Automatic Control – EEE 2002 Tutorial Exercise IV

A second order system is given by $G(s) = \dfrac{k}{as^2 + bs + c}$.

1. Write the transfer function as: $G(s) = \dfrac{k'}{s^2 + 2\zeta\omega_n s + \omega_n^2}$.
2. For *k'*=1 and $\zeta = 0.5, \omega_n = 5 rad/s$ and define a transfer function and use the command "damp" to find the damping factor and natural frequency.
3. Based on the previous answer predict the behaviour of the system for a (unit) step input.
4. Find the step response of that system using Matlab **AND** Simulink and hence crosscheck your previous answer. Also plot the system's error.
5. Use the command "*step*" as *[y,t]=step(sys)*, where "*sys*" is the transfer function of the system given in the previous question. Using these two vectors find the overshoot and peak time.
6. Using Matlab find the exact value of the steady state error using Matlab **AND** Simulink.
7. Assume a system with *k'*=1 and $\omega_n = 5 rad/s$. Use an m-file to calculate and hence plot the pole location in the s-plane for $\zeta \in [0.1, 1.5]$ (use a step size of 0.1).
8. Assume a system with $\zeta = 0.5$ and $\omega_n = 5 rad/s$. Use an m-file to calculate and hence plot the pole location in the s-plane for $k \in [0.1, 2]$ (use a step size of 0.5).
9. Assume a system with *k'*=1 and $\zeta = 0.5$. Use an m-file to calculate and hence plot the pole location in the s-plane for $\omega_n \in [0.5, 10]$ (use a step size of 1).
10. Find the unit step response and discuss the results (in connection to your answer given in the previous question) for:
    a. *k'*=0.1, *k'*=1 and *k'*=10 (keep $\zeta = 0.5, \omega_n = 5 rad/s$)`clc; clear;`
    b. $\zeta = 0.1, \zeta = 1, \zeta = 1.5$ (keep *k'*=1 and $\omega_n = 5 rad/s$)
    c. $\omega_n = 0.5 rad/s, \omega_n = 5 rad/s, \omega_n = 50 rad/s$ (keep $\zeta = 0.5, k = 1$)
11. Using the specific formula plot the overshoot versus the damping factor.
12. Using the specific formula plot the overshoot versus the natural frequency.

13. Using the specific formula plot the peak time versus the damping factor for wn=5rad/s.
14. Using the specific formula plot the peak time versus the natural frequency for z=0.1rad/s.
15. Using the specific formula plot the settling time (5% and 2% in the same graph) versus the natural frequency for z=0.1rad/s:
16. Using the specific formula plot the settling time (5% and 2% in the same graph) versus the damping factor for wn=5rad/s: