GUC
German University in Cairo
Faculty of Engineering and Material Science
Department of Mechatronics Engineering

Robust and Optimal Control

Assignment #1

Due date: Wednesday 20.2.2019

Name	
App. No.	
Group No.	

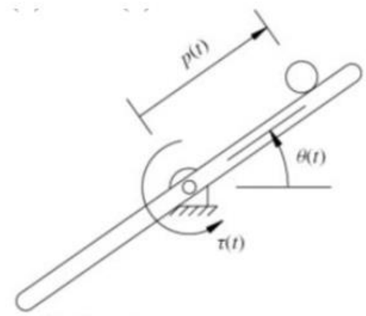
Note:
Assignments not submitted in this form will NOT be accepted.
Assignments should be submitted in hardcopy.
Cheating will not be tolerated and it is your responsibility to ensure the genuineness of your work.

Problem 1:

A system is described by the nonlinear model:

$$\left[\frac{J_b}{r^2}+m\right]\ddot{p}(t)+mg\sin\theta(t)-m\,p(t)\dot{\theta}(t)^2=0$$

$$[mp(t)^2+J+J_b]\ddot{\theta}(t)+2\,m\,p(t)\dot{p}(t)\dot{\theta}(t)$$
$$+mg\,p(t)\cos\theta\,(t)=\tau(t)$$



Ball and beam apparatus.

In which $p(t)$ is the ball position, $\theta(t)$ is the beam angle and $\tau(t)$ is the applied torque.

System parameters	Symbol	Value
Mass moment of inertia of the beam	J	9.99e-04
Mass of the ball	m	0.11 Kg
Radius of the ball	r	0.015
Mass moment of inertia of the ball	J_b	9.99e-04
Gravitational acceleration constant	g	9.81

Requirements:

1) Linearize the system around an operating point of your choice.
2) Discretize the system for a sampling time $T_s=0.1s$.
3) The system analysis: check its stability, controllability and observability.
4) Design a finite horizon linear quadratic regulator for the discrete-time system using the recursive approach for two different initial conditions. Choose your own weighing matrices.
5) Simulate your controller on the linearized system and on the nonlinear system.
6) Plot the optimal cost-to-go from time j to the end of the time horizon N.
7) Plot the response of the system outputs and control effort.
8) Comment on your results.

Note that you can use Matlab for your calculations. You should show all your steps clearly, submit all the codes used and the results.