Ball and Beam Experiment Report

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Experiment Result

1. Calibration

(1)position

Position	-30	-10	0	10	30
Voltage	5.6	4.7	4.26	3.78	2.8
$\text{Position} = a \times Volt + b$ a=-21.445 b=90.668					

(2)Angle

$V_0 = 3.24 \quad V_{-10} = 2.93$

$\text{Angle} = a \times Volt + b$

$\rightarrow$ a= 32.258 b= -104.52

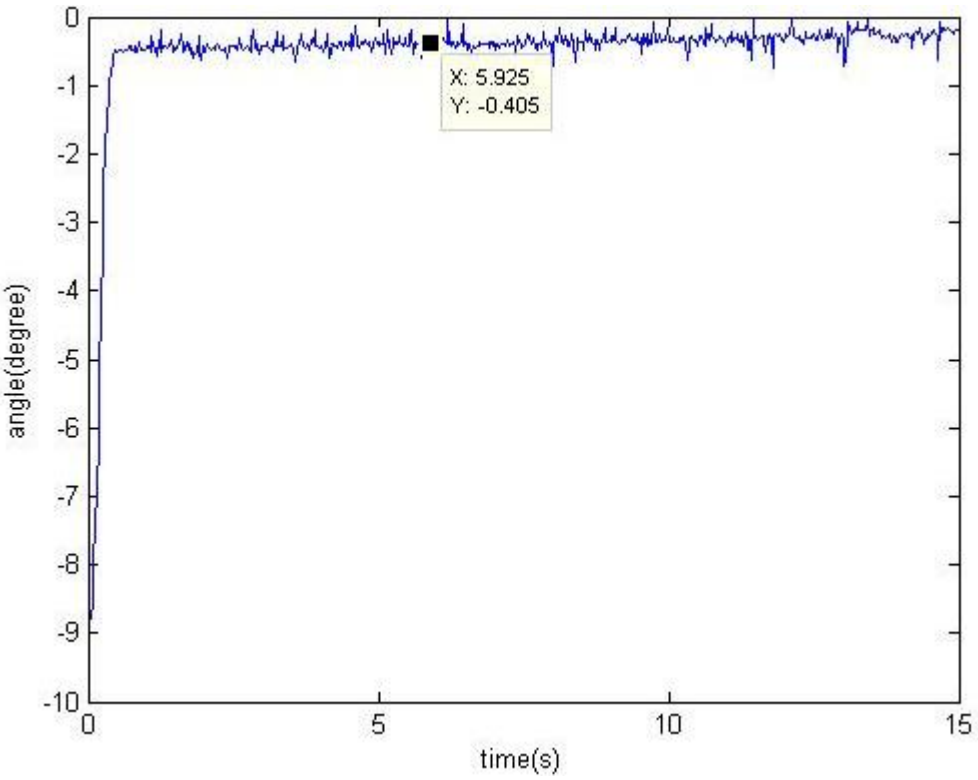
2. Beam Angle Control

(1) Desired angle is 0. Please Record the Steady-error and the data in different K_{p1}

