System and Control Project Requirements

1. Design values of K & K_f in the servomotor based on your hand analysis using ζ and ω_n of your IDs. ***Hint:*** ***J = 1 Kg/m² and a = 1 N.m/rad.sec***
2. $G(s)$ equation (hand analysis) based on the designed Circuit.
3. Code and graphs of inputting both Impulse and Step functions for the $G(s)$ (Matlab,and Simulink). ***Hint:*** ***Choose an appropriate time range.***
4. Comment on the graphs. Did you get the expected responses for both inputs? Elaborate.
5. Total transfer function (TF) (with negative unity feedback) (hand analysis).
6. Code and graphs of inputting both Impulse and Step functions for the Total T.F (Matlab, and Simulink). ***Hint:*** ***use a longer time range than that in step 3 for a clearer observation.***
7. Referring to the graphs, discuss whether the feedback got a better response than that in step 3. Clarify your answer referring to the system's stability condition.
8. Root Locus (Matlab).Comment whether the gain adjustment can enhance the stability or not.
9. Bode Plot (Matlab). Comment on the Gain and Phase margins.
10. Design PID (equations) (hand analysis) with flexibility to use P, PI, PD or PID.
    Hint1: ***you can refer to the design problem uploaded on cms if necessary.***
    Hint2: ***Do not use the pre-defined PID library in Matlab.***
11. Code and graphs of inputting different inputs (Step, Ramp, and Parabolic function) for the system with the chosen controller (Matlab, and Simulink).

    Hint: ***Sketch both the system's input and output on the same graph in two different colors and a legend.***
    Comment considering the effect of your controller block on:
    a. The system's stability.
    b. The steady state error value for unit step, ramp, and parabola using both hand analysis and Matlab referring to the system's type.
12. Find the rise time, peak time, maximum overshoot, and settling time of the system's step response after inserting the controller block (Matlab, and Simulink). ***Hint:*** ***Adjust the Matlab characteristics such that the rise time is from 0 to 100% and the settling time is within 5% error window.***
13. New values of tuning the controller parameters if needed and **repeat steps 11, and 12**.
    Hint: ***The change in k_p and k_d values should not exceed ±10.***
14. Comment on graphs and tuned values.
15. Root Locus of the system after the controller (Matlab). Did it change? How might the stability be affected?
16. Bode Plot of the system after the controller (Matlab).Comment regarding the stability. Justify your answer.
17. Design Lead-Lag Compensator (equations) (hand analysis) (**replacing the designed PID block**). With flexibility to use only Lead, only Lag, or the whole Lead-Lag design.
18. Code and graphs of inputting different inputs (Step, Ramp, and Parabolic function) for the system with the chosen compensator (Matlab, and Simulink).

    Hint: ***Sketch both the system's input and output on the same graph in two different colors and a legend.***

Comment considering the effect of your compensator block on:

a. The system's stability.
b. The steady state error value for unit step, ramp, and parabola using both hand analysis and Matlab referring to the system's type.

19. Find the rise time, peak time, maximum overshoot, and settling time of the system's step response after inserting the compensator block (Matlab, and Simulink). ***Hint: Adjust the Matlab characteristics such that the rise time is from 0 to 100% and the settling time is within 5% error window.***
20. New values of tuning the compensator parameters if needed and **repeat steps 18, and 19.**
    Hint: ***Tuning includes changing the compensator gain or slightly shifting the positions of the new poles, zeros or both.***
21. Comment on graphs and tuned values.
22. Root Locus the system with compensator (Matlab). Did it change? How might the stability be affected?
23. Bode Plot the system with compensator (Matlab). Comment regarding the stability. Justify your answer.
24. Build the hardware setup of your total system and verify the results obtained practically.(Bonus)
    Use the below link for the required hardware components, detailed steps of design and required Arduino code.

    https://srituhobby.com/what-is-a-pid-controller-and-how-does-it-work-with-an-arduino