

## EECE 360 Homework - Performance Measures

- 1) The step response of a normalized second order system and its time domain solution (inverse Laplace transform) are shown below:

$$Y(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2} \quad y(t) = u(t) - e^{-\zeta\omega_n t} \left[ \cos(\omega_n \beta t) + \frac{\zeta}{\beta} \sin(\omega_n \beta t) \right]$$

Show that the output of the step response has the rise time  $T_r$  shown below:

$$T_r = \frac{1}{\omega_n \beta} \left[ \pi - \text{atan} \left( \frac{\beta}{\zeta} \right) \right] \quad \beta = \sqrt{1 - \zeta^2}$$

- 2) For the systems with the following parameters:

- $\omega_n = 1$
- $\zeta = 0.1, 0.5, 1, 1.5$

- a. Compute  $T_r$ ,  $T_{r1}$ ,  $T_p$ ,  $T_s$  and PO.
- b. Use Simulink to check your results.