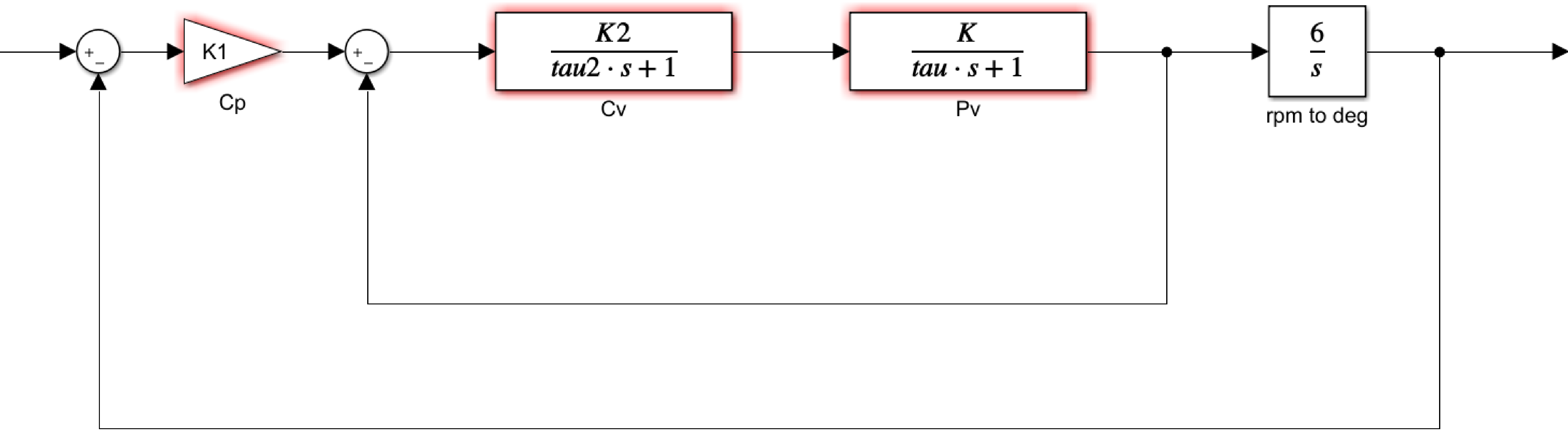
EEE-342

Lab-1 Preliminary Work Guide

Initial Parametrization

- We are dealing with the system below



- Additionally, since we are only interested in transfer function of closed position loop, the position loop controller can be represented as $C_p(s) = \frac{6K_1}{s}$

Mathematical Analysis of Closed Position Loop

Definition	**Parametrization**
Velocity loop controller $\left(C_v(s)\right)$	$C_v(s) = \dfrac{K_2}{\tau_2 s + 1}$
Velocity loop plant $\left(P_v(s)\right)$	$P_v(s) = \dfrac{K}{\tau s + 1}$
Position loop plant $\left(P_p(s) = T_v(s)\right)$	$P_p(s) = \dfrac{P_v(s)C_v(s)}{1 + P_v(s)C_v(s)}$
Position loop controller $\left(C_p(s)\right)$	$C_p(s) = \dfrac{6K_1}{s}$
Closed position loop $\left(T_p(s)\right)$	$T_p(s) = \dfrac{P_p(s)C_p(s)}{1 + P_p(s)C_P(s)}$

Mathematical Analysis of Closed Position Loop

- Instead of using numerical values, use parametric transfer functions to avoid complexity (Using 6 on $C_p(s)$ does not affect complexity).
- At the end of calculation of $T_p(s)$, you will obtain the following form

$$T_p(s) = \frac{d}{as^3 + bs^2 + cs + d} = \left(\frac{\omega_0^2}{s^2 + 2\zeta\omega_0 s + \omega_0^2}\right) \times \left(\frac{1}{\tau_x s + 1}\right)$$

$$= \frac{\omega_0^2}{\tau_x s^3 + (2\zeta\omega_0\tau_x + 1)s^2 + (\tau_x\omega_0^2 + 2\zeta\omega_0)s + \omega_0^2}$$

Mathematical Analysis of Closed Position Loop

- <u>*3 unknowns:*</u> τ_x, K, τ

- By replacing the parameters a, b, c, d with proper functions of $K, K_1, K_2, \tau, \tau_2$ that you found by calculating $T_p(s)$ from slide-3, you will have 3 equations for 3 unknowns.

→Note that since we are approximating a third order system with some nonlinearities to a second order linear system, it is unrealistic to find a matching response.

→However, there is also a crude approximation $M_p = 1 - \frac{\zeta}{0.6}$, which leads to a better matching output. (you can test it to be sure that your solution is correct, however you need to use the exact formula for M_p and explain why they do not match in your report).

