UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION NOVEMBER 2013

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.

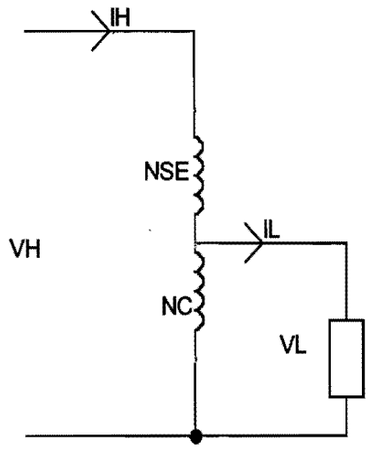
DO NOT OPEN THIS PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

This paper starts at page 1 and ends at page 16.

Question 1: Solve the following questions (13 marks)

a) 60 KVA, 24000V/480V (line to line) $\Delta - Y$ distribution transformer has an equivalent impedance referred to the primary side $Z_{eqp} = 120 + j500\ \Omega$. Calculate the primary phase voltage at the source V_{qp} and voltage regulation V_R assuming the transformer supplies rated load at 0.7 pf lagging.
(Calculate: V_{qp}, V_R)

b) 300V/30V transformer to be connected to form a step down autotransformer. A load impedance of 50 ohm is connected at the secondary side. Calculate the voltage at the low voltage side of the transformer V_L, the current at the low voltage side I_L, the voltage at the high voltage side of the transformer V_H, the current in high voltage side I_H and the output volt-ampere S_{out}.
(Calculate: $V_L, I_L, V_H, I_H, S_{out}$)



Question 2: Solve the following questions (33 marks)

a) A 400 V (line-to-line), 50 Hz, Δ connected four pole synchronous generator. The generator has a synchronous reactance of 0.3 Ω and an armature resistance of 0.05 Ω. At full load the machine supplies 500 A at 0.85 pf lagging. Calculate the internal voltage E_A, the output power from generator P_{out}, the synchronous speed in rad/sec ω_{sync}, the induced torque T_{ind} and sketch the phasor diagram.

Note: Substitute the values of voltage and current magnitudes and angles in the diagram.

(Calculate: $E_A, P_{out}, \omega_{sync}, T_{ind}$)

b) A 460V, 60 KVA, 0.8 pf, Δ connected, 60 Hz synchronous motor has a synchronous reactance of 2.6 Ω and a negligible armature resistance. The friction and windage losses are 1.8 KW and core losses are 1 KW. Initially the shaft supplies 16 hp load and the power factor of the machine is 0.8 leading. Calculate the armature current I_A and the induced voltage E_A and sketch the phasor diagram.

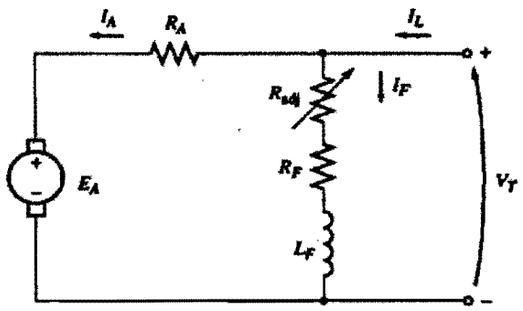
Note: Substitute the values of voltage and current magnitudes and angles in the diagram.

(Calculate: I_A, E_A)

c) Assume in b the load shaft increased to 28 hp, calculates the armature current I_A. What is the main effect of increasing motor load torque on motor current?

d) A 30 hp, 240V, 1400 rev/min DC shunt motor has an armature resistance of $R_A = 0.4\ \Omega$. The field winding has a total resistance $R_F + R_{adj}$ of 60 Ω which produces no load speed at 1400 rev/min. Calculate the speed of the motor expressed in rev/min n_m, the motor input power P_{in} and the motor induced torque T_{ind} when the input current I_L is 180 A.

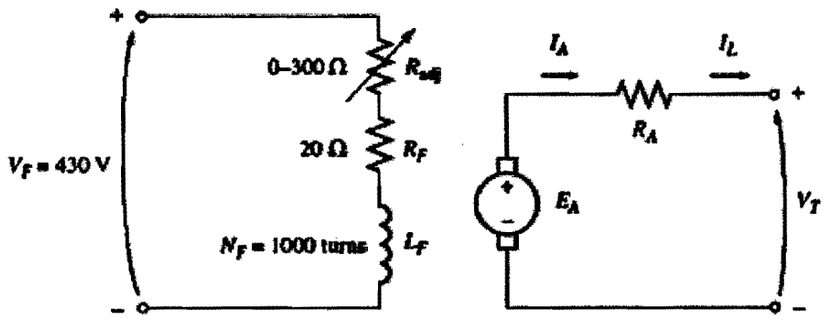
(Calculate: n_m, P_{in}, T_{ind})

