transformer, has equivalent impedance referred to primary side $Z_{eqp} = 0.06 + j0.1$ ohm. Calculate the primary phase voltage at the source $V_{\varphi p}$ and voltage regulation V_R assuming the transformer supplies rated load at 0.85 pf lagging.
(Calculate: $V_{\varphi p}, V_R$)

c) 400 VA, 240V/24V transformer to be connected to form a step up autotransformer. Calculate the voltage at the high voltage side of the transformer V_H, maximum current at the high voltage side I_H, the current in low voltage side I_L and the input volt-ampere S_{in}.

(Calculate: V_H, I_H, I_L, S_{in})



Question 2: Solve the following questions (24 marks)

a) A 480 V (line-to-line) 50 Hz Y connected two pole synchronous generator. The generator has synchronous reactance of 0.2 Ω and armature resistance of 0.04 Ω. At full load the machine supplies 600 A at 0.8 pf leading. Calculate the internal voltage E_A, the output power from generator P_{out} and the induced torque T_{ind}.
(Calculate: E_A, P_{out}, T_{ind})

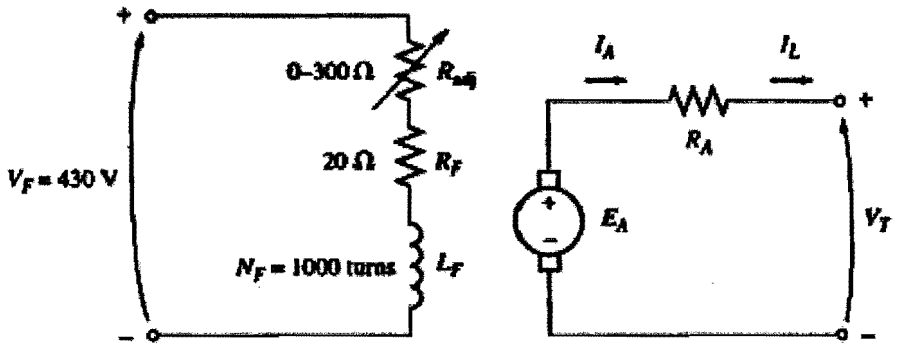
b) A 360V, 50 KVA, 0.8 pf, Δ connected, 60 Hz synchronous motor has synchronous reactance of 2.8 Ω and negligible armature resistance. The friction and windage losses are 2 KW and core losses are 1 KW. Initially the shaft supplies 20 hp load and the power factor of the machine is 0.8 leading. Calculate the armature current I_A, the induced voltage E_A and sketch the phasor diagram.
(Calculate: I_A, E_A)

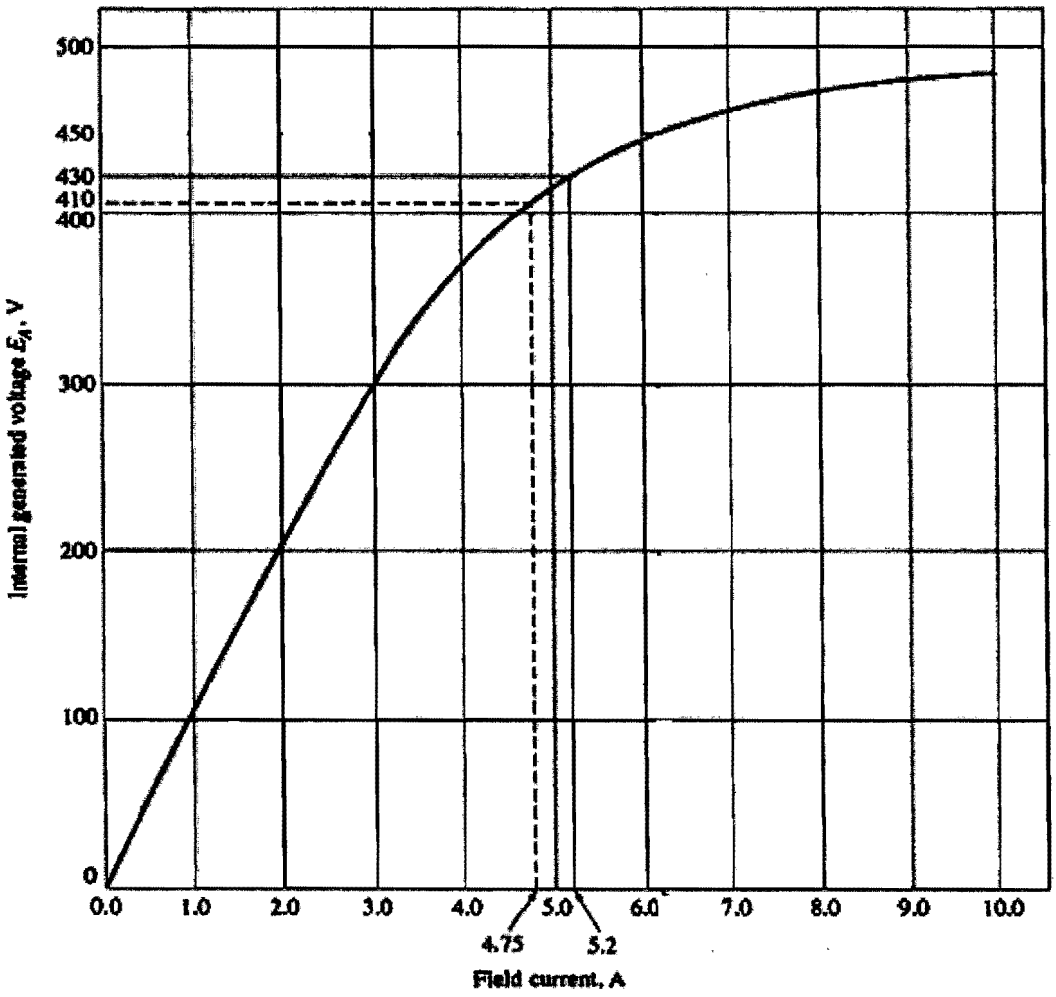
c) Assume in b, the motor flux is increased by 30%. What is the armature current I_A and induced voltage E_A in this case? What is the effect of increasing the excitation on motor current?
(Calculate: I_A, E_A)

