Assignment 2
EL2700 Model Predictive Control

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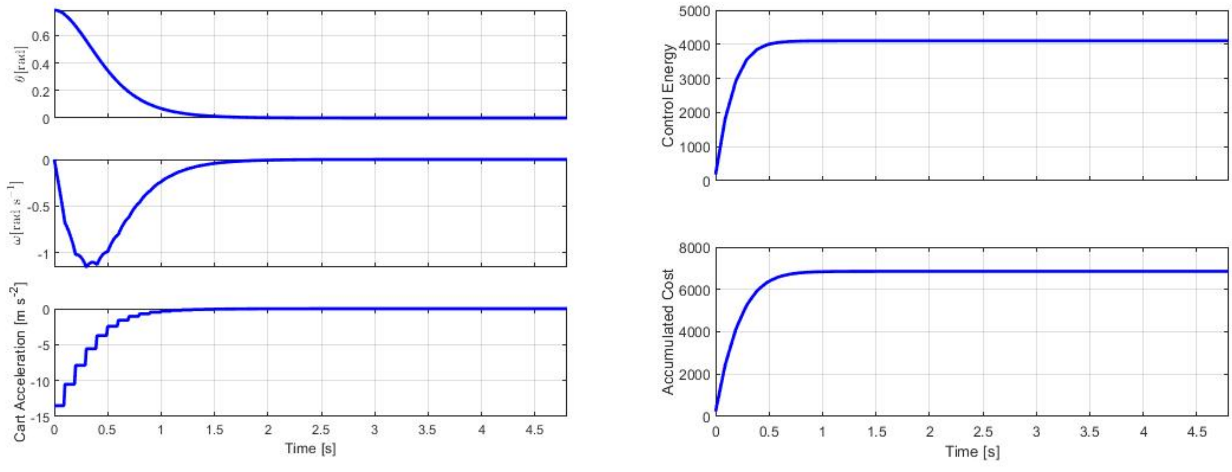
1 Dynamic Programming for Regulation

Using the solved problem 3.17 from the exercise compendium as the basis of reference, the MATLAB skeletons for linear and nonlinear controller were completed. The cost-to-go function was estimated by Gridding the state-space and calculating the value function at each grid point.

1.1 Linear Controller Design

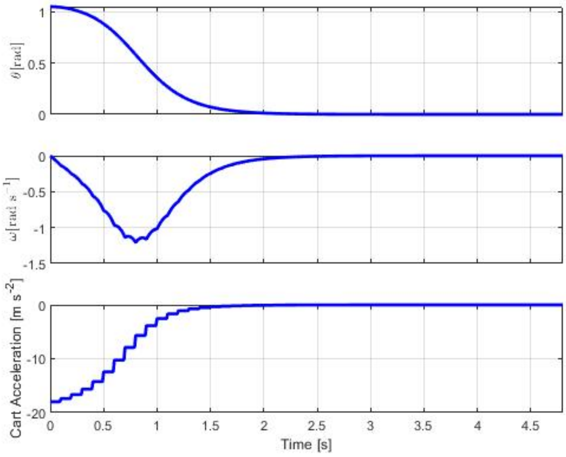
Using Q = diag([100,10]) and R = 1 we ran the simulation in Linear mode for various initial states. The following figures present results for their performance.



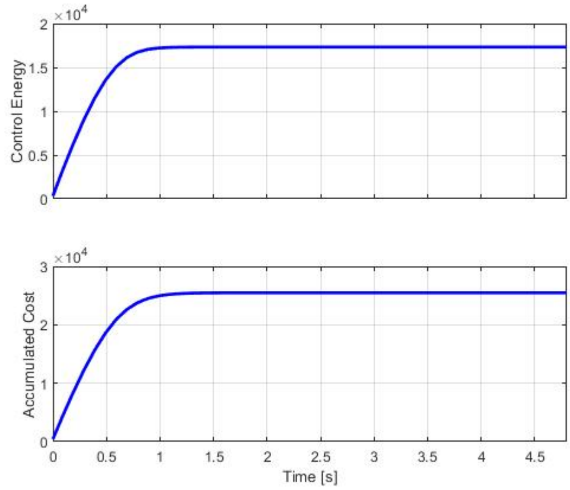
(a) Pendulum State Results

(b) Accumulated Cost and Control Energy

Figure 1: Results for initial state [pi/4 0]



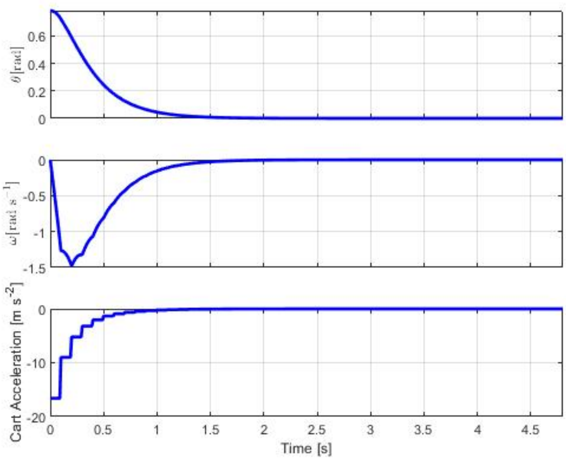
(a) Pendulum State Results



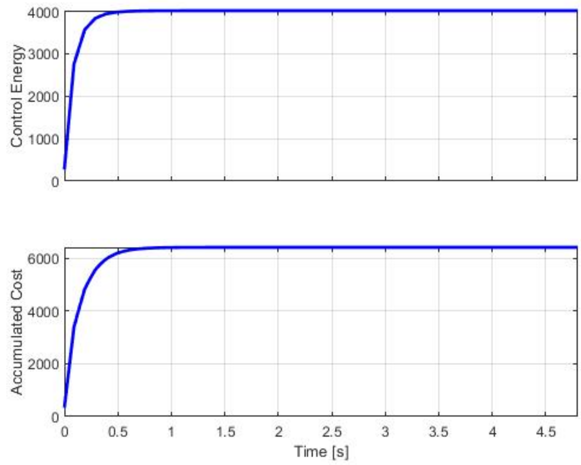
(b) Accumulated Cost and Control Energy

Figure 2: Results for initial state [pi/3 0]

