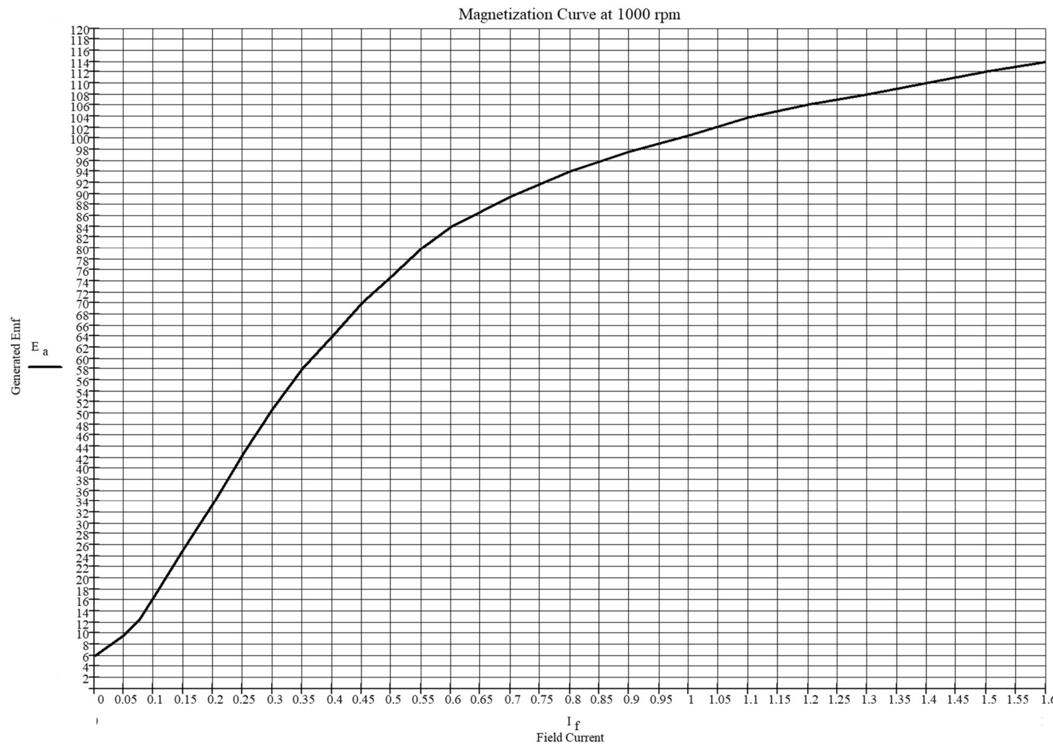
Name: ……………………………………………………………

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

Q1. The dc machine (10 kW, 100 V, 1000 rpm, $R_a = 0.1\ \Omega$, $R_{fw} = 80\ \Omega$,) 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 7.5 % when rated current flows in the armature because of armature reaction. (3 marks)

(b) 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. (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)? (2 marks)

Q2. A 350 V, 10 kW series motor is mechanically coupled to a fan and draws 30 A, and runs at $\omega_1 = 600$ rpm when connected to a 350 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 $T = k\omega^{2.25}$, where k is a constant of proportionality. $R_a = 0.5\ \Omega$ and $R_{sr} = 0.3\ \Omega$. Neglect armature reaction and the rotational losses.

(a) Determine the back emf, E_{a1}, the power delivered to the fan, P_1, and the torque developed by the motor, T_1. (3 marks)

(b) The speed is to be reduced to $\omega_2 = 500$ rpm by inserting a resistance, R_{ae2} in the armature circuit. Determine the value of this resistance and the torque developed by the motor, T_2. (3 marks)

(c) Sketch speed-torque characteristics (ω versus T) of the series DC motor for two different values of R_{ae} together with the given load profile, $T = k\omega^{2.25}$. Label clearly R_{ae1}, R_{ae2}, ω_1, ω_2, T_1, and T_2 on the sketch. (2 marks)

Q3. A 3-phase, **Δ**-connected, 380 V, 47.5 kW, 50 Hz, 575 rpm, 10-pole induction motor is operating at rated conditions has an efficiency of 92 percent. The rotational loss is 1 kW and it draws a line current of 96 A. Assume that the core losses are embedded in rotational losses. Find

i. Mechanical power (1 mark)
ii. Air gap power (1 mark)
iii. Rotor copper loss (1 mark)
iv Input power (1 mark)
v. Stator copper loss (1 mark)
vi Total losses (1 marks)
vii. Power factor (1 mark)

Q4. A 3-phase, 415 V (line to line), 50 Hz, 1430 rpm, 6-pole, **Δ**-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 rotational losses of the motor may be assumed to be constant at 275W, independent of load.

(a) Calculate the starting current and the corresponding power factor. (3 marks)
(b) Calculate the maximum torque. (3 marks)
(c) Calculate the efficiency for the full-load slip. (3 marks)

Use the approximate equivalent circuit.

Potentially useful formula

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

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

$$P = T\omega \qquad T = K_{sr}I_a^2$$

$$I_{f(\text{eff})} = I_f - I_{f(\text{AR})} \qquad N_s = \frac{120f}{p} \qquad s = \frac{N_s - N_r}{N_s}$$

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

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