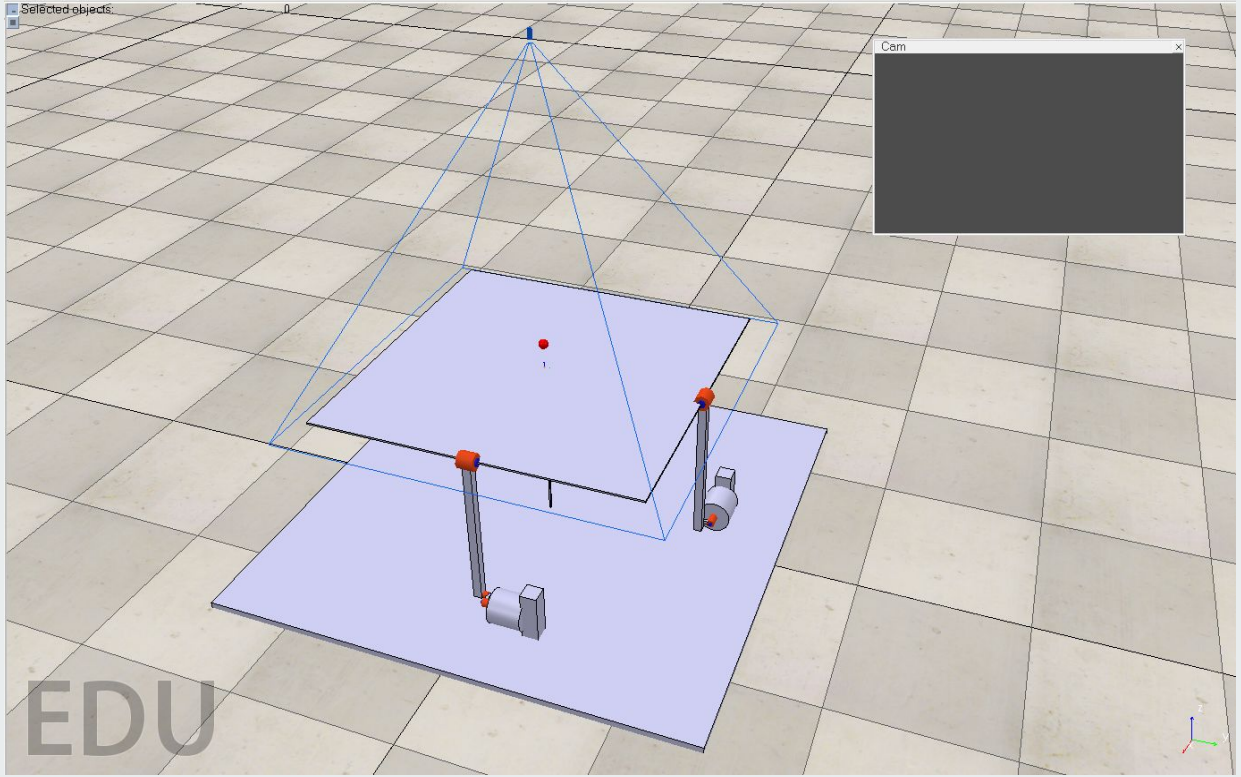
Ball and Plate



Group:

Aaron Dizon

Haitham Mohamed

Giovanni Paredes

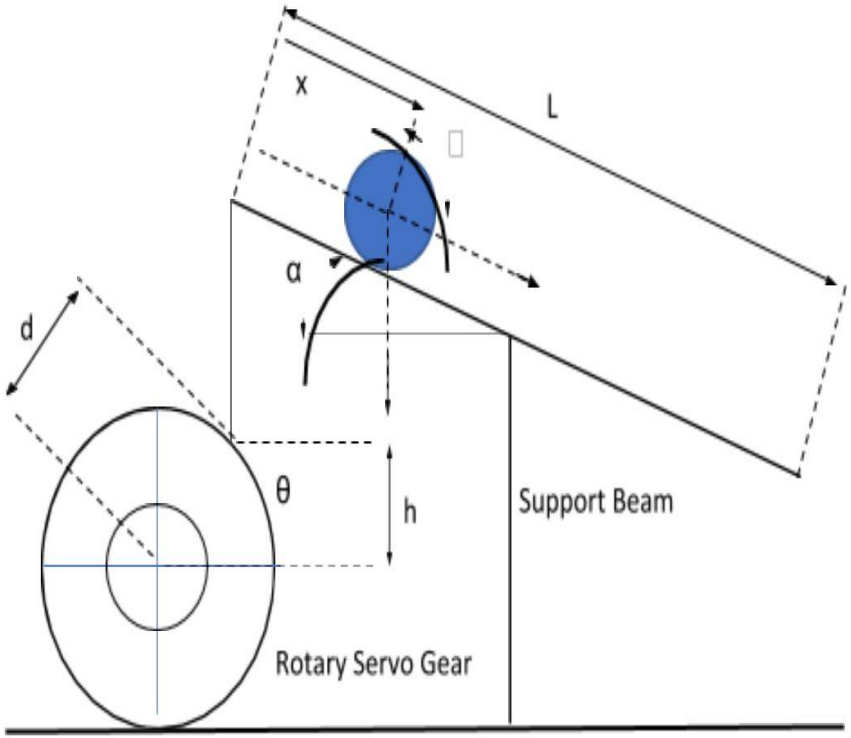
Allan Del Rosario

Linda Tsafack

Project Description

For this project we used a controller to help balance a ball on a plate system that must be designed using Matlab, Simulink and Coppelia. The overall goal of this system is keep a ball balanced at the center of the plate and must be able to react accordingly to the ball's position to avoid the ball rolling off the plate.

Modeling



Equations:

$$m\ddot{x} = mg\sin\alpha(t) - \frac{J\ddot{x}(t)}{R^2} \qquad \text{Eq 1}$$

$$\sin\alpha(t) = \frac{2h}{L} \qquad \sin\theta(t) = \frac{h}{d} \qquad \text{Eq 2 and 3}$$

$$\ddot{x}(t)\left(m + \frac{J}{R^2}\right) = \frac{2mgd\sin\theta(t)}{L} \qquad \text{Eq 4}$$

$$\ddot{x}(t)\left(m + \frac{J}{R^2}\right) = \left(\frac{2mgd}{L}\right)\theta(t) \qquad \text{Eq 5}$$

$$X(s)\left(m + \frac{J}{R^2}\right)s^2 = \left(\frac{2mgd}{L}\right)\theta(s) \qquad \text{Eq 6}$$

$$\frac{X(s)}{\theta(s)} = \frac{2mgd}{s^2L\left(m + \frac{J}{R^2}\right)} \qquad \text{Eq 7}$$

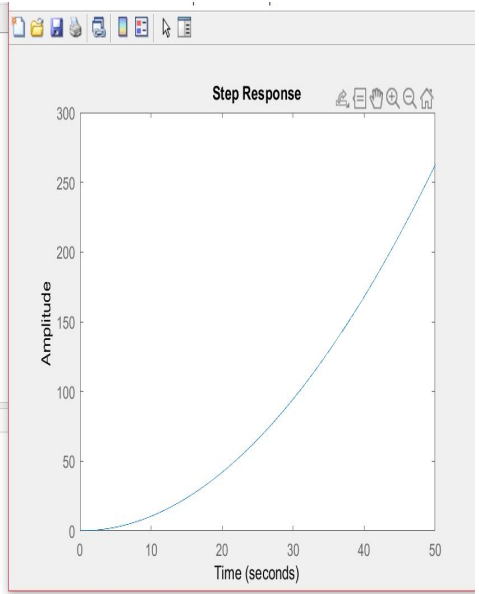
PID Controller

ball_and_plate_TF.m

```
clc
clear
m = 0.111;
R = 0.015;
g = -9.8;
L = 1.0;
d = 0.03;
J = 9.99e-6;

s = tf('s');
P_bb = (-m*g*d/L/(J/R^2+m)/s^2)
%pzmap(P_ball)
step(P_bb)
```