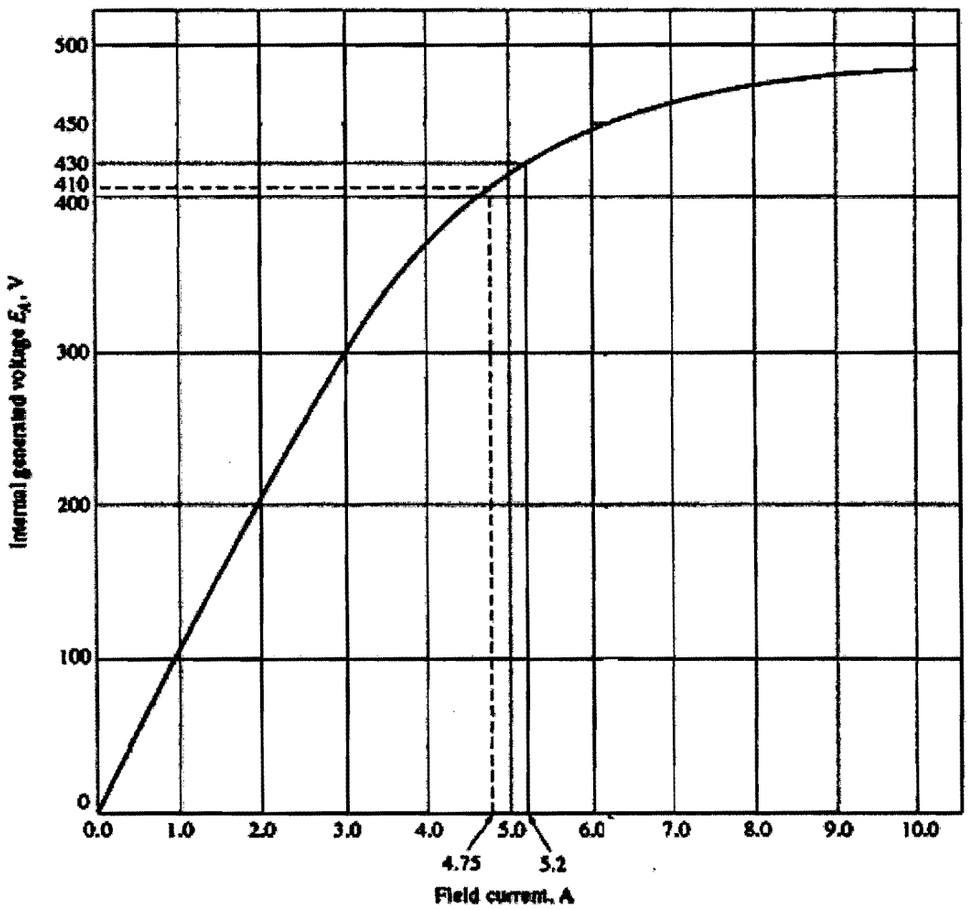


Question 3: Solve the following questions (13 marks)

A separately excited dc generator, 150 KW, 430V, 300 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:

$R_A = 0.35\ \Omega$, $V_F = 430\,\text{V}$, $R_F = 20\ \Omega$, R_{adj}=0 to 300 Ω.





If $R_{adj} = 63\ \Omega$ and the prime mover speed=1000 rev/min,
a) Calculate the no load generator voltage.

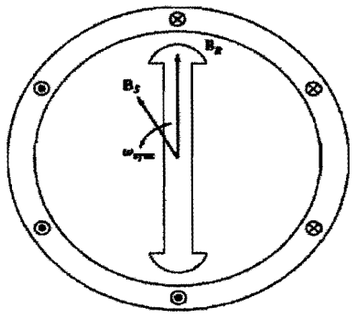
b) What is the terminal voltage V_T when a 5 Ω load is connected?
(Calculate: V_T)

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 (12 marks)

a) Explain briefly the principle of operation of the synchronous motor.

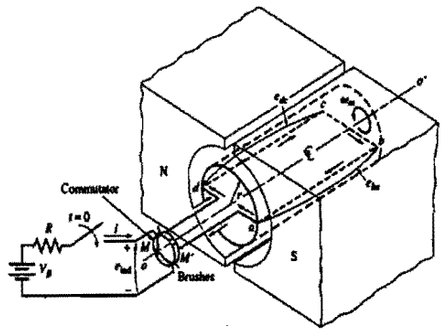


b) What is the effect of increasing the field current on synchronous motor?

c) Draw a block diagram for brush less excitation of synchronous generator.

Question 5: Answer the following questions (29 marks)

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



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

c) Explain the effect of increasing the load current on the series DC generator terminal voltage.
Note: Indicate in your explanation how the terminal voltage builds up on the series DC generator

d) How is possible to control the DC motor speed? Mention about two methods used. Indicate which method is used to control DC motor speed above base speed and which method used to control DC motor speed below base speed.

e) Derive and draw the torque speed characteristic equation of series DC motor. Mention the main advantages and disadvantages of the series DC motor.

f) Differentiate between the different types of cumulatively compounded DC generator(under compounded, over compounded and under compounded) by using a right mark(√).

	Under compounded	Over compounded	Flat compounded
Number of series winding turns N_{SE} is very large			
Number of series winding turns N_{SE} is medium			
Number of series winding turns N_{SE} is small			
No load voltage > full load voltage			
No load voltage = full load voltage			
No load voltage < full load voltage			
The effect of the increase of induced voltage E_A with load wins			
The effect of the increase in the resistive voltage drop with load wins			

g) If the supply current frequency is 60 Hz, then the rotating field speed in (rev/sec) in 8 poles machine will be

a) 30 rev/sec.
b) 60 rev/sec.
c) 15 rev/sec.

h) In armature voltage control of DC motor speed,

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

i) In field resistance control of DC motor speed,

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

j) 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.

k) The differentially compounded DC generator will have
a) Large drop in terminal voltage as load increased on the generator.
b) Small drop in terminal voltage as load increased on the generator.
c) No change in terminal voltage as load increased on the generator

l) In a synchronous generator with a given phase voltage and load current
a) The internal voltage E_A will be same for leading and lagging power factor loads..
b) More internal voltage E_A is needed for lagging power factor load.
c) More internal voltage E_A **is** needed for leading power factor load.

m) In the differentially compounded DC motor
a) Has high starting torque
a) Speed goes infinity with no load.
b) Not stable and runaway as load increased.

n) The cumulatively compounded DC motor
a) Has high starting torque and does not overspend at no load.
b) Has high starting torque and speed goes infinity at no load.
c) Has high starting torques and overspend with load.