MCTR 903 – Advanced mechatronics engineering

# Control Simulation of Ball and Beam Mechanism

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# Abstract

## The Ball on Beam system is very simple yet it is one of the most popular and important models for presenting control systems engineering. This project presents steps of creating software non-linear controllers for the Ball on Beam system

## **Introduction**

**General description** of your project system, modeling techniques and non-linear controllers.

## **Literature Review**

The ball and beam system has been built by many organisations. In the following, a brief literature review is presented.  
In 1992, Hauser [[1](#JHa92)] presented the nonlinear Ball on a Beam control problem; they found out that the relative degree of the Ball on a Beam system is not well defined and thus the system is not input–output linearizable. A simplified nonlinear model was used to approximate the original Ball on a Beam system model to solve this problem.  
In 1999, Hirsch [[2](#Rob99)] built his ‘Ball on Beam System’. An ultrasonic sensor was used to measure the position of the ball. The angle of the beam was measured though the use of a potentiometer. The motor with a gearbox was driven with a high power op-amp circuit. The system was controlled by a PD controller.  
Hauser et al. and Hirsch et al. have derived the equations for the Ball and Beam system using the Lagrangian method.

In 2001, Hirschhorn [[3](#RHi06)] proposed an incremental sliding mode controller for the Ball on a Beam system.

In 2005, Arroyo built a system named the ‘Ball on Balancing Beam’. A resistive wire sensor was used to measure the position of the ball. The resistive position sensor acted as a wiper similar to a potentiometer resulting in the position of the ball. A DC motor with reducing gear was used to move the beam. The system was controlled by PD controller. The system was easy to build and the controller was easy to design, however there were many drawbacks for this system such as: the beam was made of acrylic, which may be too brittle for a sudden impact. Additionally, the tilt angle of the beam was not measured and controlled. Therefore, the system may be not very robust. [3]

## **Objective and Tasks**

**Specifically** mention what is your objective and the tasks you are going to do in this project **in details**.

## **Time Table**

Mention what you are going to do in each of the 3 next milestones.

|  |  |  |
| --- | --- | --- |
| **Milestone num.** | **Deadline** | **Task** |
| Milestone\_1 | Wed. 27/9 | Proposal |
| Milestone\_2 | Wed. 18/10 | **Task\_1** (mention what to submit in task\_1) |
| Milestone\_3 | Wed. 22/11 | **Task\_2** (mention what to submit in task\_2) |
| Milestone\_4 | Wed. 13/12 | **Task\_3** (mention what to submit in task\_3) |

## **List of Figures**

**Insert table of figures** used in your literature review.

## **References**

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| [1] | S. Sastry and P. Kokotovic J. Hauser, "Nonlinear control via approximate input-output linearization: the ball and beam example," *IEEE Transactions on Automatic Control*, vol. 37, no. 3, pp. 392-398, March 1992. |
| [2] | Robert Hirsch, "Mechatronic Instructional Systems Ball on Beam System," Shandor Motion Systems, 1999. |
| [3] | R. Hirschorn and J. Davis, "Output Tracking for Nonlinear Systems with Singular Points," *SIAM Journal on Control and Optimization*, vol. 25, no. 3, pp. 547–557, July 2006. |

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