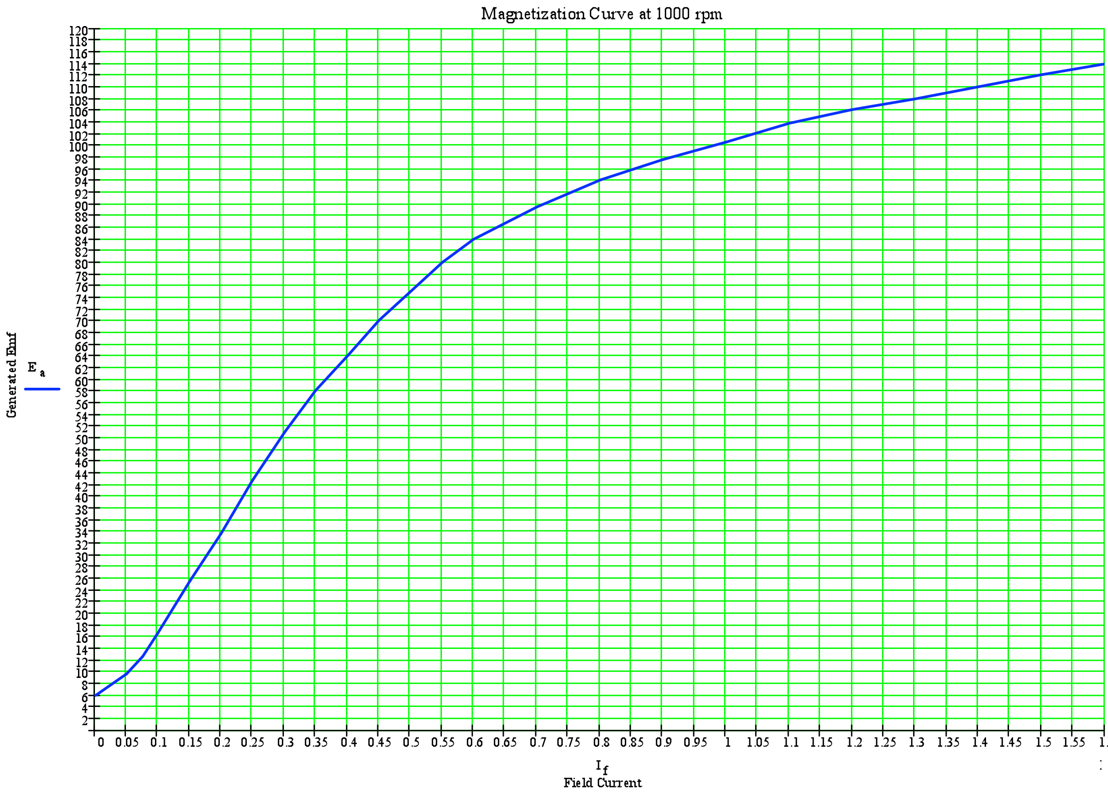
Name: ……………………………………………………………

TEST #2 **SEE 3433** **1 hour 30 minutes**

Q1. The dc machine (5 kW, 100 V, 1000 rpm, $R_a = 0.125\ \Omega$, $R_{fw} = 80\ \Omega$, $N_f = 750$ turns) is connected to a 100 V dc supply and is operated as a dc shunt motor. At no-load condition, the motor runs at $\omega_m = 1000$ rpm and $E_a = 99$ V.



(a) Find the speed in rpm when the rated current flows in the armature. Consider that the air gap flux remains the same as that at no load. (2 marks)

(b) Find the speed in rpm when the rated current flows in the armature. Consider that the air gap flux is reduced by 6 % when rated current flows in the armature because of armature reaction. (2 marks)

(c) Determine the armature reaction effect in (b) in equivalent field current. (2 marks)

(d) Find the speed in rpm when the rated current flows in the armature. Consider that the armature reaction effect in equivalent field current, $I_{f(AR)} = 0.10$ A. (2 marks)

(e) If the effect of armature reaction as in (b) and 3 turns per pole of series field winding is added to turn this machine into a differential compound motor, determine the speed of the motor. Neglect the resistance of the series winding. (2 marks)

(f) Sketch the graph of magnetization curves (E_a versus I_f) to show all the operating points in (a), (b), (d) and (e) on the graph. Label all key quantities. (3 marks)

Q2. A 250 V, 10 kW series motor is mechanically coupled to a fan and draws 25 A, and runs at 500 rpm when connected to a 250 V supply with no external resistance connected to the armature circuit (i.e. $R_{ae1} = 0$). The torque required by the fan is given by $T \propto \omega^{3/2}$. $R_a = 0.60\ \Omega$ and $R_{sr} = 0.3\ \Omega$. Neglect armature reaction and rotational loss.

(a) Draw an equivalent circuit of the series DC motor, which would be used for steady-state calculations. Label all key quantities. (2 marks)

(b) Determine the back emf, E_{a1}, the power delivered to the fan, P_1, and torque developed by the machine, T_1. (4 marks)

(c) The speed is to be reduced to 250 rpm by inserting a resistance, R_{ae2} in the armature circuit. Determine the value of this resistance. Also, determine, the armature current, I_{a2}, the back emf, E_{a2}, the power delivered to the fan, P_2, and torque developed by the machine, T_2. (4 marks)

(d) Draw speed-torque characteristic of the motor and the load to show the operating points in (b) and (c). Label all key quantities. (3 marks)

Q3. A 3-phase, Y-connected, 415-V, 100 hp, 50 Hz, 6-pole induction motor is operating at rated conditions has an efficiency of 91 percent and draws a line current of 137.4 A. The motor losses are given as follows:

The stator core loss = 1697 W
The stator copper loss = 2803 W
The rotor copper loss = 1549 W
Assumed the rotor core loss is negligible.

Determine the following:

i. Input power (2 marks)
ii. Total losses (2 marks)
iii. Air-gap power (2 marks)
iv. Rotor speed (2 marks)
v. Power factor (2 marks)
vi. Combined windage and friction losses (2 marks)
vii. Output Torque (2 marks)
viii Draw the power flow diagram to show all the power involved. (2 marks)

Notes: 1 hp = 746 watts

Q4. A 3-phase, 415 V (line to line), 50 Hz, 6-pole, star connected, induction motor has the following equivalent circuit constants in ohms per phase.

$R_1 = 1.4\ \Omega$, $R_2' = 0.6\ \Omega$, $X_1 = 2\ \Omega$, $X_2' = 1\ \Omega$ and $X_m = 50\ \Omega$.

The total windage and friction losses of the motor may be assumed to be constant at 275W, independent of load.

(a) Calculate the starting torque and the corresponding airgap power. (4 marks)
(b) Calculate the maximum torque and the corresponding input power. (4 marks)
(c) Calculate the rotor speed, line current and power factor for a slip of 0.03. (4 marks)
(d) Sketch the torque/speed curved for 415 V (line to line), 50 Hz operation, to show the results of (a), (b) and (c). (3 marks)

Use the approximate equivalent circuit.