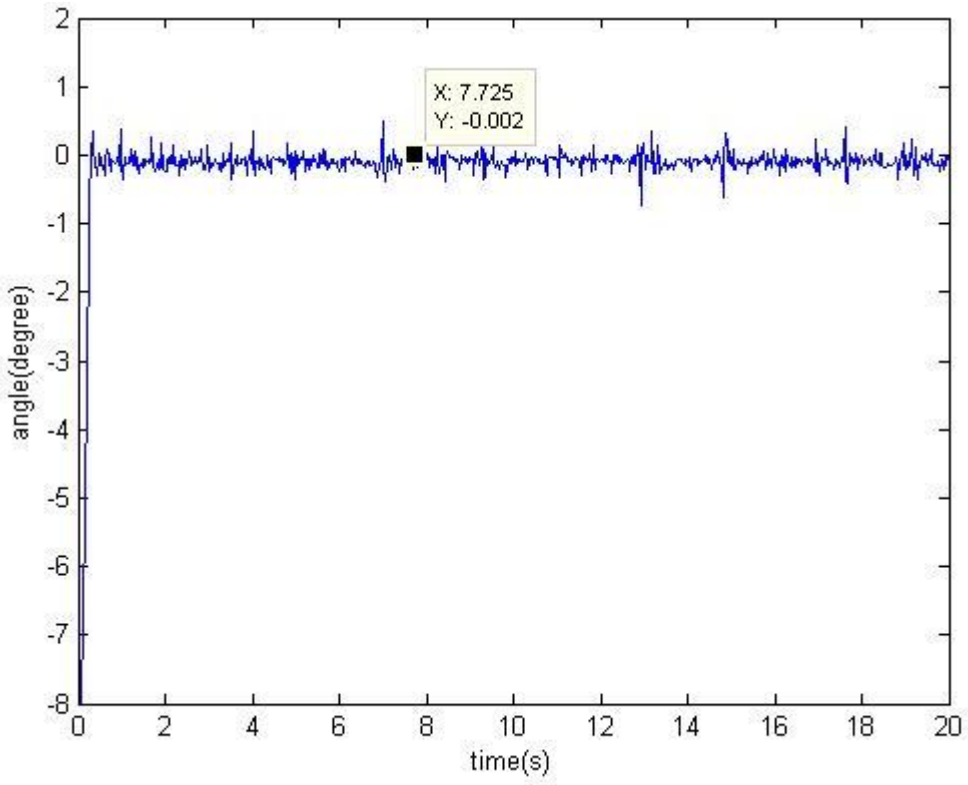
K_{p1}	1	3	5	7	15	20
Steady-error	0.405	0.002	0.136	0.763	0.975	1.107

