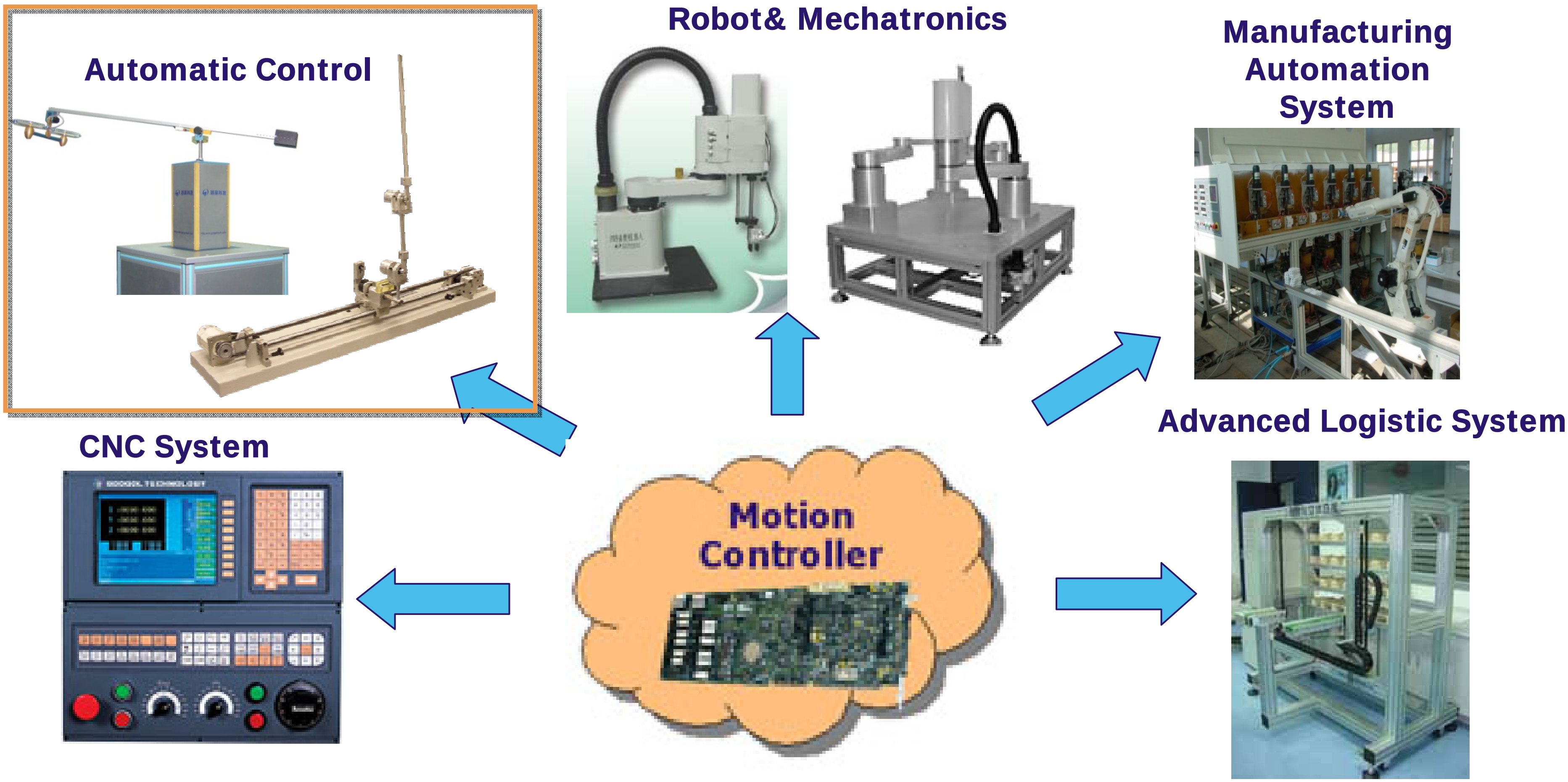
Educational Products



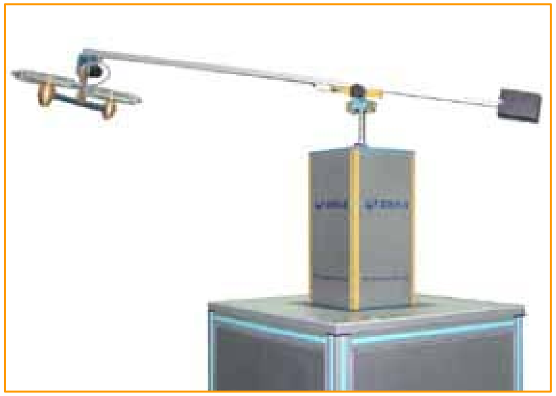
Based on open architectural motion control as the core technology, Googol developed its educational products family to facilitate the study and research in the area of robotics and automation……

Equipments and Systems for Automation Control

Today's training, tomorrow's challenge

IP Family

- 1-4 stage LIP
- 1-3 stage PIP
- Circular IP
- Configurable IP
- Flexible Joint IP



