EE 30372, Spring 2007
Exam 1
8 March, 2007

Show all your work and your answers clearly on the test pages. In any plots and sketches, label and include units (if possible) on anything that might be of interest. For full credit, simplify your answers as much as possible. You may use calculators for numerical evaluations but no programming capabilities. This exam is closed-book.

Problem 1 (15) _____

Problem 2 (25) _____

Problem 3 (25) _____

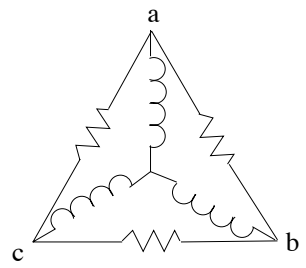
Problem 4 (25) _____

Problem 5 (10) _____

Total (100) _____

Name_____

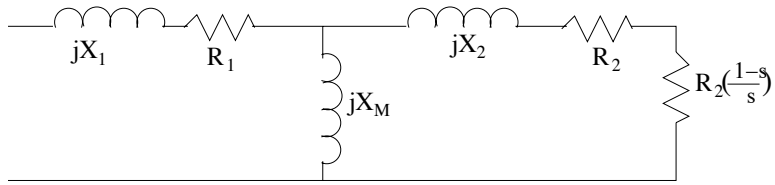
1. In the College of Engineering Sacred Stained Glass Window on the second floor of Cushing Hall, one of the panels representing EE looks something like the figure below. Each of the resistors is 3 ohms and each inductor has reactance of 3 ohms.



(a) (5 pts.) What is the power factor of this load?

(b) (5 pts.) Find the real, reactive and apparent power consumed by this load when it is connected to a three-phase source of 208 V line-line. Sketch this as a complex power vector in our standard format.

(c) (5 pts.) Create a Δ-connected load with only one branch between each pair of exterior terminals, and having the same node-to-node impedances as the circuit in the original figure.



2. (25 pts.) Above is the *per-phase* equivalent circuit model of a 280V, 50 Hz, 4-pole, three-phase, Y-connected induction motor. Its parameters are $R_1 = 0.1\Omega$, $X_1 = 0.2\Omega$, $R_2 = 0.1\Omega$, $X_2 = 0.1\Omega$, $X_M = 10\Omega$. The mechanical, core, and miscellaneous losses total 500 W. (You may recall that when these losses are lumped together, they are subtracted on the mechanical side of power analysis.) At a slip of 4%, find (a) the line current into the motor, (b) the air-gap power P_{AG}, (c) the rotor copper losses, (d) the induced torque, (e) the mechanical speed of rotation in rpm, and (f) the machine's efficiency.

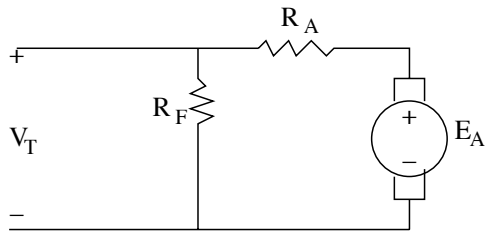
3. A 50,000 kVA, 480V/135kV, Y-Y transformer has per-unit resistance of 0.01pu, per-unit reactance of 0.02pu, excitation (core loss) resistance of $R_C = 100pu$ and excitation impedance of $X_M = 50pu$. For your comfort, recall that we usually place the excitation branch on the primary side of the the series impedances.

   (a) (10 pts.) The transformer feeds an external load of 45,000 kVA with power factor 0.9 lagging. Find the line current out of the transformer and draw the phasor diagram under these conditions.

   (b) (5 pts.) Compute the voltage regulation under these conditions.

(c) (10 pts.) Draw the per-phase equivalent circuit for the transformer in real ohms and volts, referenced to the low-voltage side

4. A DC motor, connected in shunt as given in the circuit model below, is connected to a 130V DC source. At full load, the motor runs at 1500 rpm, and follows the magnetization curve on the following page. The armature and field resistances, resulting from the copper windings, are R_A of 0.8 ohms and R_F of 5 ohms. Mechanical losses are 100W.



(a) (10 pts.) What will be the armature and field currents at full load?

(b) (5 pts.) What horsepower rating would you assign this motor? Show how you've computed your rating.

(c) (10 pts.) The same DC machine is now wired in series. Compare the starting torques of the motor at V_T of 130V for the series and shunt states, assuming that the field flux is a linear function of field current, and the machine can take whatever currents the model dictates.

5. (10 pts.) A two-pole, 60 Hz, 230V, three-phase generator powers a load consuming 20 kW of power with power factor 0.8 leading. Ignoring any internal impedances of the generator, find (quantitatively) and sketch accurately the relationship between the stator and rotor magnetic fields in the machine if it is rotating clockwise.