1.2 Non-Linear Controller Design

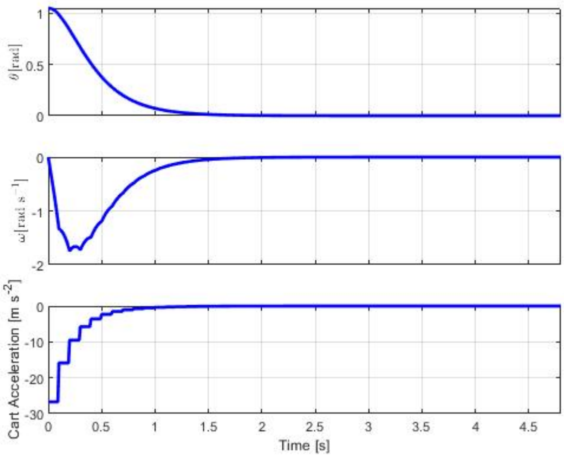


(a) Pendulum State Results

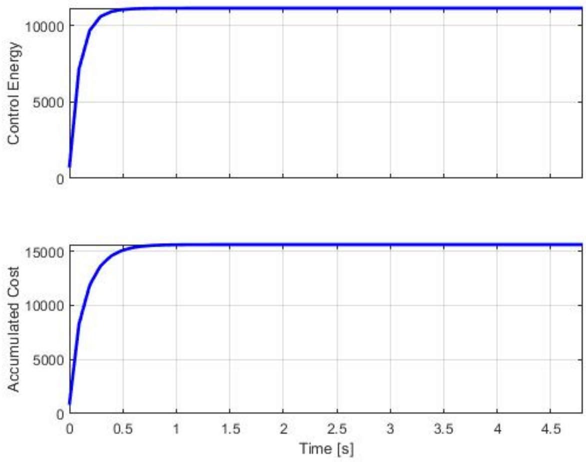


(b) Accumulated Cost and Control Energy

Figure 3: Results for initial state [pi/4 0]



(a) Pendulum State Results



(b) Accumulated Cost and Control Energy

Figure 4: Results for initial state [pi/3 0]

1.3 Comparison

From the results it can be seen that the control energy and accumulated cost is lower for the non-linear case.

	Linear		Non-Linear	
	Control Energy	Accumulated Cost	Control Energy	Accumulated Cost
pi/4	4103	6855	4017	6.41E+03
pi/3	1.73E+04	2.55E+04	1.12E+04	1.56E+04

Figure 5: Cost Energy and Accumulated Cost

The computational time for running the linear mode is lower as compared to the nonlinear mode. This was verified by running the two cases multiple times and taking an average.

	Linear	Non-Linear
pi/4	1.55	1.43
pi/3	2.06	1.56

Figure 6: Convergence time

The convergence rate here is taken as the time taken to reach 0.01 rad from the initial state. The convergence to final value for the non-linear controller is faster.

	Linear	Non-Linear
1st Run	9.98	14.79
2nd Run	10.08	14.9652
3rd Run	10.05	15.24
Average	10.04	15.001

Figure 7: Computational Time

2 Dynamic Programming for Reference Tracking

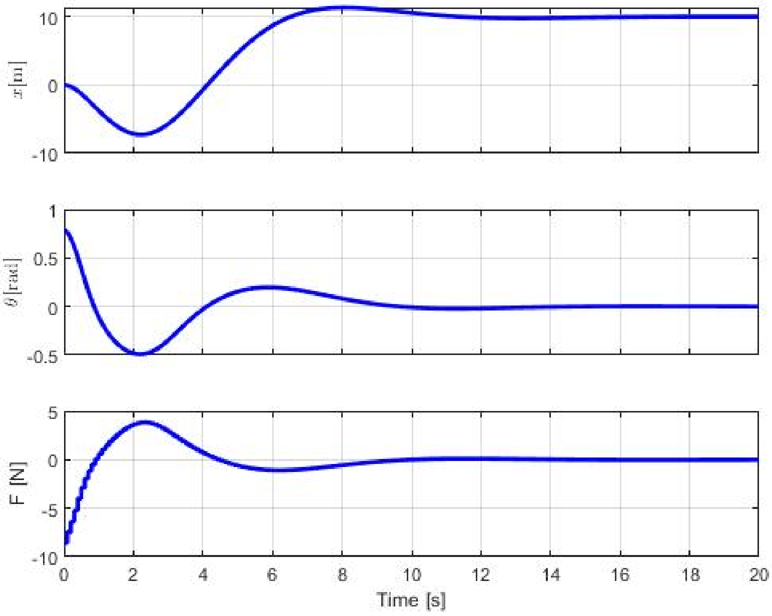


Figure 8: DP for Reference Tracking Results

On comparing the tracking performance against the State feedback regulator we designed in the Part I of the report, we observed that there are oscillations in the angle θ. These are caused due to coupling between the position x and angle θ. Thus, the convergence of the Pendulum angle is also delayed. But, there are no steady state errors in the tracking controller as well as the regulator.