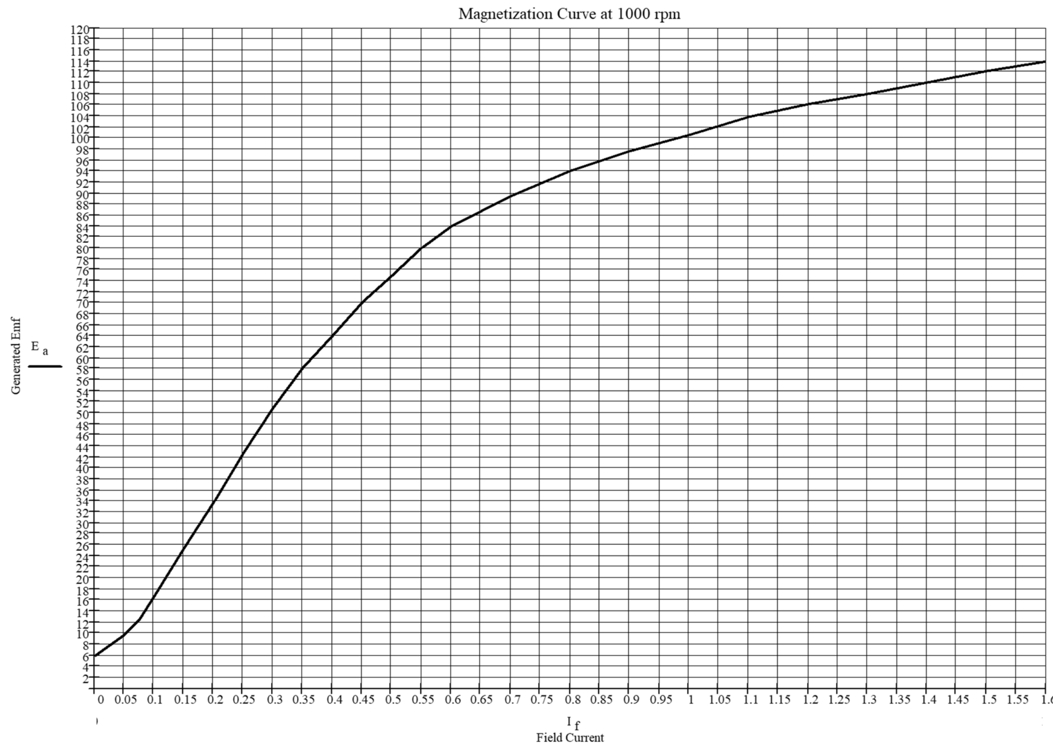
Name: ……………………………………………………………

TEST #2 **SKEE4633/SEE3433** **1 hour 20 minutes**

Q1. The dc machine (10 kW, 100 V, 1000 rpm, $R_a = 0.1\ \Omega$, $R_{fw} = 80\ \Omega$, $N_f = 800$ 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 is reduced by 5.8% when rated current flows in the armature because of armature reaction. (3 marks)

(b) How many series field turns per pole should be added to make this machine into cumulatively compound motor whose speed will be 818 rpm at full-load? Consider that the armature reaction effect in equivalent field current, $I_{f(AR)} = 0.15$ A. (3 marks)

(c) What is the reduction of the flux due to the armature reaction in equivalent field current, $I_{f(AR)}$, for the problem in (a)? (3 marks)

Q2. A 330 V, 10 kW series motor is mechanically coupled to a fan and draws 28 A, and runs at the speed of 500 rpm when connected to a 330 V supply with no external resistance connected to the armature circuit (i.e. $R_{ae} = 0$). The torque required by the fan is given by $T_L = k\omega$, where k is a constant of proportionality. $R_a = 0.6\ \Omega$ and $R_{sr} = 0.4\ \Omega$. Neglect armature reaction and the rotational losses.

(a) Determine the back emf, the power delivered to the fan, and the torque developed by the motor. (3 marks)

(b) The speed is to be reduced to 400 rpm by inserting a resistance, R_{ae} in the armature circuit. Determine the value of this resistance and the torque developed by the motor. (3 marks)

(c) Sketch speed-torque characteristics (ω versus T) of the series DC motor for two different values of external armature resistances together with the load torque profile. Label key quantities. (2 marks)

Q3. A 3-phase, **Δ**-connected, 415 V, 50 Hz, 700 rpm, 8-pole induction motor is operating at rated conditions with an efficiency of 85 percent. The power transferred from stator to rotor through air gap (P_{ag}) is 53 kW. The rotational loss is 1 kW and its draws a **phase** current of 90 A. Assume that the core losses are embedded in rotational loss. Calculate:

i.	Slip and synchronous speed	(1 mark)
ii.	Mechanical power	(1 mark)
iii.	Output power	(1 mark)
iv	Rotor copper loss	(1 mark)
v.	Input power	(1 mark)
vi.	Stator copper loss	(1 mark)
vii.	Total losses	(1 mark)
viii.	Power factor	(1 mark)

Q4. A 3-phase, 460 V (line to line), 50 Hz, 970 rpm, 6-pole, **Δ**-connected, induction motor has the following equivalent circuit constants in ohms per phase.

$R_1 = 0.5\ \Omega$, $R_2' = 1.2\ \Omega$, $X_1 = 2\ \Omega$, $X_2' = 1.0\ \Omega$ and $X_m = 60\ \Omega$.

The rotational losses of the motor may be assumed to be constant at 900 W, independent of load. Based on the above specifications, using the **approximate** equivalent induction motor circuit, calculate:

(i) the synchronous speed, slip and slip speed.	(2 marks)
(ii the input current and power factor.	(2 marks)
(iii) the air gap power and rotor copper loss.	(2 marks)
(iv) mechanical power developed.	(1 mark)
(v) output power and input power.	(2 marks)
(vi) the efficiency of the motor.	(1 mark)

Use the approximate equivalent circuit.

Potentially useful formula

$$E_a = K_a\phi\omega \qquad E_a = V_t - I_aR_a \qquad \frac{E_{aFL}}{E_{aNL}} = \frac{K_a\emptyset\omega_{FL}}{K_a\emptyset\omega_{NL}}$$

$$P = E_aI_a \qquad E_a = V_t - I_a(R_a + R_{sr} + R_{ae}) \qquad E_a = K_{sr}I_a\omega_m$$

$$P = T\omega \qquad I_{f(\text{eff})} = I_f - I_{f(\text{AR})} \pm \frac{N_{sr}}{N_f}I_t \qquad T = K_{sr}I_a^2$$

$$N_s = \frac{120f}{p} \qquad P = \sqrt{3}V_LI_L\cos(\theta) \qquad s = \frac{N_s - N_r}{N_s}$$

$$P_{rotor} = sP_{ag} \qquad P_m = (1-s)P_{ag} \qquad P_{ag} = I_2'^2\frac{R_2'}{s}$$

$$P_{ag} = T\omega_s \qquad S_{Tmax} = \frac{R_2'}{\sqrt{[(R_1^2 + (X_1 + X_2)^2]}} \qquad I_2' = \frac{V_1}{R_1 + \frac{R_2'}{s} + j(X_1 + X_2')}$$