Tutorial Two

0.1. Design PI controllers for the systems with the transfer function $G(s) = \frac{b}{s+a}$, where the parameters a and b given as follows:

1. $a = 0.1$ and $b = 3$;
2. $a = 10$ and $b = -0.1$
3. $a = 3$ and $b = 1$

In the design, the desired closed-loop polynomial is selected as $s^2 + 2\xi w_n s + w_n^2$ with $\xi = 0.707$ and choosing the bandwidth w_n as a, $5a$ and $10a$. Compare the proportional controller gain K_c and the integral time constant τ_I for the three choices of the bandwidth. What are your observations?

0.2. In the design of a PI controller, it is often to approximate a higher order system with a first order transfer function. Design PI controllers for the following systems with appropriate approximation of the complex dynamics. The desired closed-loop performance is specified using the polynomial $s^2 + 2\xi w_n s + w_n^2$, where $\xi = 0.707$ and w_n is 5 times of the dominant plant pole.

1. $G(s) = \frac{0.1}{(s+0.2)(s+3)}$
2. $G(s) = \frac{-5}{(s+0.1)(s+6)^2}$.
3. $G(s) = \frac{e^{-4s}}{s+0.1}$. (hint: use Pade approximation to the time-delay in order to find the dominant dynamics, $e^{-ds} \approx \frac{-ds+2}{ds+2}$)

0.3. Find the PID controller parameters using pole-assignment controller design technique and apply pole-zero cancellation to simplify the parameter solutions. Here, the PID controller structure is assumed to be $K_c + \frac{K_c}{\tau_I s} + K_c \tau_D s$. Take approximation of the complex dynamics if necessary.

1. $G(s) = \frac{10}{(s+20)s}$. The desired closed-loop polynomial is $(s^2 + 2\xi w_n s + w_n^2)$, $w_n = 5$ and $\xi = 0.707$. Where are the closed-loop poles? Verify your answer.
2. $G(s) = \frac{2}{(s+3)(s-1)}$. The desired closed-loop polynomial is $(s^2 + 2\xi w_n s + w_n^2)$, $w_n = 1$ and $\xi = 0.707$. Where are the closed-loop poles? Verify your answer.
3. $G(s) = \frac{e^{-0.1s}}{(s+3)s}$. The desired closed-loop polynomial is $(s^2 + 2\xi w_n s + w_n^2)$, $w_n = 1$ and $\xi = 0.707$. Where are the closed-loop poles? Verify your answer.
4. $G(s) = \frac{s-3}{s(s+0.4)(s+10)}$. The desired closed-loop polynomial is $(s^2 + 2\xi w_n s + w_n^2)$, $w_n = 0.2$ and $\xi = 0.707$. Where are the closed-loop poles? Verify your answer.

0.4. Find the parameters for PID controller with a filter using pole-assignment controller design technique. Use pole-zero cancellation technique to simplify the parameter solution and take approximation of the complex dynamics if necessary.

1. $G(s) = \frac{e^{-s}}{(s+5)(s+2)(s+0.1)}$. The desired closed-loop polynomial is $(s^2 + 2\xi w_n s + w_n^2)(s+\lambda)$, $w_n = \lambda = 1$ and $\xi = 0.707$.
2. $G(s) = \frac{s-1}{(s+10)(s+0.01)s}$. The desired closed-loop polynomial is $(s^2+2\xi w_n s+ w_n^2)(s+\lambda)$, $w_n = \lambda = 0.1$ and $\xi = 0.707$.