(2)Data Plot

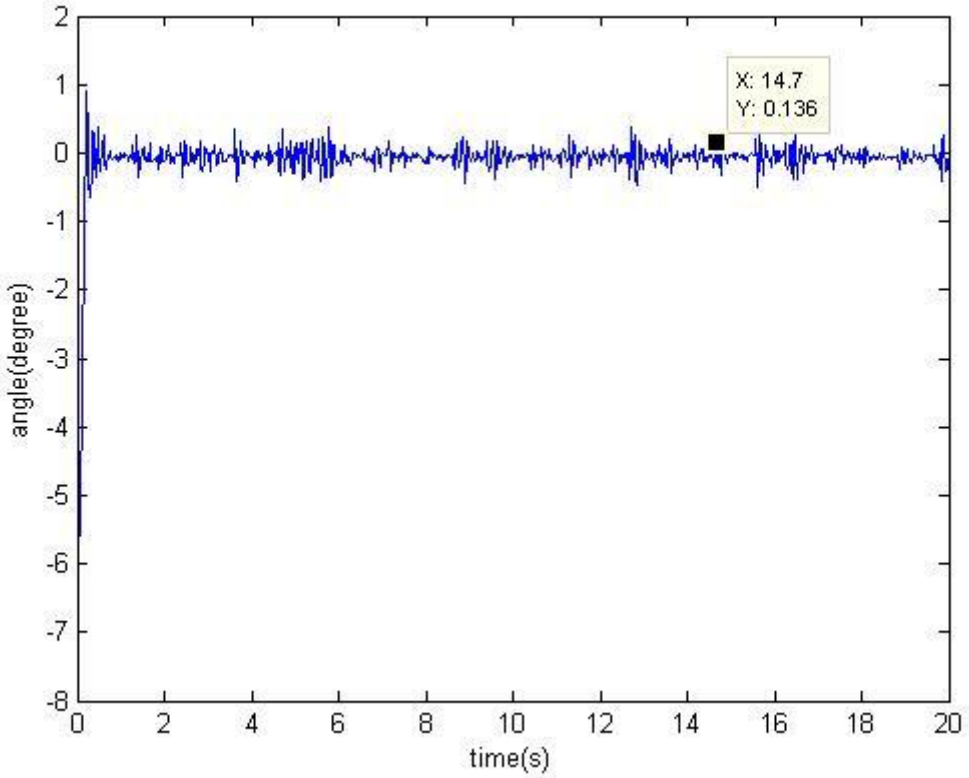
$$K_{p1} = 1$$



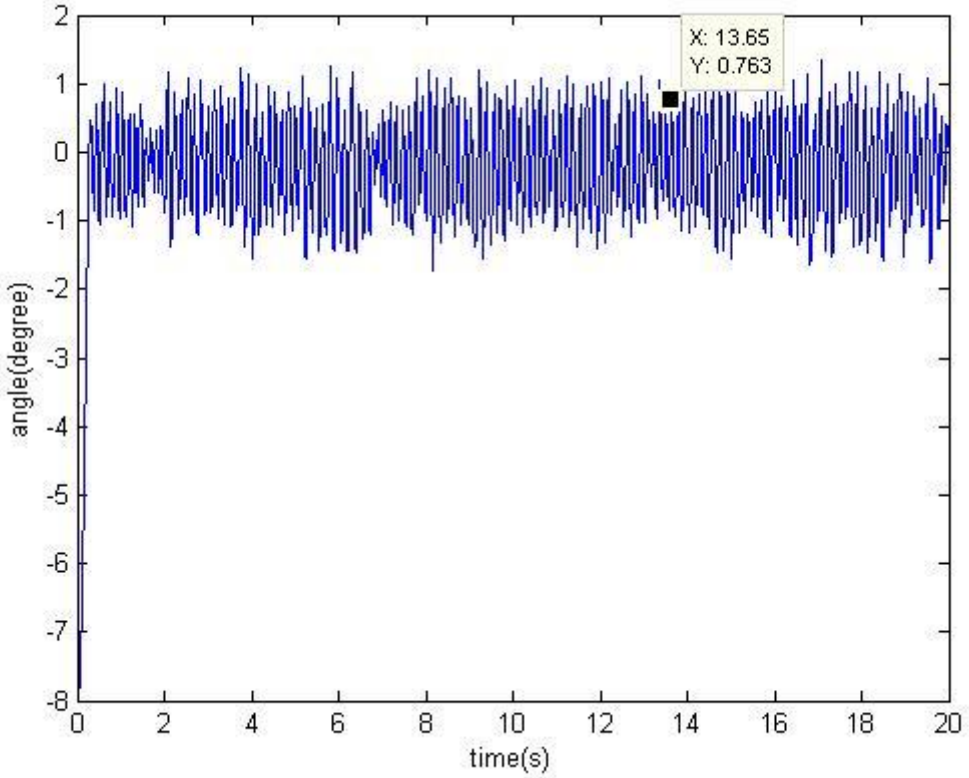
$$K_{p1} = 3$$



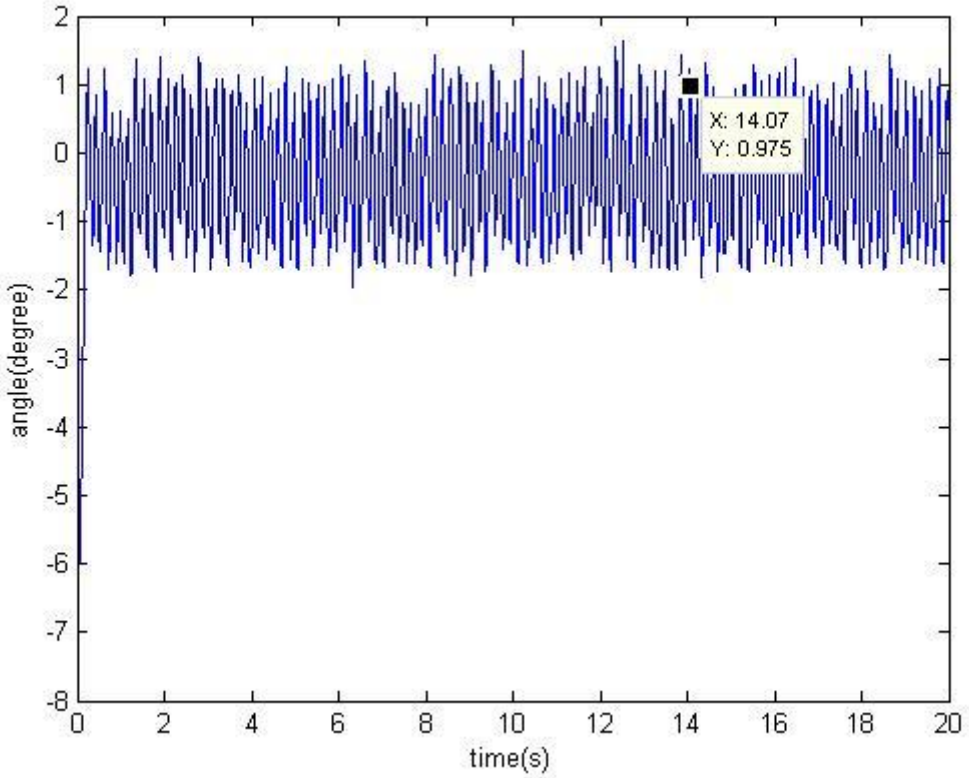
$$K_{p1} = 5$$


X: 14.7
Y: 0.136
angle(degree)