Command Window

```
P_bb =

  0.21
  ----
  s^2

Continuous-time transfer function.
```

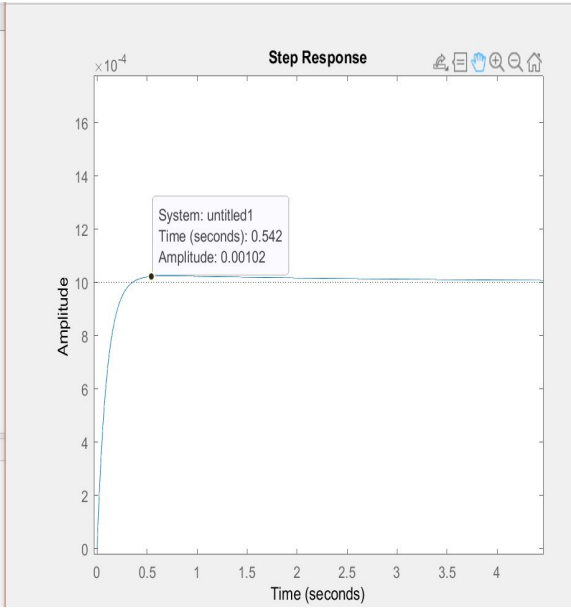


ball_and_plate_TF.m

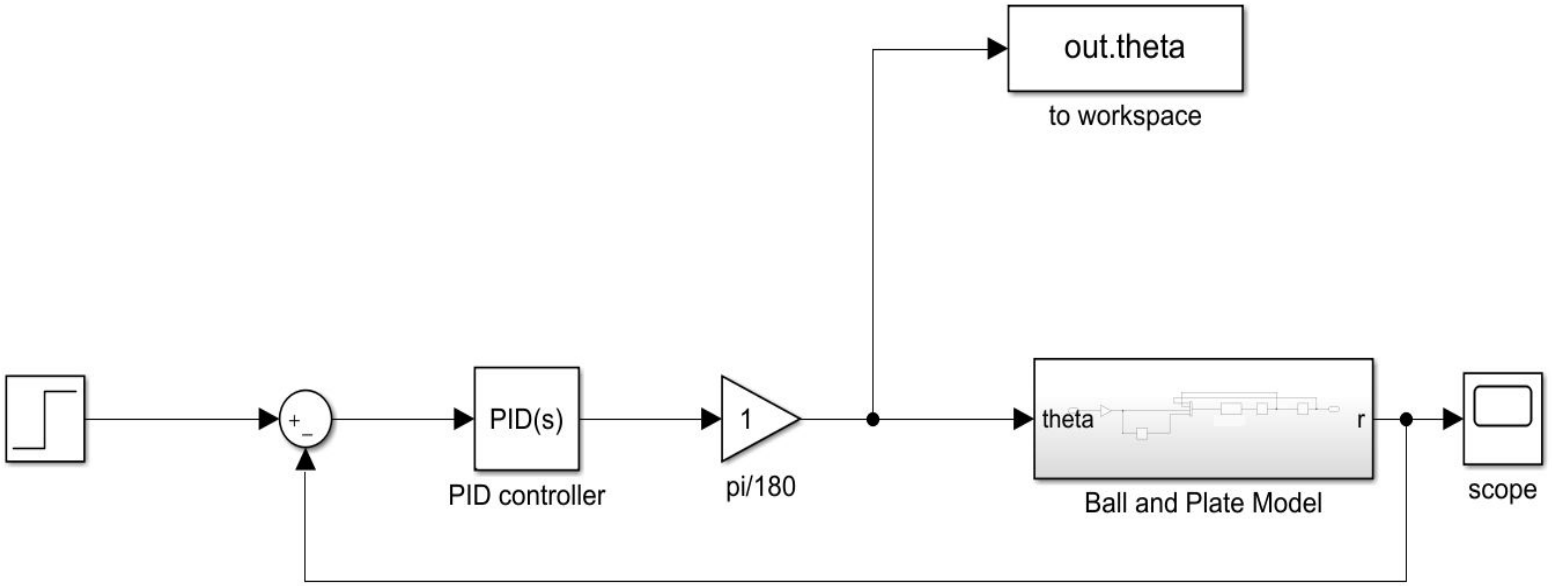
```
clc
clear
m = 0.111;
R = 0.015;
g = -9.8;
L = 1.0;
d = 0.03;
J = 9.99e-6;

s = tf('s');
P_bb = (-m*g*d/L/(J/R^2+m)/s^2)

Kp = 15;%gain%
Kd = 50;%derivative%
Ki=0;%integral
C = pid(Kp,Ki,Kd);
sys_cl=feedback(C*P_bb,1);
step(0.001*sys_cl)%
```

