Please do your assignment independently.

Problem 1

10pt Consider the linear system

$$\dot{x} = \theta x + u$$

Suppose the true parameter for $\theta = 10$ but is unknown. Design the adaptive controller that stablizes the system to the origin.
- note: you would need to implement a ode function to generate the response of the system given this adaptive control input. In this ode function, you can use the true value for θ. But in the controller, you should not use the value for θ but an "estimate" of this θ. Check if you start with different initial states, will you converge to the same values of θ estimate or different values? Plot the trajectories for both x and θ as functions of time.

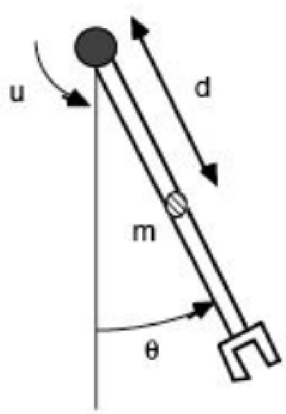
Problem 2

10pt
Consider a one-link robot arm with true model

$$I\ddot{\theta} + mgd\sin\theta + f_v\dot{\theta} = u$$

(with friction)
And the model estimate is

$$\bar{I}\ddot{\theta} + \bar{m}g\bar{d}\sin\theta + \bar{f}_v\dot{\theta} = u$$



Given the real dynamic coefficients

$$I = 7.2,\ mgd = 1;\ f_v = 1$$

and initial estimate

$$\bar{I} = 8, \bar{m}g\bar{d} = 5, \bar{f}_v = 2.5$$

- Generate a desired trajectory that takes the system from an initial configuration (at your choice) and a final configuration (at your choice) using polynomial functions of time.
- Design the adaptive controller for trajectory tracking. Plot the following figures in your report:
  - The state trajectory and the desired state trajectory over time.
  - The input trajectory over time.

– The errors in parameters over time.

Note: Again, in the ode function which you use to simulate the system dynamics, the actual parameter can be used. But in the controller and in the update for the parameter, you should not use the actual parameters of the system.

Problem 3

10pt
For the same system, design a robust controller to track the desired trajectory.
Feel free to change the parameters

$$\bar{I} = 8, \bar{m}g\bar{d} = 5, \bar{f}_v = 2.5$$

to different values, and observe the performance of the robust controller given large deviation and small deviation in the robust control. Compare that with the adaptive control. And conclude your findings.