time(s)

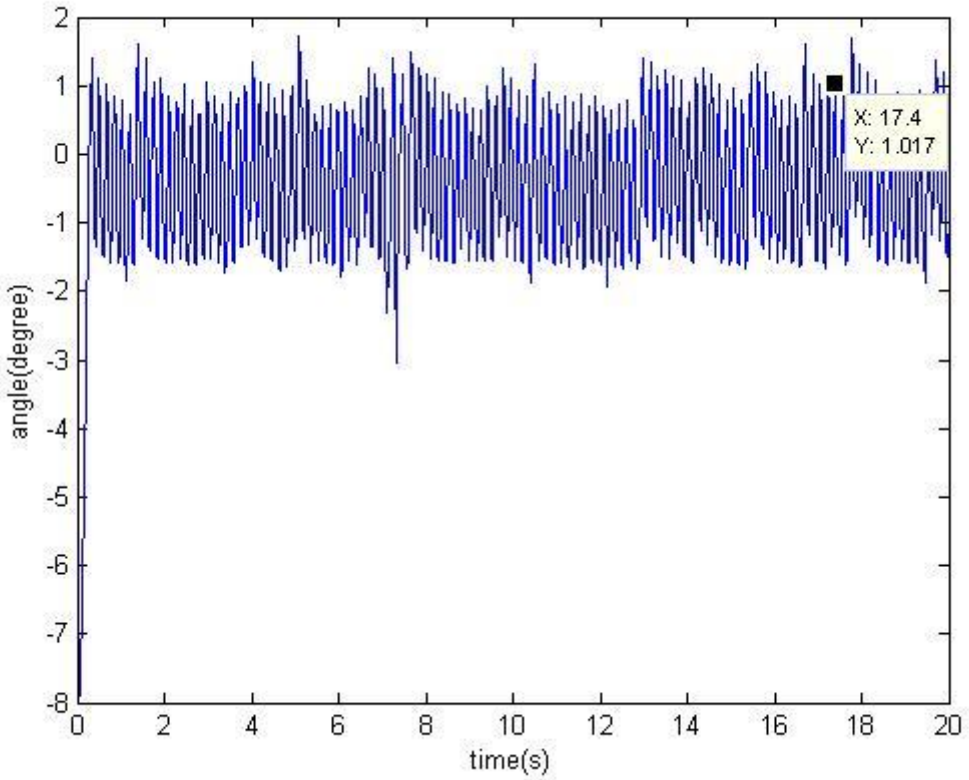
$$K_{p1} = 7$$


X: 13.65
Y: 0.763
angle(degree)
time(s)

$$K_{p1} = 15$$


X: 14.07
Y: 0.975
angle(degree)
time(s)

$$K_{p1} = 20$$


X: 17.4
Y: 1.017
angle(degree)
time(s)

