

BALL AND BEAM 1: Basics

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ABSTRACT: This is one of a series of white papers on systems modelling, analysis and control, prepared by Control Systems Principles.co.uk to give insights into important principles and processes in control. In control systems there are a number of generic systems and methods which are encountered in all areas of industry and technology. These white papers aim to explain these important systems and methods in straightforward terms. The white papers describe what makes a particular type of system/method important, how it works and then demonstrates how to control it. The control demonstrations are performed using models of real systems that I designed, and which have been developed for manufacture by TQ Education and Training Ltd in their CE range of equipment. This white paper is about a very useful and influential laboratory system for teaching control of unstable systems – the Ball and Beam System.

1. What is the Ball and Beam?

The ball and beam system is one of the most enduringly popular and important laboratory models for teaching control systems engineering. The ball and beam system is widely used because it is very simple to understand as a system, and yet the control techniques that can be studied it cover many important classical and modern design methods. It has a very important property – it is open loop unstable.

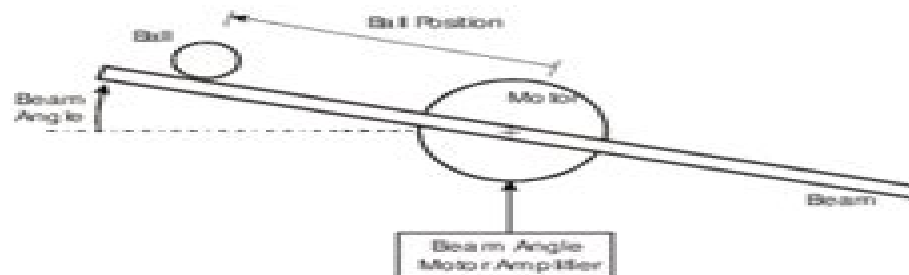


Figure 1. The Ball and Beam System.

The system (shown in figure 1) is very simple – a steel ball rolling on the top of a long beam. The beam is mounted on the output shaft of an electric motor and so the beam can be tilted about its centre axis by applying an electrical control signal to the motor amplifier. The position of the ball on the beam can be measured using a special sensor.

The control job is to automatically regulate the position of the ball on the beam by changing the angle of the beam. This is a difficult control task because the ball does not stay in one place on the beam but moves with an acceleration that is proportional to the tilt of the beam. In control technology the system is open loop unstable because the system output (the ball position) increases without limit for a fixed input (beam angle). Feedback control must be used to keep the ball in a desired position on the beam.

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