ECE 431 homework assignment #7 (Due – Wednesday, April 22, 2019)

Q1 A shunt-connected, 75-kW, 250-V dc motor has an armature resistance of 50 mΩ and a field resistance of 200 Ω . When operated at 250 V, its no-load speed is 1850 r/min.

a) The motor is operating under load at a terminal voltage of 250 V and a terminal current of 290 A. Calculate (i) the motor speed in r/min, (ii) the load power in kW, and (iii) the load torque in N·m.
b) Assuming the load torque remains constant as a function of speed at the value calculated in part (a), calculate (i) the motor speed and (ii) the terminal current if the terminal voltage is reduced to 200 V.
c) Repeat part (b) if the load torque of part (a) varies with the square of the speed.

Q2 A 230 V shunt DC motor has a no-load speed of 1500 RPM. At this speed, its internal voltage may be approximated by:

$$E_a = 15 + 180\, I_{sh}$$

The armature resistance is 5 Ohms.

a) What value of resistance should be added in series with your 230 Volt supply to limit the terminal current to 8 Amps during startup?
b) What speed will the motor reach with your starting resistance in the terminal circuit if the machine is unloaded?

Q3 A 240 V, 20 HP, 63 A, 3000 RPM, dc machine has the following parameters:
Armature resistance 0.2 Ω, armature inductance 1.5 mH
Field resistance (shunt) 300 Ω, field inductance 20 H
Shunt field constant: k = 0.90 V-s/rad (Note: at rated field current)
The machine is connected to a load that draws torque $T_{load} = 0.001\omega^2$.

a) Find the steady-state operating current, speed, and torque when this motor operates as a shunt machine at rated voltage.
b) What will change if a control resistance of 30 Ω is inserted in series with the shunt winding?
c) Find the steady-state operating currents, speed, and torque when this machine operates as a separately excited device with 240 V on the field winding and 120 V on the armature winding.

Q4 A permanent magnet DC motor rated at 600V, 15kW, 650rpm is directly connected to a 0.5m diameter drum as shown in the diagram.
This system is used to lift a 200kg weight with rated voltage applied.
The motor has parameters Ra = 0.30Ω and k_f = 9.0 V·s/rad.

a) Calculate the torque, armature current and speed of the motor under these conditions and evaluate if it is safe to operate the motor continuously with this load.

b) Determine the maximum diameter of the drum for safe operation, and calculate the torque, armature current, and speed of the motor.