ECE 763  
Homework #7

Problems:

1. The no-load speed at the output of a DC motor and gear unit (n=50) is 7.5 RPM for an input voltage of 3 volts. When the motor is stalled with a 3 volt input, it draws 1.0 amp of current and exerts a torque (at the output of the gear) of 2.5 nt-m. When the motor is turning with no load and the input voltage is removed (0 volts), the speed falls to 36.8% (which is $e^{-1}$) of the no-load speed in 160 ms. Find the following parameters for the motor: $J_m$, $B_m$, $K_T$, $K_h$, R. Assume that $L$ and $\tau_f$ are zero. Be sure to give the units on all quantities.

2. The continuity equation for a pump-controlled linear hydraulic actuator is given as follows:

$$Q_L = A_p \ddot{x}_p + C_t P_L + (V_o/\beta_c)(dP_L/dt)$$

Give a description of the significance of each of the terms in the equation.

3. The basic equations that may be used to model a pump-controlled, linear hydraulic actuator (in addition to the continuity equation given above) are given as follows:

$$Q_L = K_p N_p \phi$$

$$A_p P_L = M_t \ddot{x}_p + B_p \dot{x}_p + F_L + F_f.$$  

(a) Derive the transfer function $X_p(s)/\Phi(s)$ assuming $F_L = 0$ (no load) and $|F_f| = 0$.

(b) Using the following values for the actuator parameters, what are the poles of the system?

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\begin{align*}
\beta_c &= 10^5 \text{ psi} \\
B_p &= 4.0 \text{ lb/(in/sec)} \\
C_t &= 0.01 \text{ (in}^3/\text{sec})/\text{psi} \\
K_p &= 0.00243 \text{ in}^3/(\text{RPM-deg-sec}) \\
M_t &= 2.0 \text{ lb/(in/deg-sec)} \\
A_p &= 2.356 \text{ in}^2 \\
V_o &= 35 \text{ in}^3 \\
N_p &= 3000 \text{ RPM}
\end{align*}
\]

From the values for the poles of the actuator, what can you say about its general damping characteristics?