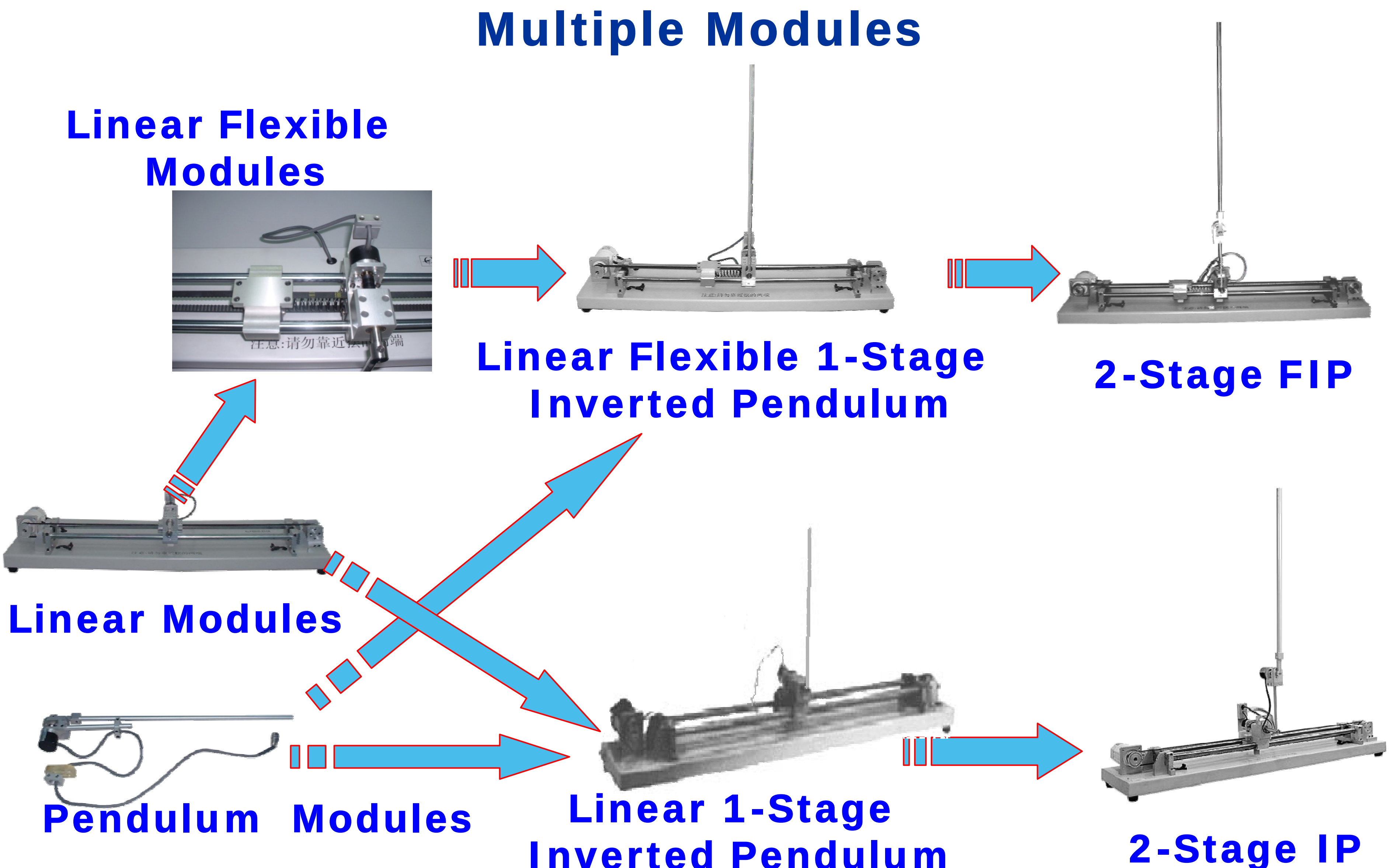
3DOF Helicopter

Magnetic Levitator

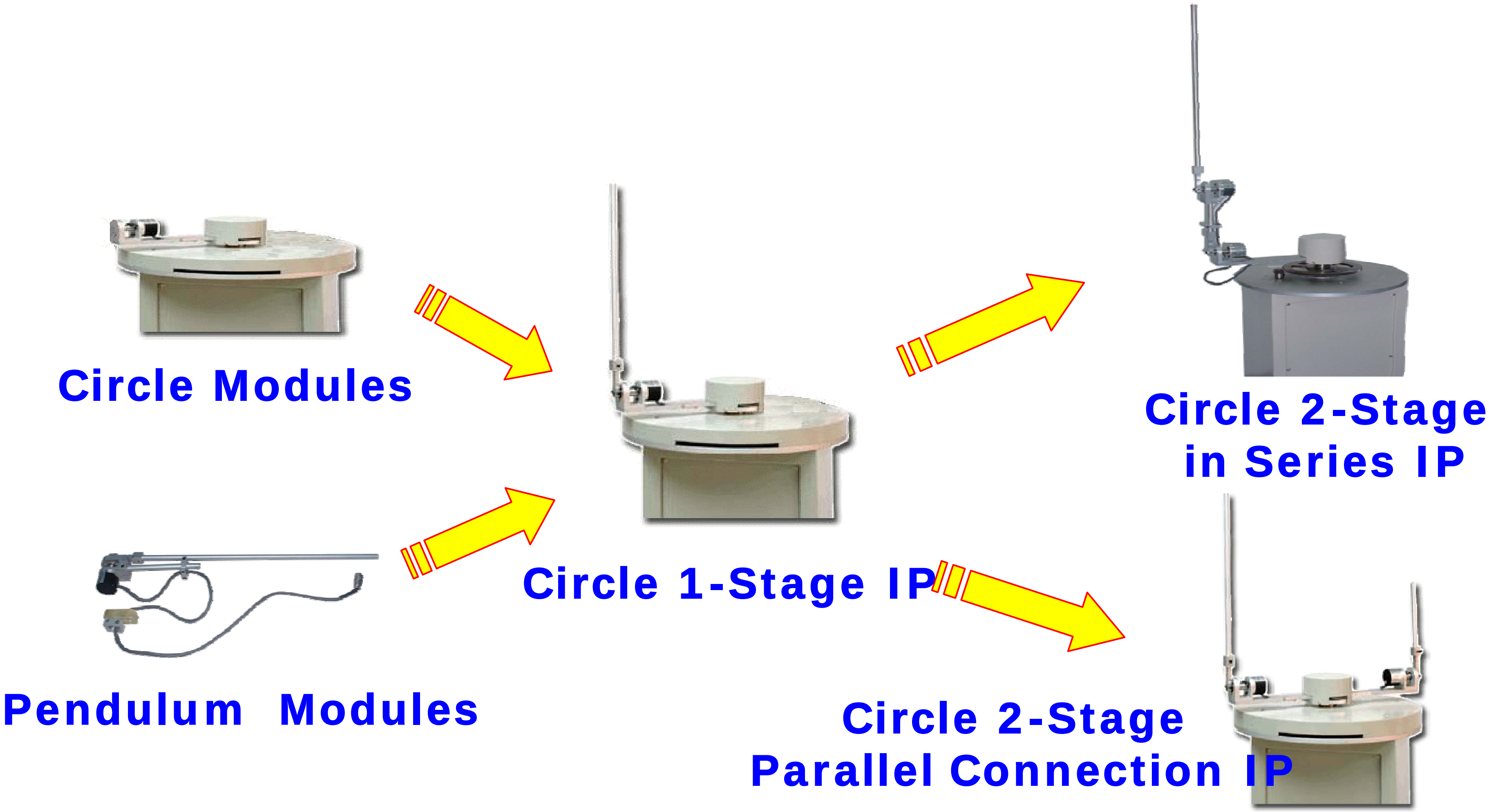
Ball & Beam

Example:
Inverted Pendulum…

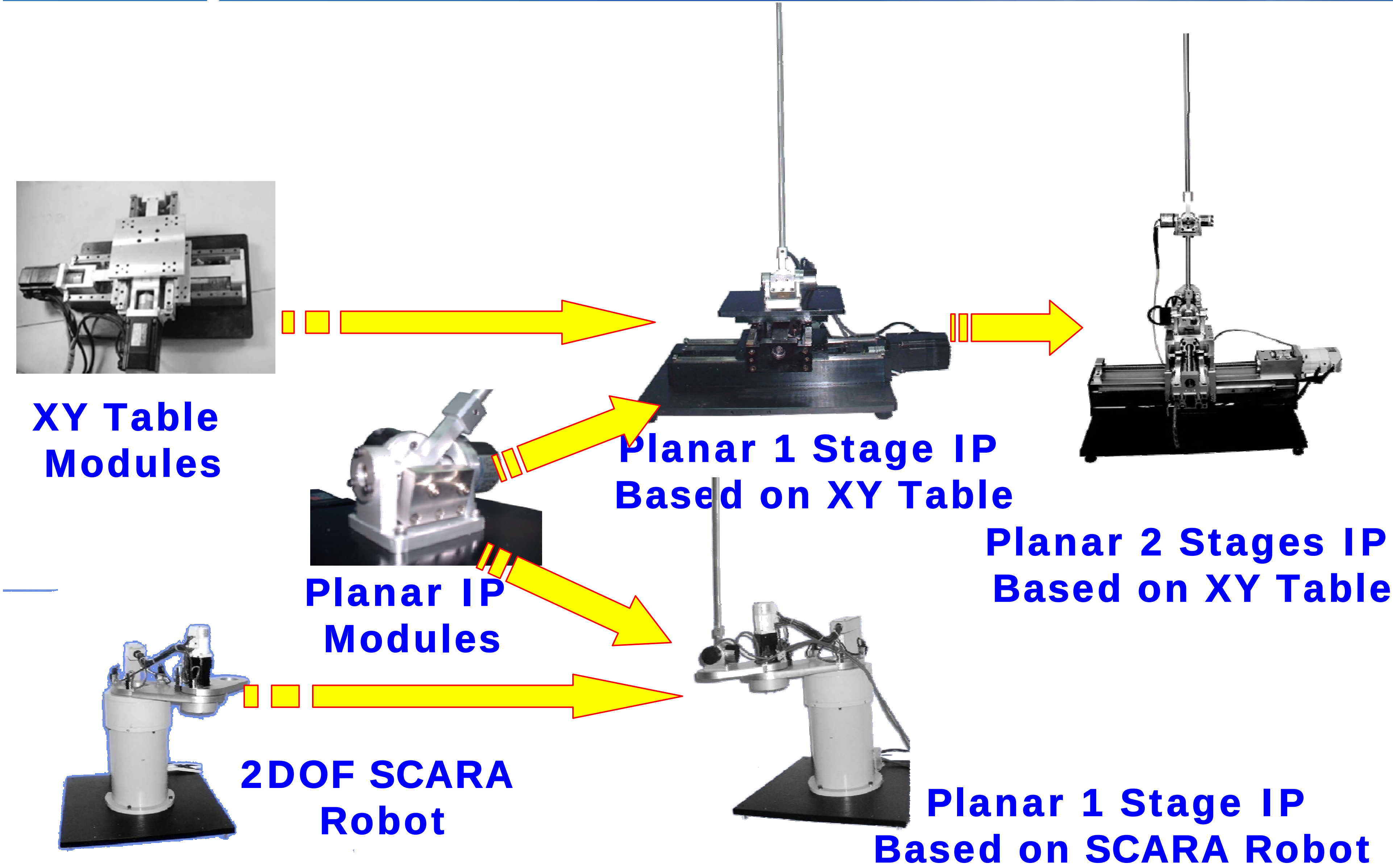
Multi-Platform Support for Teaching and Research



Family of Inverted Pendulum - Circular



Family of Inverted Pendulum - Planar