Command Window

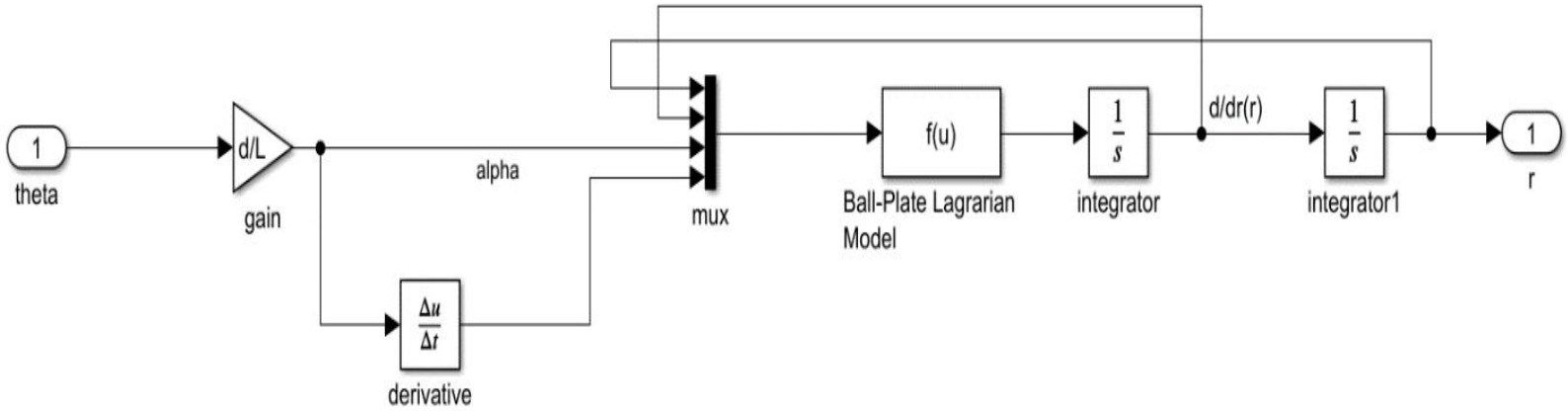
```
P_bb =

  0.21
  ----
  s^2

fx Continuous-time transfer function.
```



