Introductory Control Systems
Exercises #9 – Dominant and Insignificant Poles

For each of the transfer functions shown below, find an ***approximate, lower-order*** transfer function and ***estimate*** the ***2 % settling time*** (T_s) and the ***percent overshoot*** $(\%OS)$ for a ***unit step input***.

1. $T(s) = \dfrac{12500}{(s^2+50s+2500)(s^2+6s+25)}$

   Answers: $T(\mathrm{s}) \approx \dfrac{5}{s^2+6s+25}$ (2nd order); $\%OS \approx 10\%$ (Fig. 5.8); $T_s \approx 1.\overline{3}$ (sec)

2. $\dfrac{Y}{R}(s) = \dfrac{7500}{(s+3)(s^2+70s+2500)}$

   Answers: $T(s) \approx \dfrac{3}{s+3}$ (1st order); $\%OS \approx 0\%$; $T_s \approx \frac{4}{3} = 1.33$ (sec)

3. $T(s) = \dfrac{1000}{(s+2)(s^2+36s+625)}$

   Answers: $T(s) \approx \dfrac{1.6}{s+2}$ (1st order); $\%OS \approx 0\%$; $T_s \approx 2$ (sec)

4. $T(s) = \dfrac{400\,(s+6)}{(s+25)(s^2+6s+100)}$

   Answers: $T(s) \approx \dfrac{16(s+6)}{s^2+6s+100}$ (2nd order, case 2); $\%OS \approx 90\%$ (Fig 5.13); $T_s \approx \frac{4}{3} = 1.33$ (sec)

5. $T(s) = \dfrac{1000\,(s+3)}{(s+100)(s^2+6s+36)}$

   Answers: $T(s) \approx \dfrac{10(s+3)}{s^2+6s+36}$ (2nd order, case 2); $\%OS \approx 70\%$ (Fig 5.13); $T_s \approx \frac{4}{3} = 1.33$ (sec)

6. $T(s) = \dfrac{8000(s+6)}{(s^2+50s+1600)(s^2+6s+36)}$

   Answers: $T(s) \approx \dfrac{5(s+6)}{s^2+6s+36}$ (2nd order, case 2); $\%OS \approx 30\%$ (Fig. 5.13); $T_s \approx 1.33$ (sec)

7. $T(s) = \dfrac{850}{(s+2)(s^2+36s+500)}$

   Answers: $T(s) \approx \dfrac{1.7}{s+2}$ (1st order); $\%OS \approx 0$; $T_s \approx \frac{4}{2} = 2$ (sec)

8. $T(s) = \dfrac{32400}{(s^2+48s+900)(s^2+6s+36)}$

   Answers: $T(s) \approx \dfrac{36}{s^2+6s+36}$ (2nd order); $\%OS \approx 16-17\%$ (Fig. 5.8); $T_s \approx 1.33$ (sec)

9. $T(s)=\dfrac{850(s+7)}{(s+60)(s^2+14s+100)}$

Answers: $T(s)\cong\dfrac{\frac{85}{6}(s+7)}{s^2+14s+100}$ (2nd order, case 2); $\%OS\approx 22\%$ (Fig. 5.13); $T_s\approx 0.57$ (sec)

10. $T(s)=\dfrac{50000}{(s^2+50s+2500)(s^2+4s+25)}$

Answers: $T(s)\approx\dfrac{20}{s^2+4s+25}$ (2nd order); $\%OS\approx 26\%$ (Fig. 5.8); $T_s\approx 2$ (sec)

11. $T(s)=\dfrac{700\,(s+5)}{(s+40)(s^2+10s+100)}$

Answers: $T(s)\approx\dfrac{17.5(s+5)}{s^2+10s+100}$ (2nd order, case 2), $\%OS\approx 70\%$ (Fig 5.13), $T_s\approx 0.8$ (sec)

12. $T(s)=\dfrac{15000}{(s^2+36s+625)(s^2+4s+25)}$

Answers: $T(s)\approx\dfrac{24}{s^2+4s+25}$ (2nd order, case 1), $\%OS\approx 25\%$ (Fig 5.8), $T_s\approx\frac{4}{2}=2$ (sec)

13. $T(s)=\dfrac{975(s+6)}{(s+65)(s^2+12s+100)}$

Answers: $T(s)\approx\dfrac{15(s+6)}{s^2+12s+100}$ (2nd order, case 2); $\%OS\approx 40\%$ (Fig.5.13); $T_s\approx 0.67$ (sec)

14. $T(s)=\dfrac{1500(s+9)}{(s+80)(s^2+18s+225)}$

Answers: $T(s)\approx\dfrac{18.75(s+9)}{s^2+18s+225}$ (2nd order, case 2); $\%OS\approx 40\%$ (Fig. 5.13); $T_s\approx\frac{4}{9}=0.\overline{44}$ (sec)