3F2 Short Lab Write-Up

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**Abstract**

Two controllers were investigated for a crane and an inverted pendulum. The system poles were calculated from the transient and step responses to the two experiments. Studying firstly the crane controller, the pole placement was investigated and the resulting sensitivity. A marginally stable system was studied as a contoller, applying to it the Routh-Hurwitz stability test. Then the same procedure was applied for the inverted pendulum controller.

**Discussion**

In this experiment, Track 2 and Apparatus controller 3 was used. Using the tools provided the moving frictional force F and the static friction force were measured to be 1.25N and 0.85N respectively.

Initially the carriage controller coefficients were set to **p** = [0.35 0.15 0 0][[1]](#footnote-2). Oscillations for non-zero values of p3 and p4 were attempted to be minimised by varying the values of these coefficients, and the corresponding theoretical close-loop pole positions were calculated in MATLAB to be (-4.75±24.9j) and (-1.31±4.96j). A critically damped step response was observed with these controller settings **and is shown in** **figure \*\***. The poles are all in the left-half plane and are therefore stable.

The closed-loop poles were placed at -ω1=-(√78.1), which meant that the controller potentiometer values were set to **p = [**0.127 0.215 0.230 0]. The corresponding theoretical poles were: (-12.21, -6.46,-8.41±2.73j). This was not a fully critically damped condition however these poles seemed to be surrounding the target pole position of -ω1.

To increase the speed of the step response, pole positions of (-15,-12, -10±10j) were chosen. **figure \*\* shows this.** This gave a better critically damped response than the previous.

Finally the value of p2 was varied until instability just occured. This occurred at p2 = 0.39, and the step response prior to the onset of oscillations **is shown in figure \*\*.**

**???**

The controller was then changed to the Inverted Pendulum setting. The potentiometer settings were set to **p** = [0 0 0.5 0.11]. Setting p1 = p2 = 0 removed feedback from the carriage. Placing the pendulum vertically and turning the controller on, the carriage moved rapidly to the left end of the rail and the reset was triggered. The pendulum stayed vertical throughout this motion however. Since there was no feedback from the carriage, any slight force caused it to accelerate in the direction of the disturbance. This could be explained by the fact that there were repeated poles at the origin, causing the system to be marginally stable.

Next, the closed-loop poles were chosen to be at -ω1=-(√78.1), setting the potentiometer values to **p** = [0.254 0.322 0.347 0.280]. **this step response is shown in fugure \*\***.

Setting the potentiometers to **p** = [0.23 0.50 0.63 0.40], the system's limit cycle was investigated. The value of p2 was decreased until large oscillations occurred at the lowest value of p2 = 0.19. **figure \*\* shows the response to a step**. The value of p2 was then increased and an upper bound was found at p2 = 0.82, where the system was still stable.

If the system was implemented with p3 = p4 = 0 (ie. no pendulum feedback), **\*\*?**

1. **p =** [p1 p2 p3 p4] [↑](#footnote-ref-2)