Multi-Platform Support for Teaching and Research

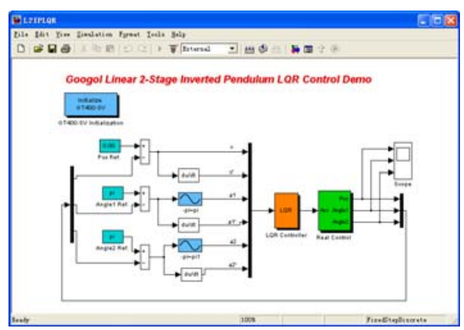
Multi-Platform Support

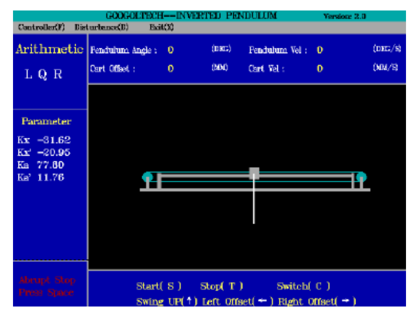
LabVIEW

- Drivers for G400
- Sample .vi on request

- Full Experiments Doc
- Simulink Models
- Experiments Files

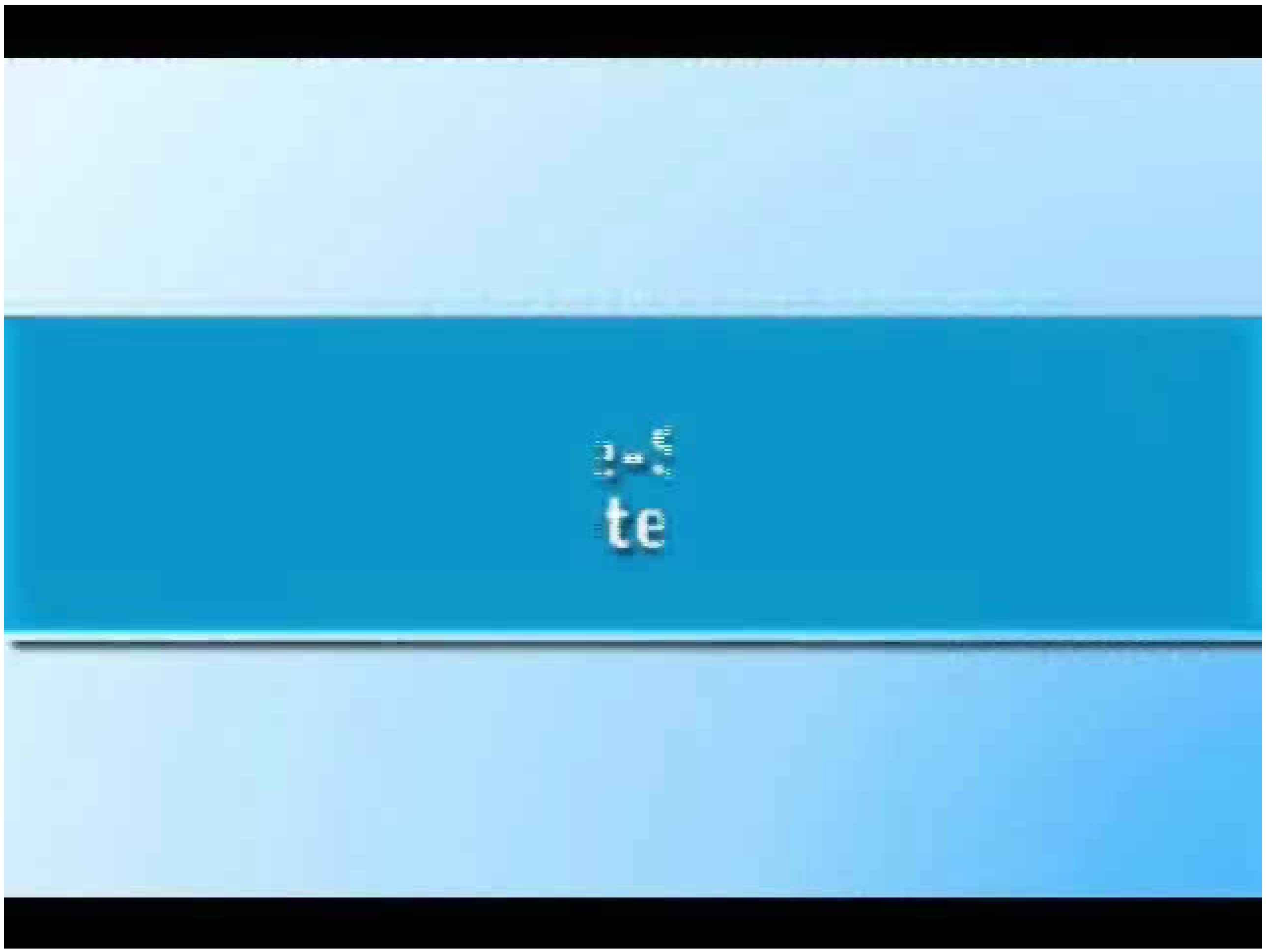
- Source Code Provided for DOS with Turbo C