Question 3: Solve the following questions (13 marks)

A separately excited dc generator, 180 KW, 430V, 350 A and 1800 rpm. The DC generator equivalent circuit and its magnetization curve are shown in the following figures. The machine has the following characteristics:

$R_A = 0.2\ \Omega$, $V_F = 430$ V, $R_F = 20\ \Omega$, R_{adj}=0 to 300 Ω.





If $R_{adj} = 63\ \Omega$ and the prime mover speed=1400 rev/min,
a) Calculate the no load generator voltage.

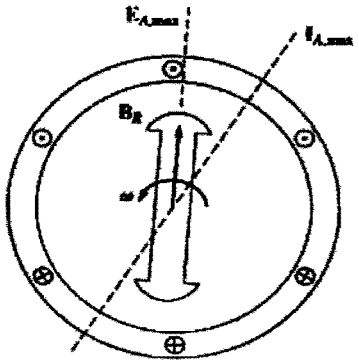
b) What is the terminal voltage V_T when a 4 Ω load is connected?
(Calculate: V_T)

c) Calculate the induced voltage E_A to restore V_T at no load value.
(Calculate: E_A')

d) How much the field current and the field adjustable resistance needed to restore V_T at no load value? .
(Calculate: I_F, R_{adj})

Question 4: Solve the following questions (17 marks)

a) Explain briefly the principle of operation of the synchronous generator.
Note: Its is required to explain how the equivalent circuit of synchronous generator is derived.



b) Indicate, for a given phase voltage and load current, will a more internal voltage E_A is needed for leading power factor load or lagging power factor load?

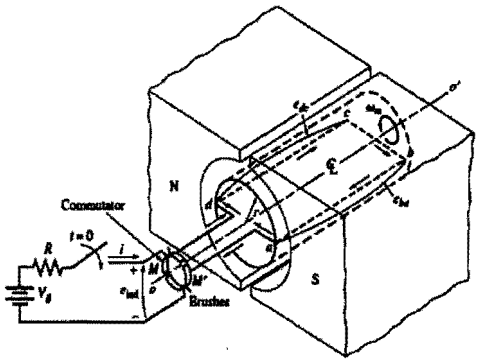
c) What is the effect of increasing mechanical load torque on the synchronous motor?

d) What is the effect of increasing the field current on synchronous motor?

e) How is possible to control the synchronous motor speed? Mention about two methods used.

Question 5: Answer the following questions (25 marks)

a) Explain briefly the principle of operation of the DC motor.
Note: Its is required to explain how the equivalent circuit of DC motor is derived.



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

c) Draw the equivalent circuit and torque speed characteristics of the series DC motor. Mention the advantages and disadvantage of series DC motor.

d) What is the effect of increasing the electrical load on the DC generator terminal voltage?

e) How it is possible to increase the DC generator terminal voltage?

f) Mention briefly how the terminal voltage in shunt DC generator will build up:

g) As the field current in the DC motor is increased then
a) The speed of DC motor decreases
b) The speed of DC motor increases
c) No change in the DC motor speed

h) As the armature voltage applied to DC motor is increased then
a) The speed of DC motor decreases
b) The speed of DC motor increases
c) No change in the DC motor speed

i) In armature voltage control,

a) The maximum torque will increase and the maximum power will be constant as speed increased.

b) The maximum torque will decrease and the maximum power will constant as speed increased.

c) The maximum torque will be constant and the maximum power will increase as speed increased.

j) In field resistance control,

a) The maximum torque will be constant and the maximum power will increase as speed increased.
b) The maximum torque will increase and the maximum power will be constant as speed increased.
c) The maximum torque will decrease and the maximum power will be constant as speed increased

k) In a DC motor,

a) Both the armature voltage control and field resistance control will control the motor speed above base speed.
b) The armature voltage control will control the motor speed above base speed while field resistance control will control motor speed below base speed.

c) The armature voltage control will control the motor speed below base speed while field resistance control will control motor speed above base speed

l) The disadvantages of differentially compounded DC motor is

a) The motor has low starting torque.
b) The motor over speed at no load.
c) The motor is unstable.

m) The main characteristics of cumulatively compounded DC motor is

a) The motor has low starting torque and does not over speed at no load.
b) The motor has high starting torque and does not over speed at no load.
c) The motor has high starting torque and over speeds at no load.

o) The main function of the starting resistance in DC motor is

a) To decrease the armature current during starting.
b) To increase the armature current during starting.
c) To limit the motor speed during starting.

p) When the number of series winding turns N_{SE} of the cumulatively compounded DC generator is small, the DC generator is

a) Flat compounded.
b) Under compounded.
c) Over compounded.

q) The over compounded DC generator will have

a) No load voltage > full load voltage.
b) No load voltage = full load voltage.
c) No load voltage < full load voltage.

r) The differentially compounded DC generator will have

a) Small drop in terminal voltage as load increased on the generator.
b) Large drop in terminal voltage as load increased on the generator.
c) No change in terminal voltage as load increased on the generator