3. BALL AND BEAM EXPERIMENT - PART I

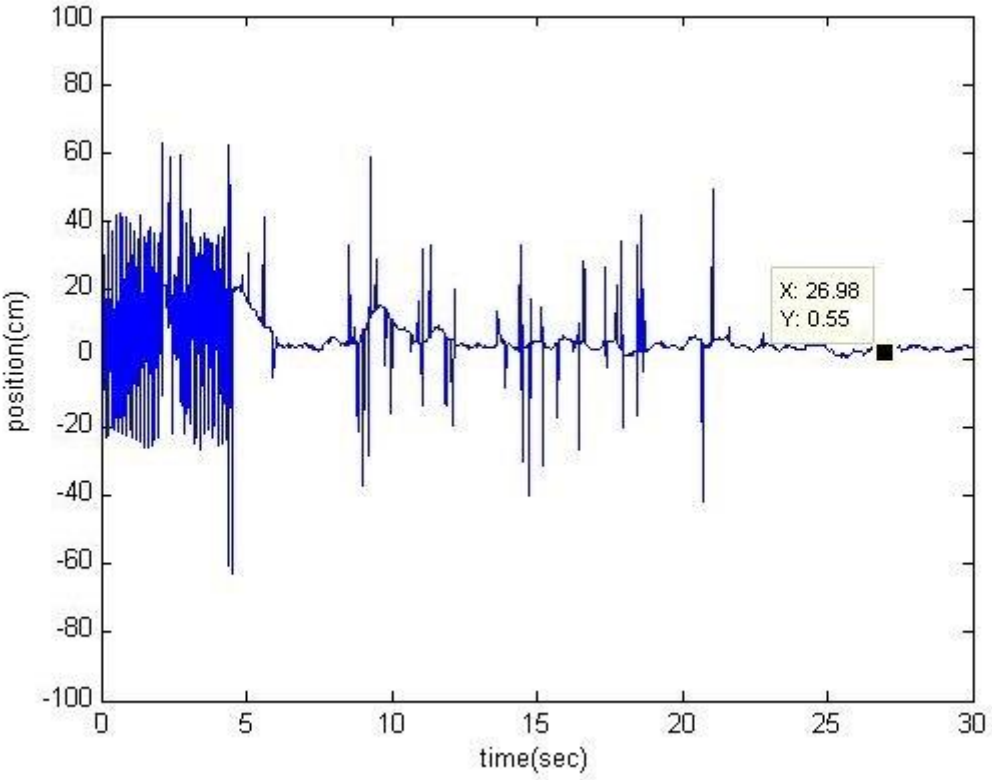
(1) Find the parameter K_p, K_d of the control ,with different damping ratio ξ and natural frequency ω_n

	K_p	K_d
$\xi = 1, \omega_n = 3$	0.92	0.612
$\xi = 0.707, \omega_n = 1$	0.1	0.144
$\xi = 0.707, \omega_n = 3$	0.92	0.433
$\xi = 0.5, \omega_n = 1$	0.1	0.1
$\xi = 0.5, \omega_n = 3$	0.92	0.31

