Review: Phase Margin for 2nd-Order System

$$G(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s}, \qquad \text{closed-loop t.f.} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$\text{PM}\Big|_{K=1} = \tan^{-1}\left(\frac{2\zeta}{\sqrt{4\zeta^4 + 1} - 2\zeta^2}\right) \approx 100 \cdot \zeta$$

Conclusions:

larger PM $\iff$ better damping

(open-loop quantity) (closed-loop characteristic)

Thus, the overshoot $M_p = \exp\left(-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}\right)$ and resonant peak $M_r = \frac{1}{2\zeta\sqrt{1-\zeta^2}} - 1$ are both related to PM through ζ!!