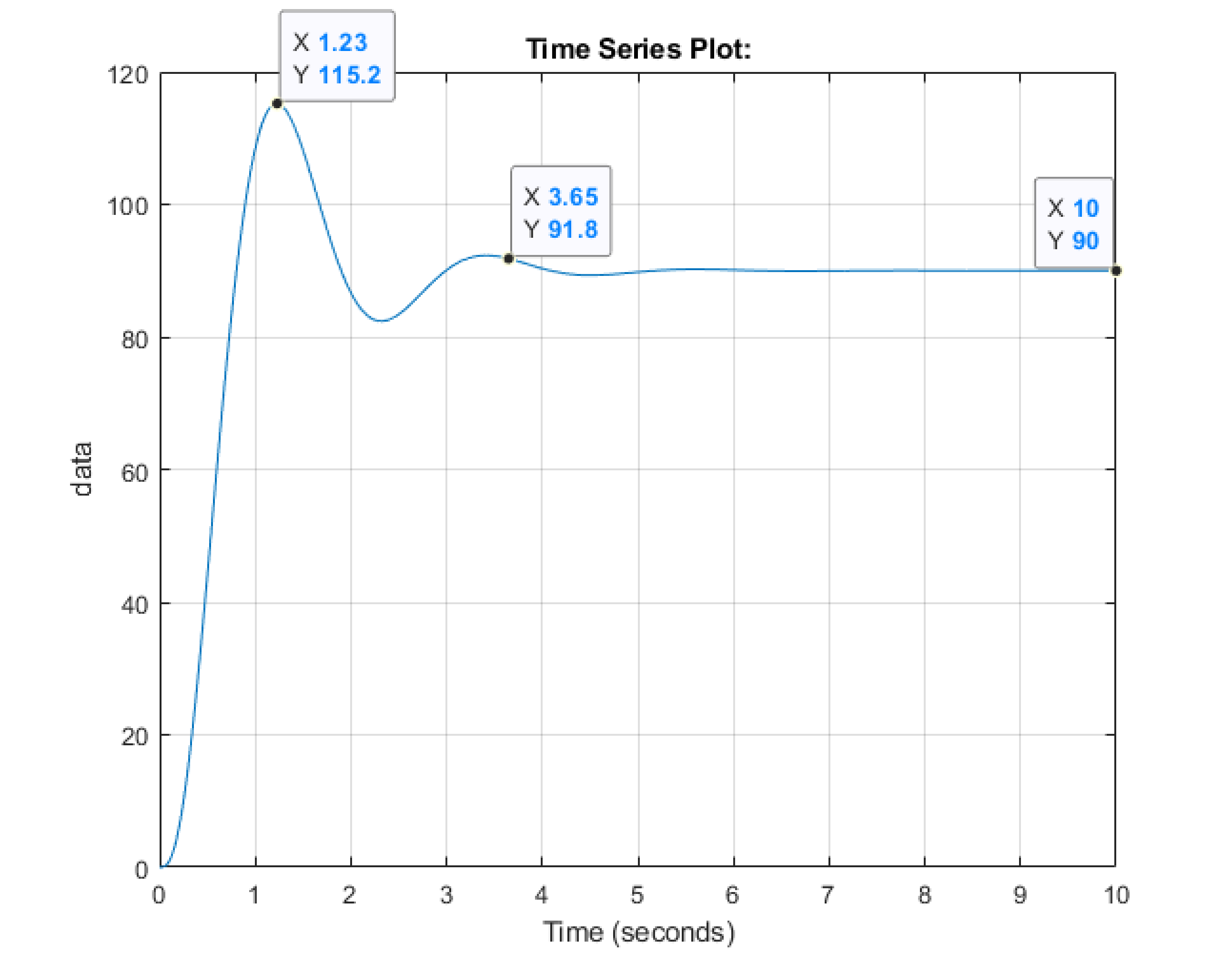
Estimation of ω_0 and ζ

<u>Second Order System Response</u>

- M_p: Maximum overshoot
- T_s: Settling time

→Find the constants above by using data (the figure shows an example for another data).

→Estimate ω_0 and ζ by using appropriate formulas for second order system



Estimation of K and τ

- Implement the parametric equations you found in Matlab. Initialize $K_1, K_2, \tau_2, \omega_0$ and ζ with proper values. Use the code to obtain K and τ.

- Therefore, you do not need to do any numerical computation manually.

- Just put the parametric equations and the code you implemented in your reports. Also, show the values of K and τ that are returned from Matlab.

If you have any questions, do not hesitate to send mail to
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