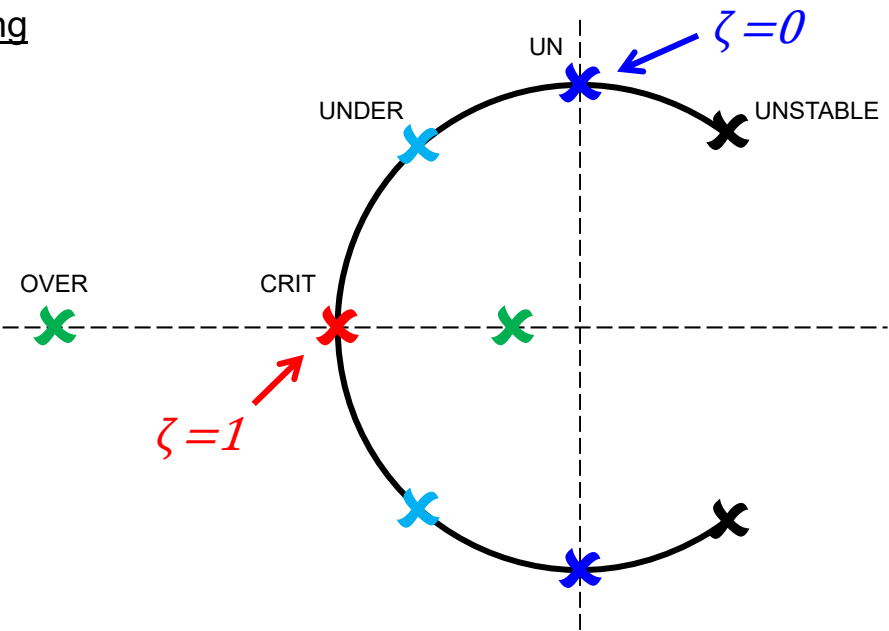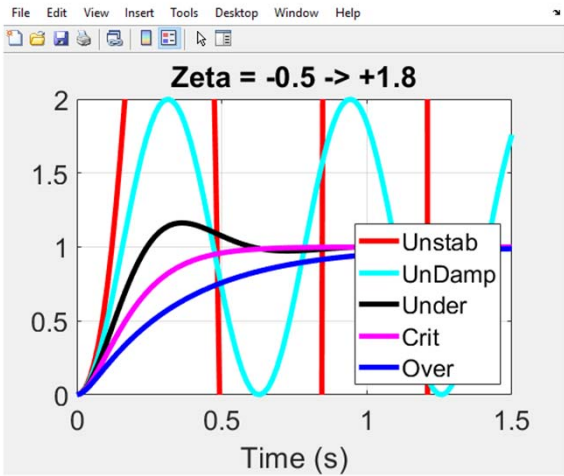Normalized O² Form

$$K_{DC} \frac{\omega_n{}^2}{s^2 + 2\zeta\omega_n s + \omega_n{}^2}$$
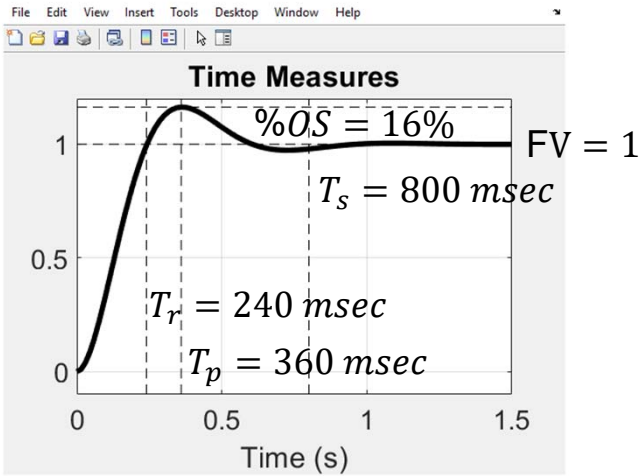
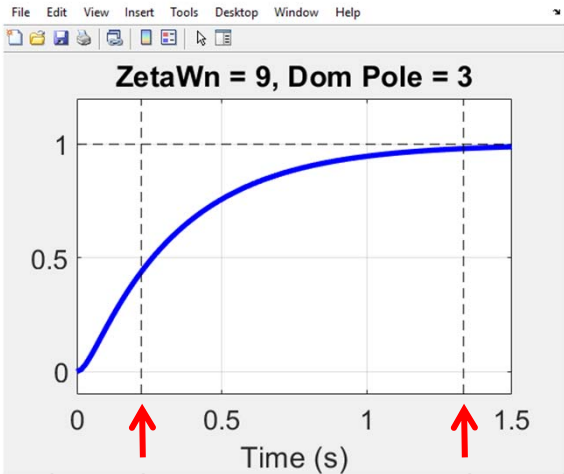Damping