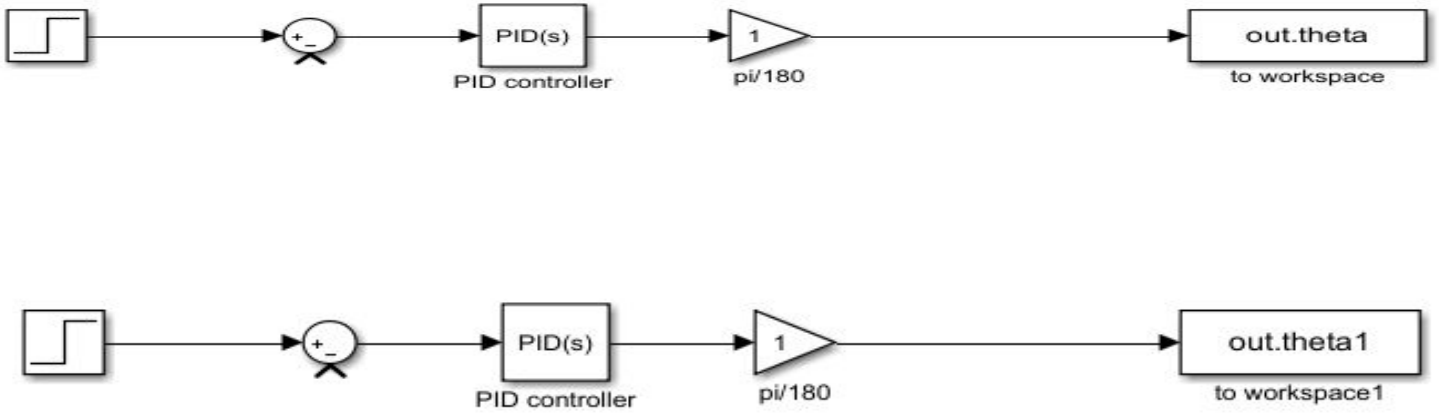
Simulink Model of the System



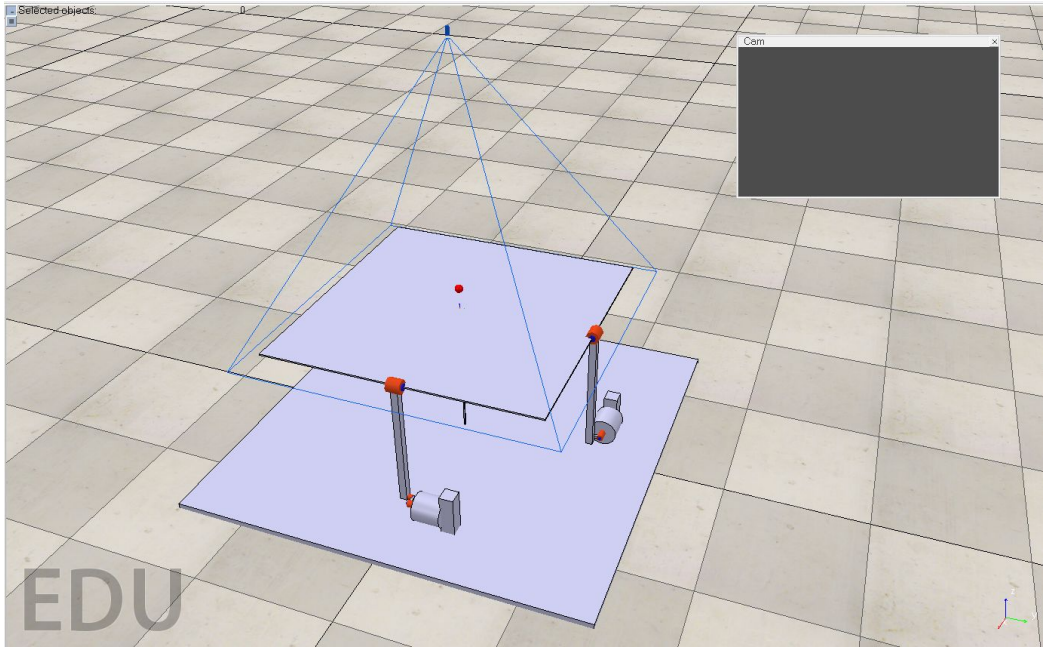
Ball and Beam Simulink Model



Simulink Model Used With Coppelia



COPPELIA simulation



CoppeliaSim model provided by Sinan Bank.