Demo: Linear Inverted Pendulum using SIMULINK

3 and 4 Stages Linear and Flexible Inverted Pendulum



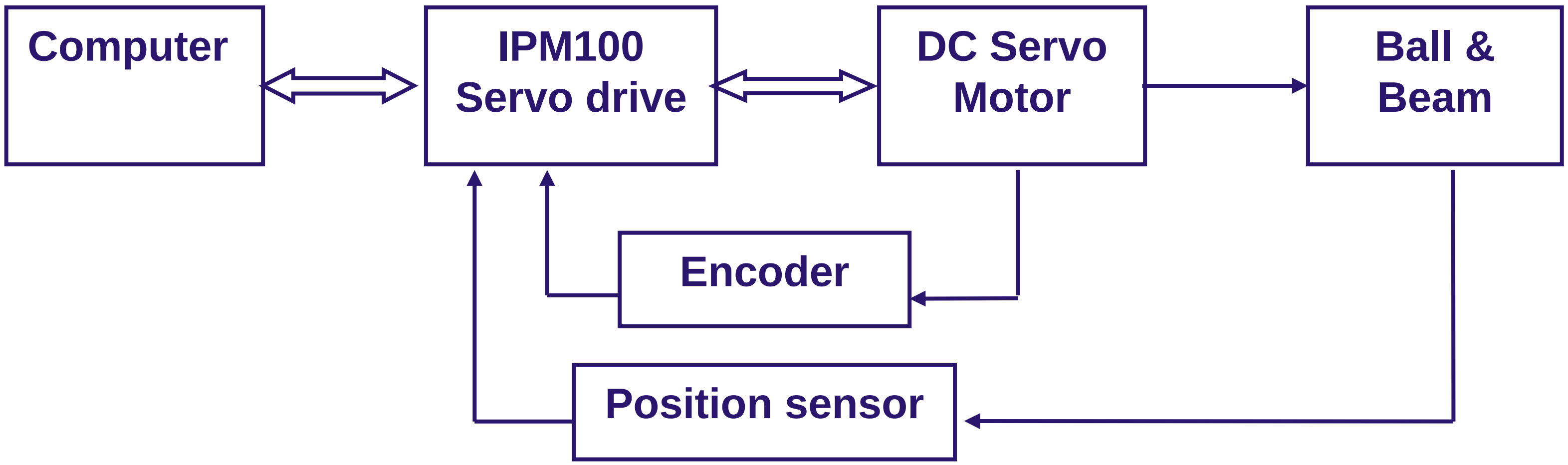
Example 2: Ball and Beam System

Ball & Beam System

- Digital Feedback Control System
- Suitable for University Level Students
- Experimental Device for Feedback Control Course

Ball & Beam Control system

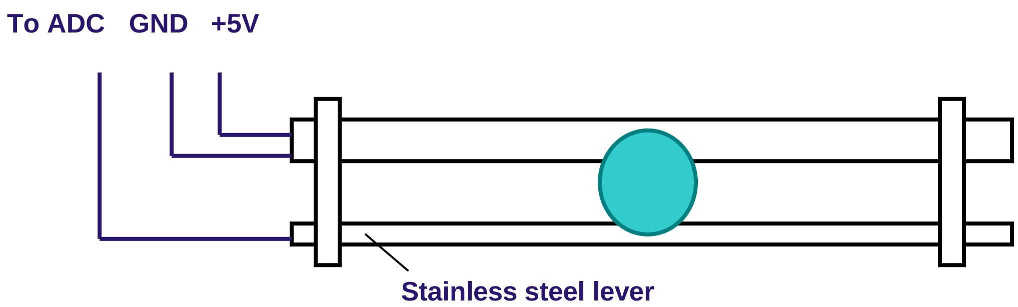
Ball & Beam Control System



- **Typical Feedback Control Problem**
- **Various Control Theories Apply**
  - PID
  - Root Locus
  - Frequency Response
  - User Defined Controller

System Components

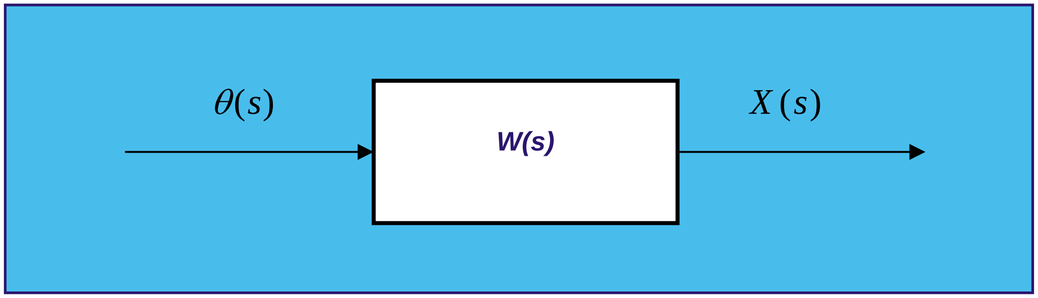
- **Actuator**
  - DC Motor
  - Timing Belt with Pulley
- **Feedback Sensor**
  - Motor Encoder
  - High Precision Linear Potentiometer

