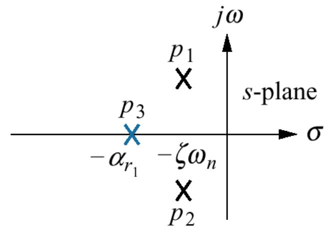
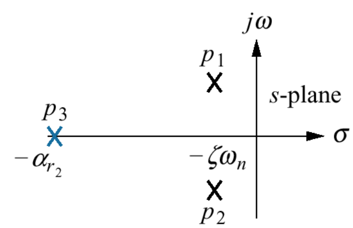
- **Lets have a look at these 3 cases below:**

  - **<u>Case I</u> : all poles are close or near to each other, where p_1 and p_2 are complex conjugate and near to the imaginary axis.**



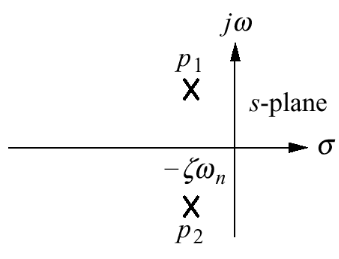
Case I

  - **<u>Case II</u> : the poles, p_1 and p_2, are at the same location as in the first case but p_3 is at some distance away from the imaginary axis.**



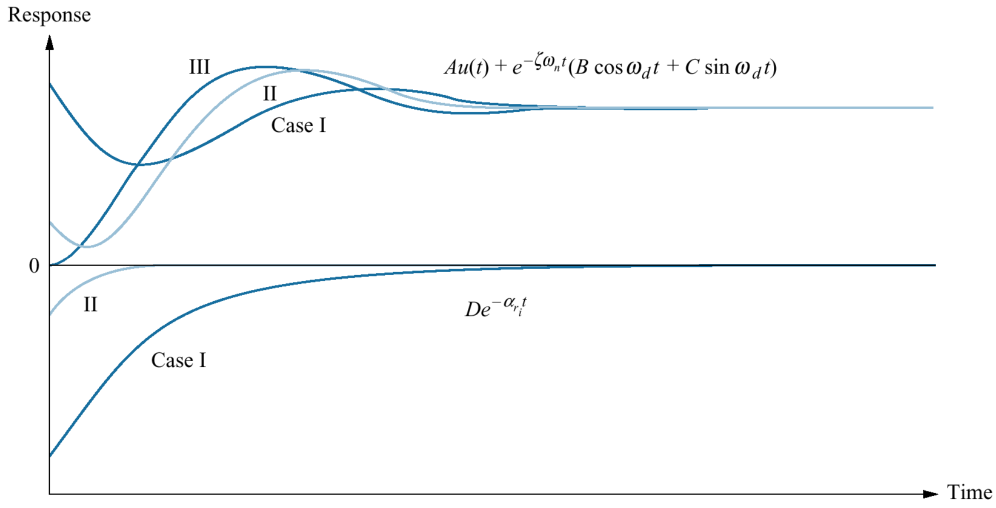
Case II

  - **<u>Case III</u> : the poles, p_1 and p_2, are at the same location as in the first case but no other poles present, ie, a second order system.**



Case III

- **The output response for the cases above:**



- **Case I : since the pole, p_3, is near to the other two poles (p_1 and p_2), the output response from p_3 cannot be ignored, ie, the transient response from p_3 must be included in the output response expression.**

$$c(t) = Au(t) + e^{-\zeta\omega_n t}(B\cos\omega_d t + C\sin\omega_d t) + De^{-\alpha_{r_1} t}$$

- **Case II : the output response from p_3 decays out to zero faster than the response in the first case (depends on the distance of the pole from the imaginary axis); in this case, p_3 can be ignored provided that p_1 and p_2 can be confirmed as the dominant poles of the system, where the system performance analysis of a second order system can be carried out.**

- **Case III : output response from a second order system; if the second case satisfies the dominant poles condition, it can be assumed to be having the same output response as in the third case.**

- **Condition for dominant poles assumption, and hence enabling a higher order system to be approximate as a second order system, is:**

  ➔for a system with 3 or more poles, the real poles must be FIVE times farther away to the left than the dominant poles (which are nearer to the imaginary axis).

- **If the above condition applies, any higher order system can be approximated as a second order system, and therefore, all the second order system performance specification can be used.**

- **This simplifies the time domain analysis of higher order systems.**

- **Example : Comparison of 3-pole system**

  - $G_1(s) = \dfrac{24.542}{s^2 + 4s + 24.542}$

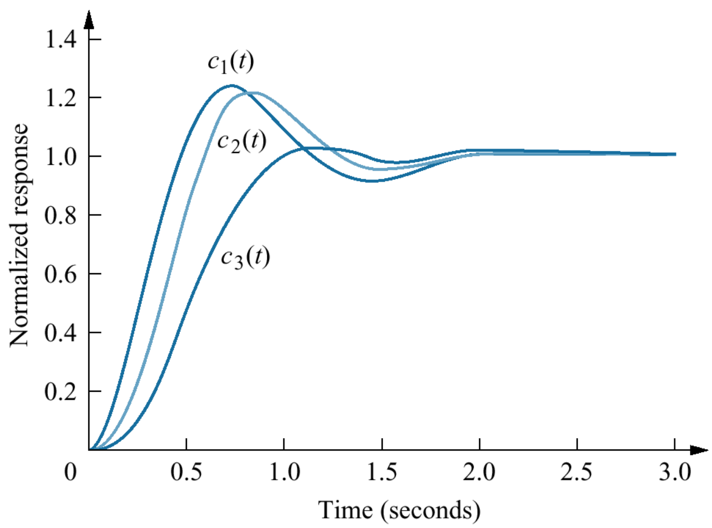
    ➔ $c_1(t) = 1 - 1.09e^{-2t}\cos(4.532t - 23.8°)$

  - $G_2(s) = \dfrac{24.542}{(s+10)(s^2 + 4s + 24.542)}$

    ➔ $c_2(t) = 1 - 0.29e^{-10t} - 1.189e^{-2t}\cos(4.532t - 53.34°)$

  - $G_3(s) = \dfrac{24.542}{(s+3)(s^2 + 4s + 24.542)}$

    ➔ $c_3(t) = 1 - 1.14e^{-3t} + 0.707e^{-2t}\cos(4.532t + 78.63°)$



  - **The output response $c_2(t)$ is approximately the same as that of $c_1(t)$ due to the fact that the pole *-10* of $G_2(s)$ is further away if compared to that of the pole *-3* of $G_3(s)$. This means that by assuming $G_2(s)$ as a second order system (provided it satisfies the dominant pole condition), its system performance can be analyzed using the normal second order system specification.**