ECE370 POWER & ENERGY SYSTEMS
Homework Sets 9 & 10, plus the Final Review – WOW!!

9.1 A three-phase, 440 V, six-pole, 60 Hz, wye-connected induction motor takes 18 kVAR at 0.8 lag pf and runs at a slip of 3.5%. The stator losses are 500 W and the rotational losses are 350 W. Determine:

a) Rotor copper loss.
b) Shaft output torque and horsepower.
c) Efficiency.

9.2 The following test results were obtained for a three-phase, 100 hp, 440 V, eight-pole, wye-connected induction motor.

a) Determine the exact equivalent circuit.

Test performed	Voltage (V)	Current (A)	Power (W)
No-load	440	38	3800
Locked-rotor (performed at 15 Hz)	80	110	4800
Rotational loss	-	-	1800
DC (measured between phases a – b)	8	50	-

b) **Estimate** the efficiency when rated load is supplied.

9.3 A three-phase, four-pole, 60 Hz induction machine is rated at 7.98 hp, 208 V, and 1755 rpm. The parameters of the equivalent circuit of the motor are:

$R_1 = 0.15\ \Omega$ $R_2 = 0.15\ \Omega$ R_c can be neglected
$X_1 = 0.4\ \Omega$ $X_2 = 0.25\ \Omega$ $X_m = 30\ \Omega$

The rotational losses are 500 W. For rated load calculate:

a) Line current and power factor.
b) Output torque.
c) Efficiency of the motor.
d) Starting current and torque.

9.4 A three-phase, 440 V, 60 Hz, four-pole, wound-rotor induction motor has a stator impedance of 1.0 + j 1.6 Ω/ph. The rotor impedance referred to the stator is 0.8 + j 1.4 Ω/ph. Core-loss resistance can be neglected and magnetizing reactance is 30Ω/ph. Determine:

a) The maximum torque developed by the motor and the speed at which it occurs if no additional external rotor resistance is applied.

b) Additional external resistance needed to make T_{max} occur at start-up, if the actual rotor resistance is measured through the slip-rings as 0.4 Ω/phase.

9.5 A three-phase induction motor is rated: 480 V, 25 hp, 3450 rpm. It is used to drive a compressor rated: 30 hp, 3600 rpm. The power input of the compressor is proportional to speed^3 (speed cubed). Determine the hp output of the motor and its speed in rpm.

9.6 A bank of three identical single-phase transformers is to be used to transform a 34.5 kV three-phase supply down to 12.47 kV. Each transformer is rated 12 MVA, 34.5 kV to 7.2 kV.

a) Draw a diagram showing how each transformer should be connected. Be sure to mark the polarity of each winding.

b) What is the MVA rating of the three-phase bank?

c) What are the primary and secondary rated line currents?

9.7 A 1200 V dc shunt motor is rated at 500 hp, 3000 rpm. It has an armature resistance of 0.17 Ω and a total field circuit resistance of 120 Ω. It draws a current of 350 A from the supply when delivering rated load. Ignore magnetic saturation and determine:

a) Rated output torque.

b) Rated developed torque.

c) Rated efficiency.

d) Rotational losses at rated speed.

e) Line current when the load is changed, causing the speed to become 3067 rpm. (Field resistance is unaltered.)

f) Developed torque for the conditions in part (e).

g) Horsepower output for the conditions in (e) if the rotational losses are proportional to speed^2.

9.8 A 600 V dc series motor is rated at 250 hp, 2000 rpm. It has an armature resistance of 0.1 Ω and a field resistance of 0.05 Ω. It draws a current of 360 A from the supply when delivering rated load. Ignore magnetic saturation and determine:

a) Rated output torque.
b) Rated developed torque.
c) Rated efficiency.
d) Rotational losses at rated speed.
e) Speed when the load is changed, causing the line current to drop to 180 A.
f) Developed torque for the conditions in part (e).
g) Horsepower output for the conditions in (e) if the rotational losses are proportional to speed^2.
h) Efficiency for the conditions in part (e).

9.9

a) A solar energy system consists of eight panels that are 15% efficient and each one is 2 m by 1.5 m. At noon, the zenith angle is 20^0, the transmittance of gasses is 73%, the water vapor absorption is 8%, and the transmittance of aerosol is 85%. Calculate:

i) Power density
ii) Solar efficiency
iii) Power output of the system.

b) The solar power density at the site in part (a) is: $\rho = 0.7e^{-(t-12)^2/18}\ kW/m^2$.

i) What is the daily energy produced?
ii) What is the power output of the array at 3:00 p.m.?

9.10 The induction machine in problem 9.3 is used as a generator that is driven by a wind turbine with a blade length of 10 m and fixed TSR of 0.75. It is required to produce power when wind speed is above 3 m/s, which corresponds to a generator slip of 0.4% (s = -0.004). Calculate the necessary gear ratio and the real and reactive power at the rated slip of 2.5% (s = -0.025).