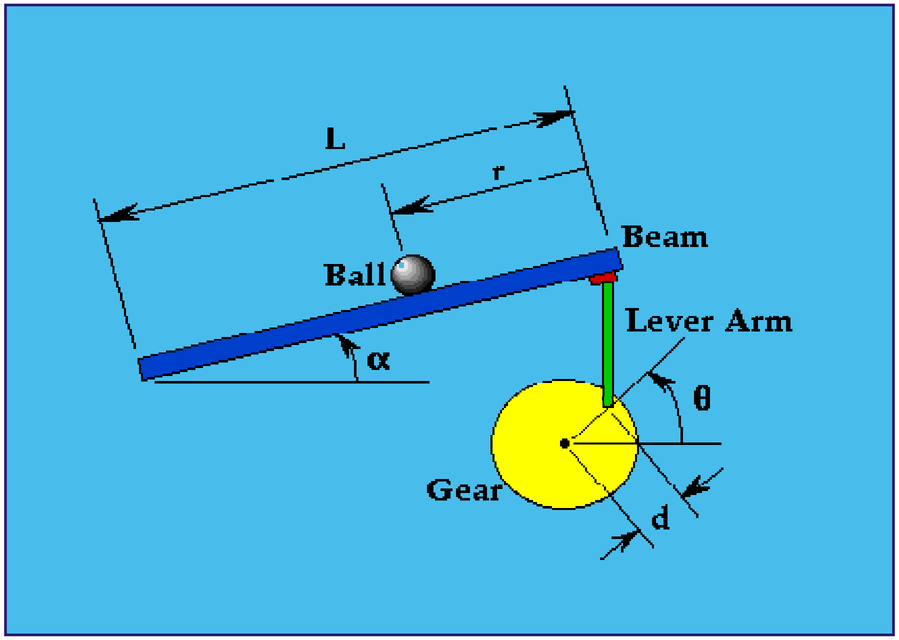


- **Length: 400 mm**
- **Precision: 0.01mm**

Open Loop Model

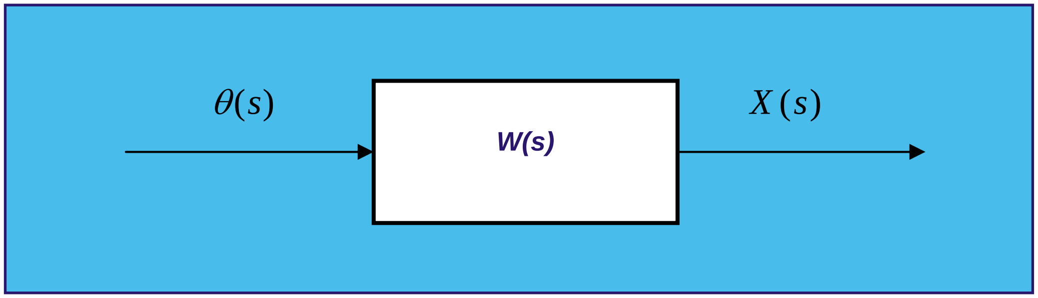
- Ball&Beam represents a Single Input Single Output (SISO) system.





Open Loop Model

- **Ball&Beam represents a Single Input Single Output (SISO) system.**

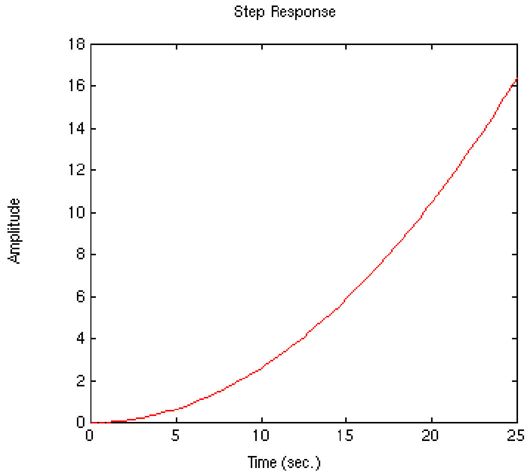


- **Where the transfer function is**

$$W(s) = \frac{X(s)}{\theta(s)} = \frac{mgd}{L(\frac{J}{R^2} + m)} \frac{1}{s^2} = c\frac{1}{s^2}$$

g = 9.8
m = mass of ball
d = radius of pulley
L = length of beam
J = moment of inertial
r = position of ball
R = radius of ball

- The step responds for this model is

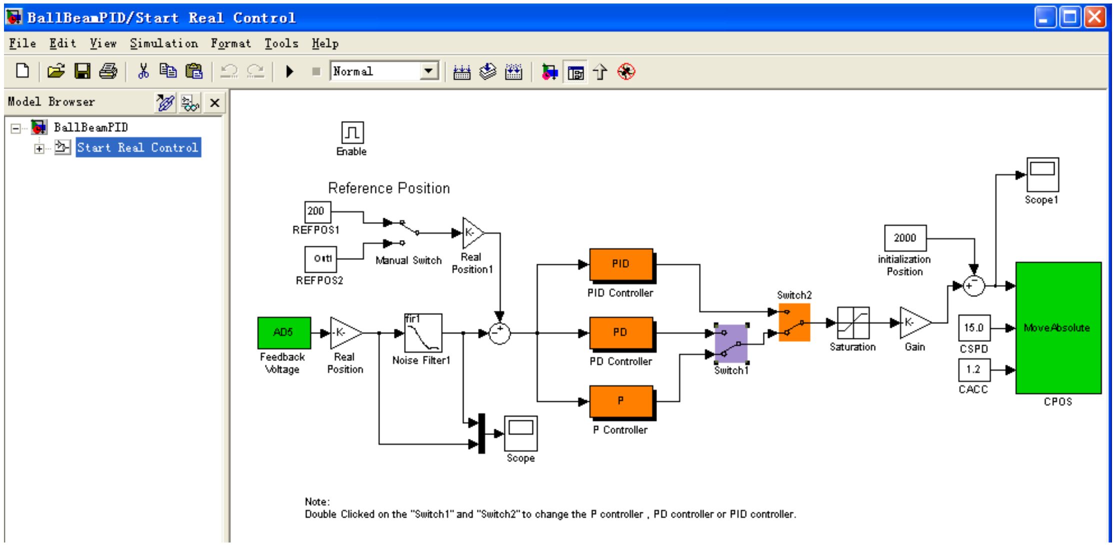


- Unstable System
- Close loop controller should be designed
  - PID
  - Root Locus
  - Frequency Responds
  - User Defined Controller

