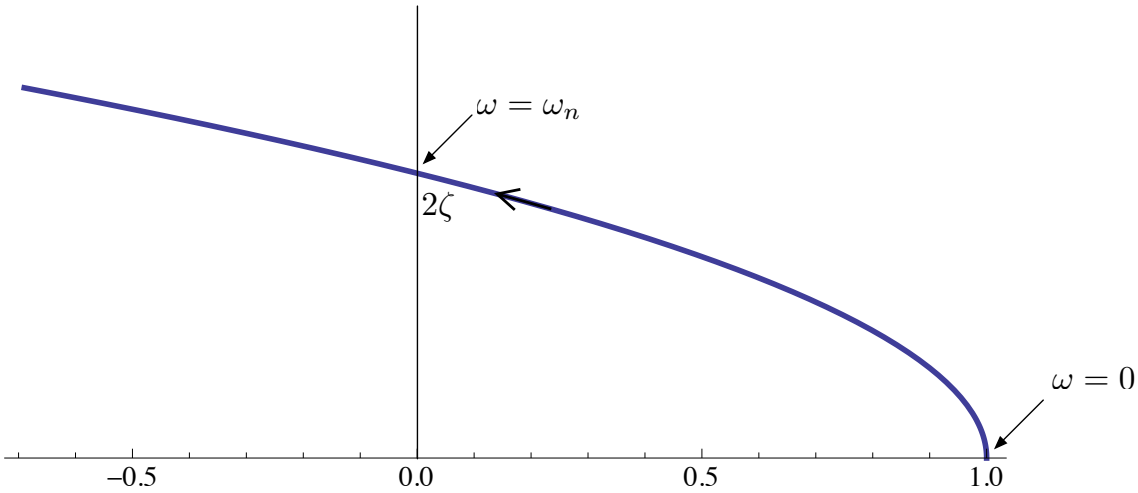
Type 3: $\left(\frac{j\omega}{\omega_n}\right)^2 + 2\zeta\frac{j\omega}{\omega_n} + 1$, Phase



Nyquist plot
$(0 < \omega < \infty)$

$$(R(\omega), I(\omega)) = \left(1 - \left(\frac{\omega}{\omega_n}\right)^2, 2\zeta\frac{\omega}{\omega_n}\right)$$

Phase:

- for $\omega \ll \omega_n$, $\phi \approx 0°$ (real and positive)
- for $\omega = \omega_n$, $\phi = 90°$ (Re $= 0$, Im > 0)
- for $\omega \gg \omega_n$, $\phi \approx 180°$ (Re $\sim -\omega^2$, Im $\sim \omega$)

For a stable complex zero, the phase steps up by 180° as we go through the breakpoint; as $\zeta \to 0$, the transition through the break-point gets sharper, almost step-like.

For a pole, the phase is multiplied by -1.