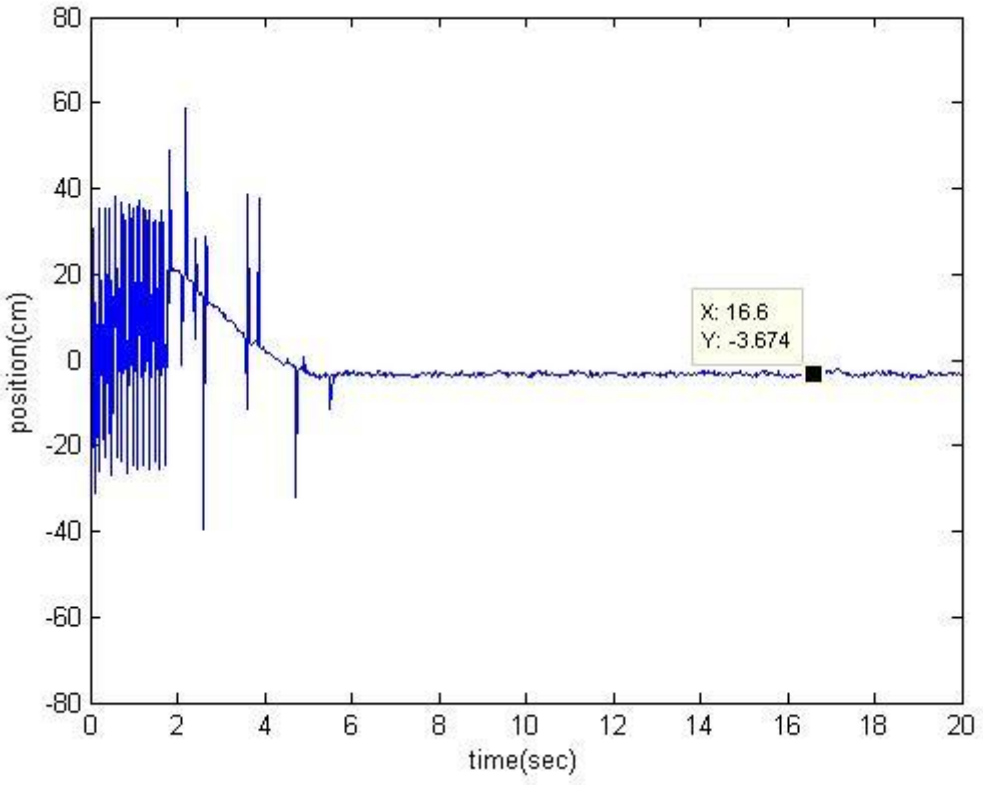
$$\begin{cases} gK_d = 2\xi\omega_n \\ gK_p = \omega_n{}^2 \end{cases}$$

(2) Desired position is 0 cm. Set up all the parameter and plot the performance data.