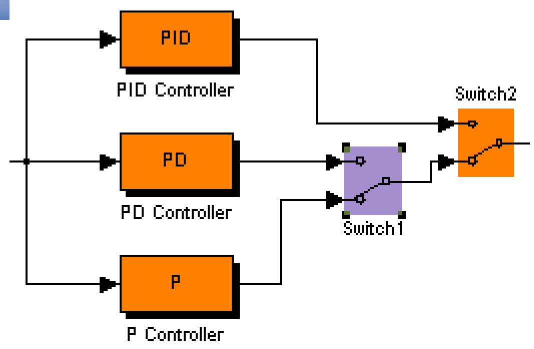
❖ The transfer function for a general PID controller is

$$K_P + \frac{K_I}{s} + K_D s = \frac{K_D s^2 + K_P s + K_I}{s}$$

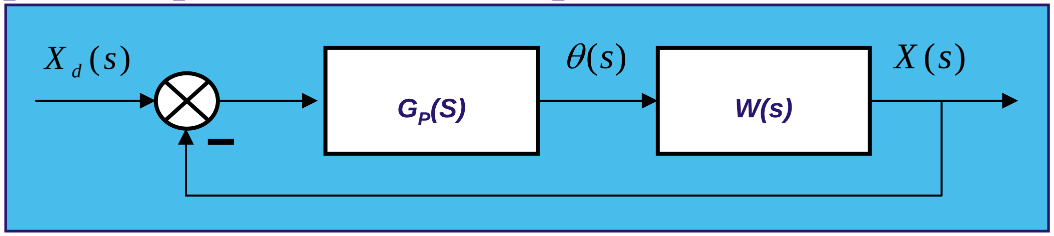
- P Controller
- PD Controller
- PID Controller



Ball&Beam P Controller



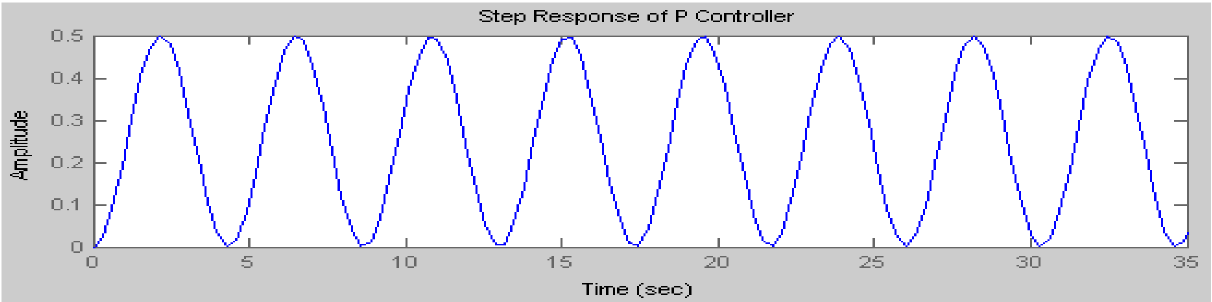
- P (Proportional) Controller



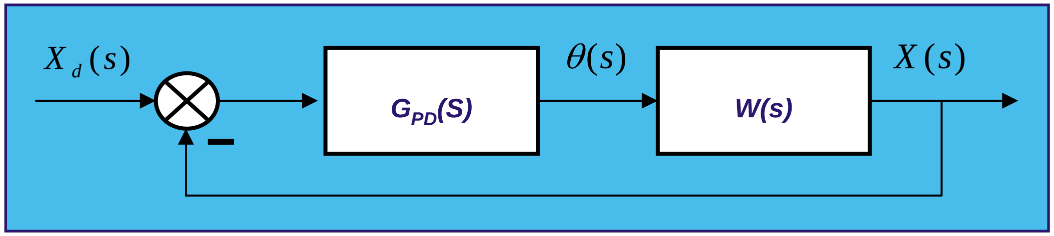
- The transfer becomes

$$\frac{X(s)}{X_d(s)} = \frac{G_P(s)W(s)}{1+G_P(s)W(s)} = \frac{cK_P}{s^2+cK_P}$$

- Kp = 3, Step responds of the system



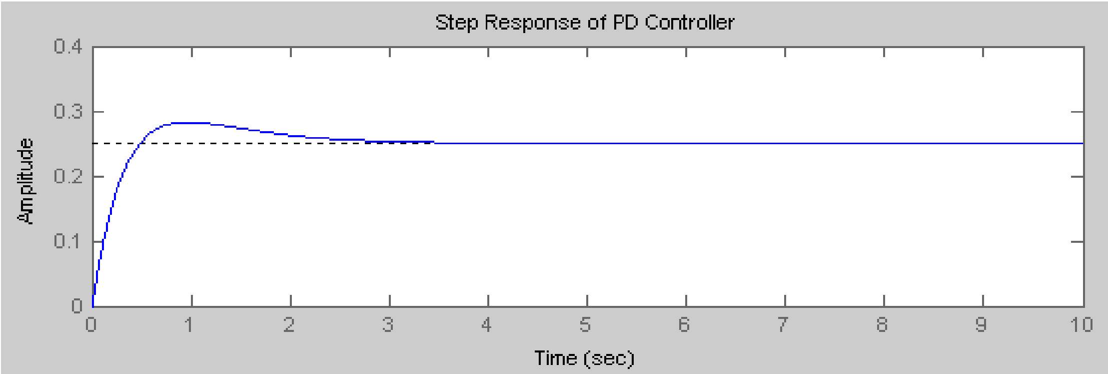
- PD Controller



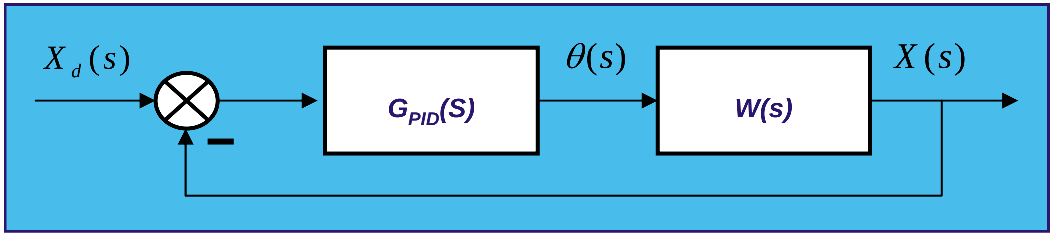
- The transfer becomes

$$\frac{X(s)}{X_d(s)} = \frac{G_{PD}(s)W(s)}{1+G_{PD}(s)W(s)} = \frac{c(K_P + K_D s)}{s^2 + cK_D s + cK_P}$$