Step Response   (ω_n = 10)

Under-Damped

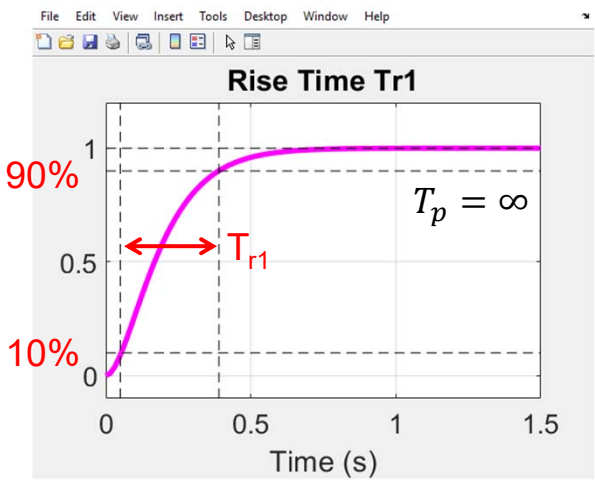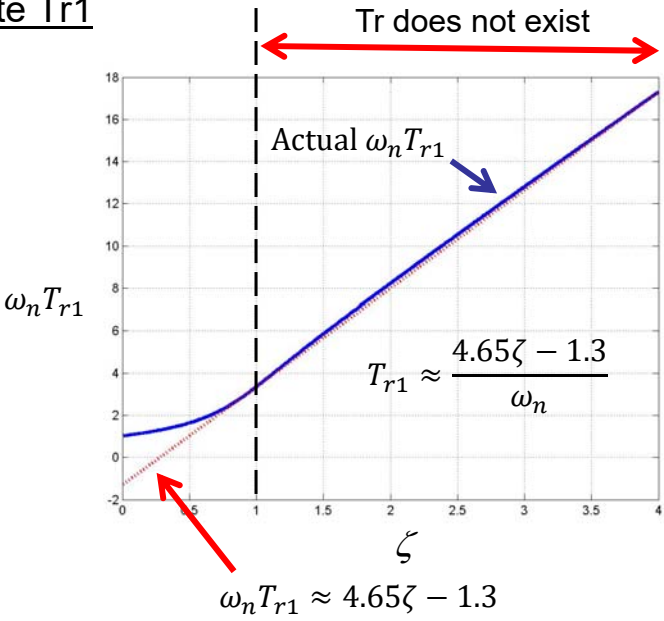## Over-Damped

ZetaWn = 9, Dom Pole = 3

$$\frac{4}{\zeta \omega_n} = \frac{4}{9} = 240 \ msec \qquad \frac{4}{pole} = \frac{4}{3} = 1.33 \ sec$$

Over-Damped

Rise Time Tr1

$T_p = \infty$

90%

10%

T_{r1}

Time (s)

Approximate Tr1

Tr does not exist

Actual $\omega_n T_{r1}$

$\omega_n T_{r1}$

$$T_{r1} \approx \frac{4.65\zeta - 1.3}{\omega_n}$$

ζ

$$\omega_n T_{r1} \approx 4.65\zeta - 1.3$$

2nd Order Measures

Performance Measures @ ω_n=1

Underdamped ζ Overdamped