```
clc
clear all
close all

%Inverted Pendulum: PID Controller Design
%System structure
M = 0.5;
m = 0.2;
b = 0.1;
I = 0.006;
g = 9.8;
l = 0.3;
q = (M + m)*(I + m*l^2) - (m*l)^2;
s = tf('s');
P_pend = (m*l*s/q) / (s^3 + (b*(I + m*l^2))*s^2/q - ((M + m)*m*g*l)*s/q - b*m*g*l/q)

Kp = 1;
Ki = 1;
Kd = 1;
C = pid(Kp, Ki, Kd)
T = feedback(P_pend, C)
t = 0:0.01:10;
figure(1)
impulse(T, t)
title({'Response of Pendulum Position to an Impulse Disturbance'; 'under PID Control: Kp = 1,
Ki = 1, Kd = 1'});

Kp = 100;
Ki = 1;
Kd = 1;
C = pid(Kp, Ki, Kd)
T = feedback(P_pend, C)
t = 0:0.01:10;
figure(2)
impulse(T, t)
axis([0, 2.5, -0.2, 0.2]);
title({'Response of Pendulum Position to an Impulse Disturbance'; 'under PID Control: Kp = 100,
Ki = 1, Kd = 1'});

Kp = 100;
Ki = 1;
Kd = 20;
C = pid(Kp, Ki, Kd)
T = feedback(P_pend, C)
t = 0:0.01:10;
figure(3)
impulse(T, t)
axis([0, 2.5, -0.2, 0.2]);
title({'Response of Pendulum Position to an Impulse Disturbance'; 'under PID Control: Kp = 100,
Ki = 1, Kd = 20'});

P_cart = (((I + m*l^2) / q) * s^2 - (m*g*l / q)) / (s^4 + (b * (I + m*l^2)) * s^3 / q - ((M +
m) * m * g * l) * s^2 / q - b * m * g * l * s / q)
T2 = feedback(1, P_pend * C) * P_cart
t = 0:0.01:5;
figure(4)
impulse(T2, t);
title({'Response of Cart Position to an Impulse Disturbance'; 'under PID Control: Kp = 100, Ki
= 1, Kd = 20'});
```