- $K_p = 6$, $K_d = 6$, Step responds is



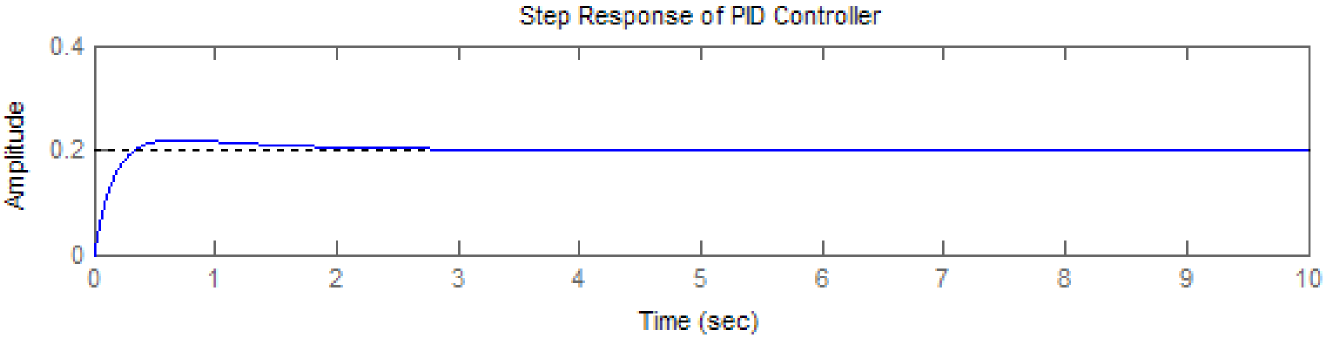
PID Controller



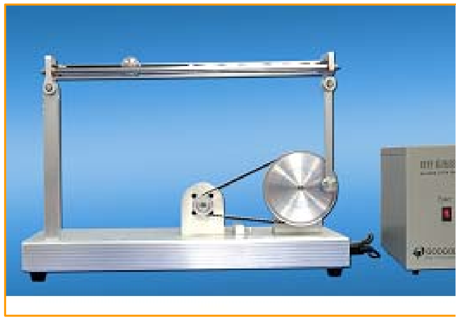
The transfer becomes

$$\frac{X(s)}{X_d(s)} = \frac{G_{PID}(s)W(s)}{1+G_{PID}(s)W(s)} = \frac{c(K_D s^2 + K_P s + K_I)}{s^3 + c(K_D s^2 + K_P s + K_I)}$$

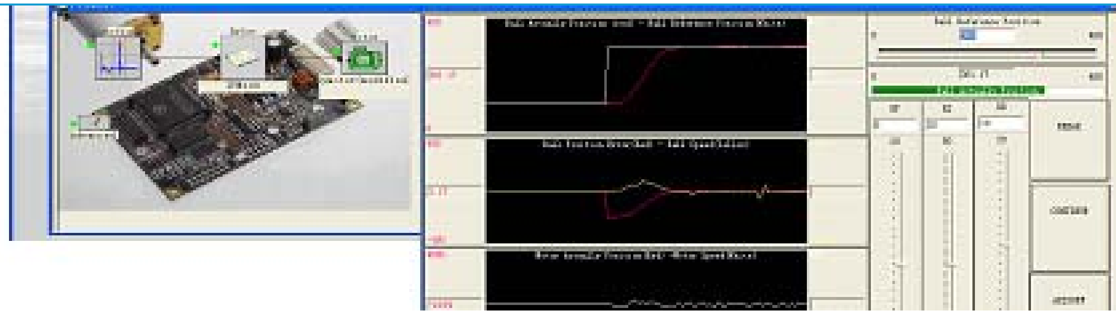
K_p = 10, K_d = 10, K_I = 1 Step responds is



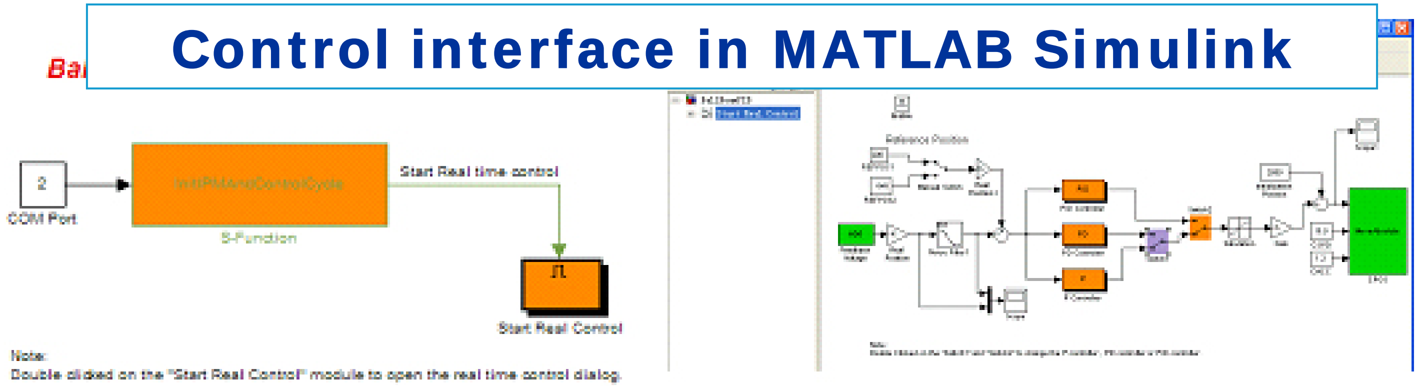
Multi-Platform Support for Teaching and Research



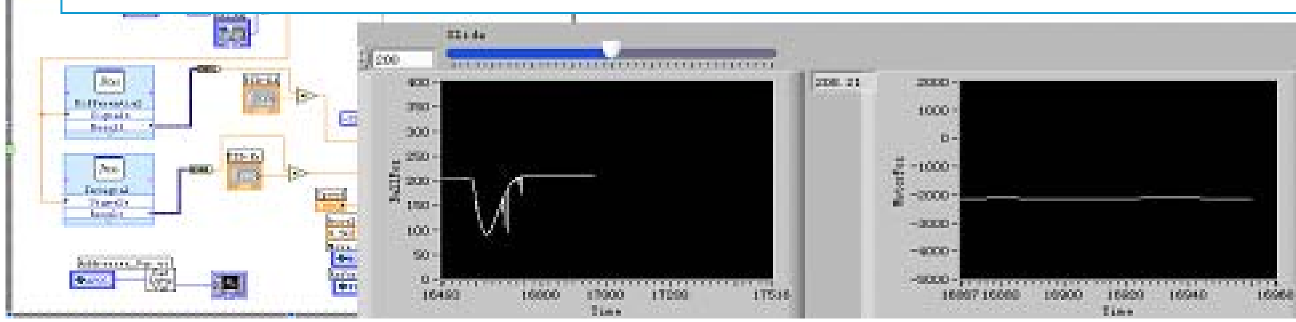
Control interface in IPM Motion Studio



Control interface in MATLAB Simulink

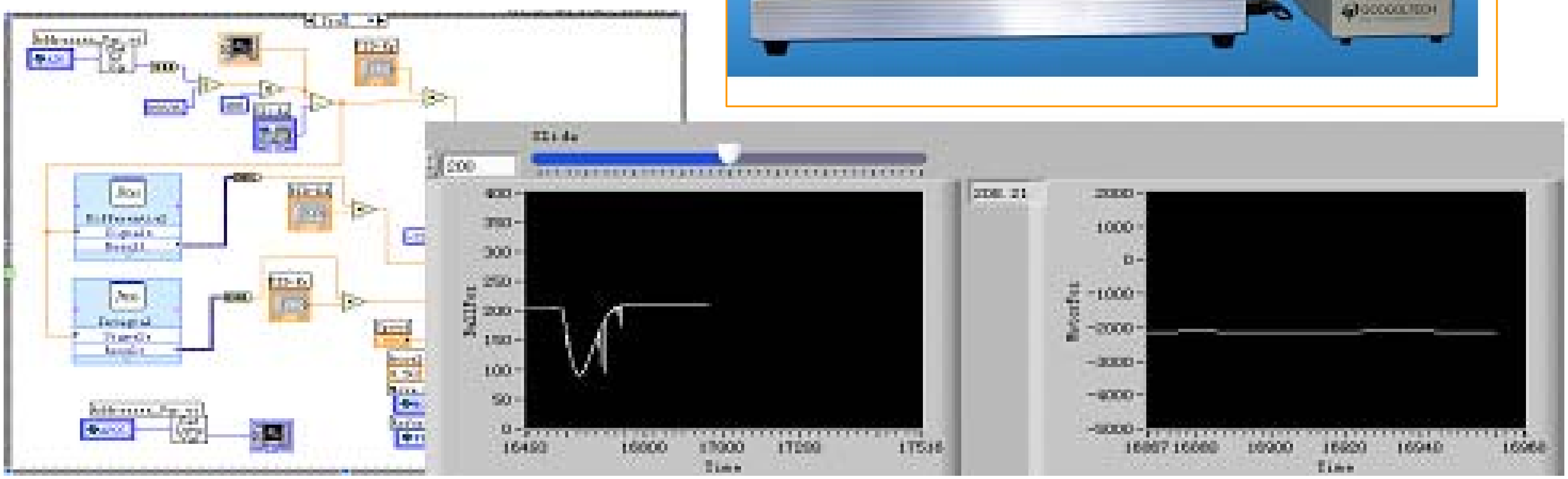


Control interface in LabVIEW

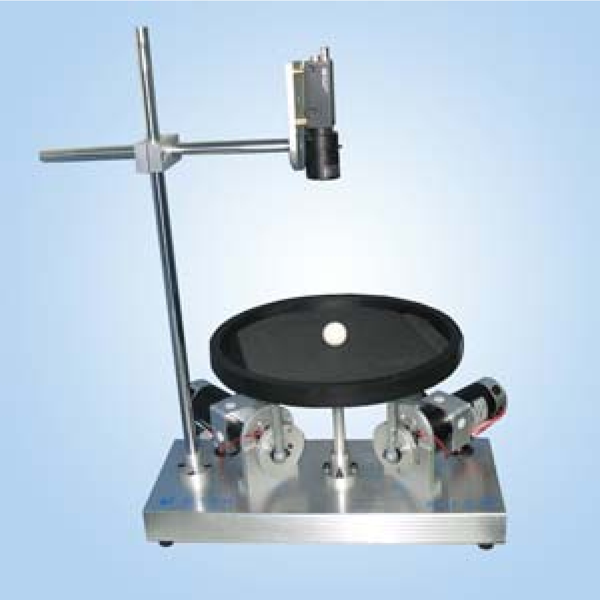


Multi-Platform Support for Teaching and Research

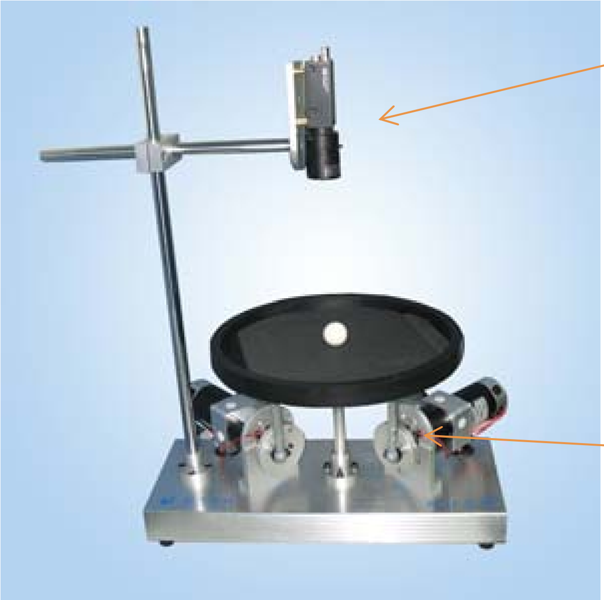
Demo: Ball & Beam using Labview



Example 3: Ball and Plate System



Cross Application for Advance Research

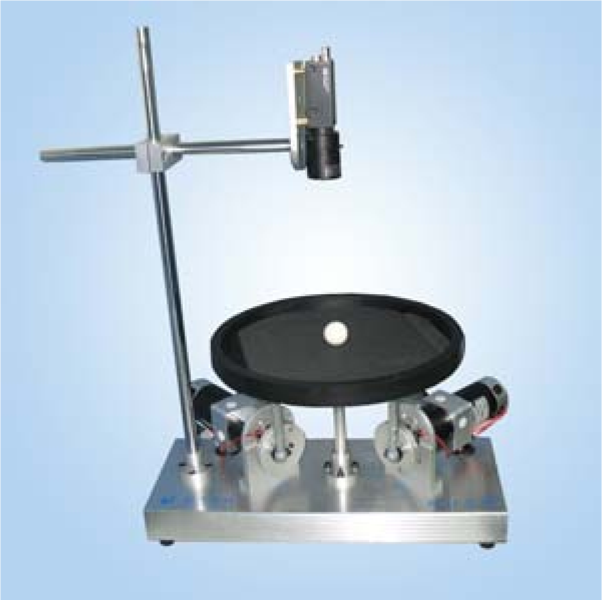


Vision Feedback (Video and Image processing)

Control Loop (Control Design)

- Position of the ball is detected by visual device.
- DC serve motors + 1000-line rotary encoders
- PC + open architecture motion control platform
- High performance image acquisition card
- High quality camera and lens
- Source code in C++ is provided.

Demo: Ball & Plate for Vision and Control Research



Acrobatic Robot

THANK YOU!