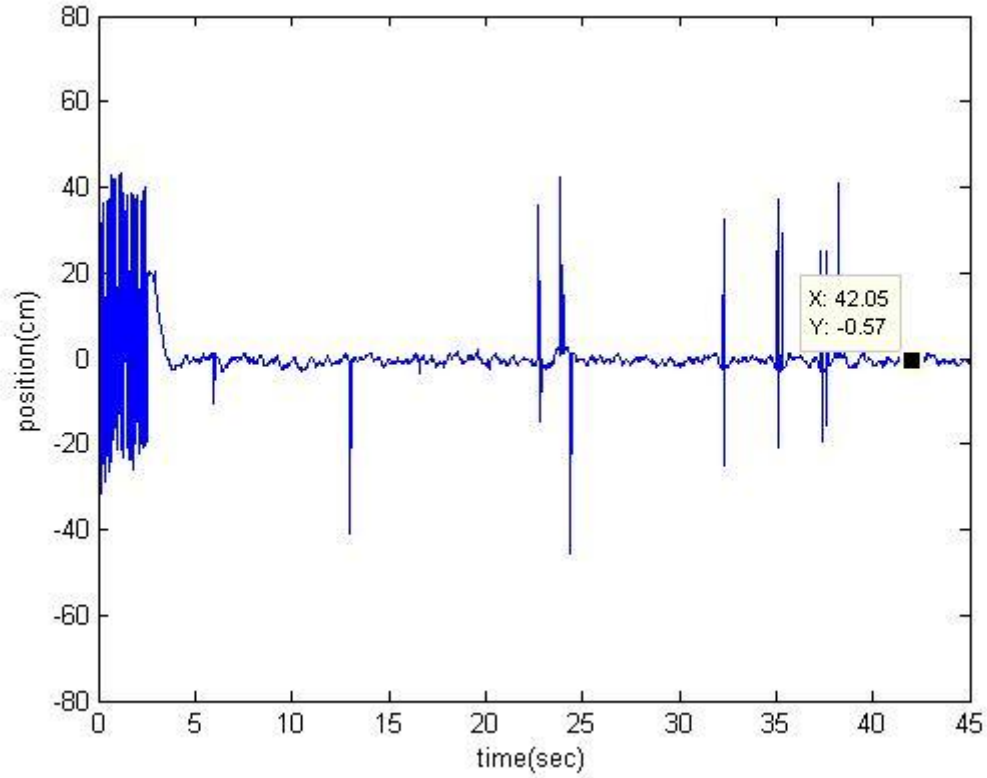
$$K_p = 0.92 \quad K_d = 0.612$$



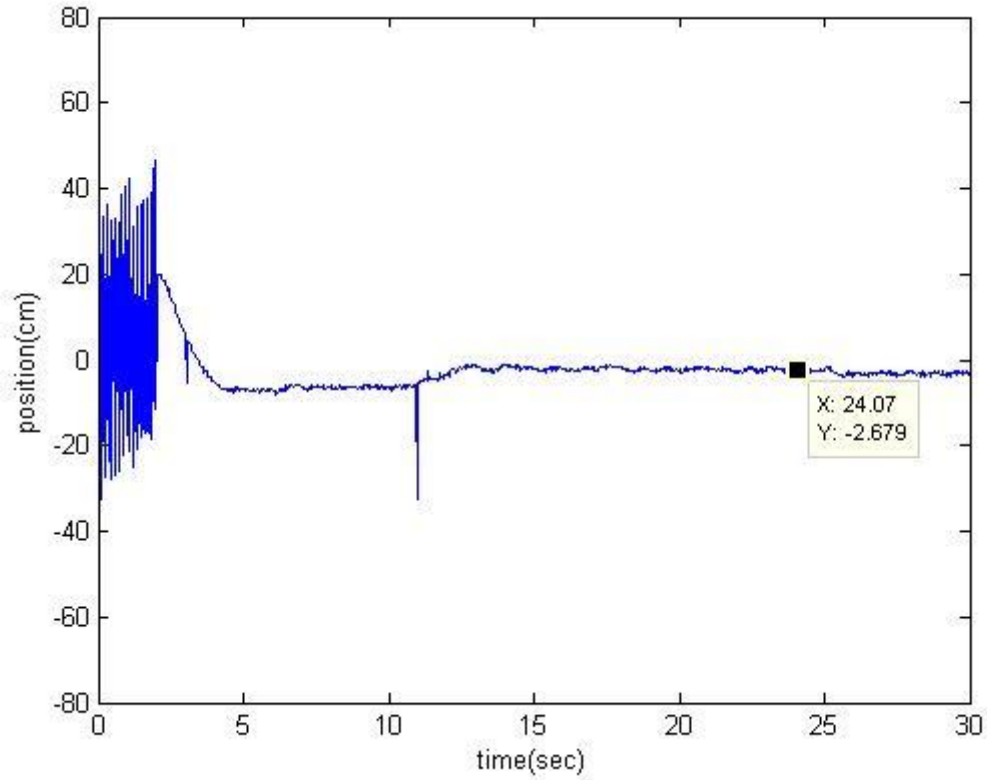
$$K_p = 0.1 \quad K_d = 0.144$$



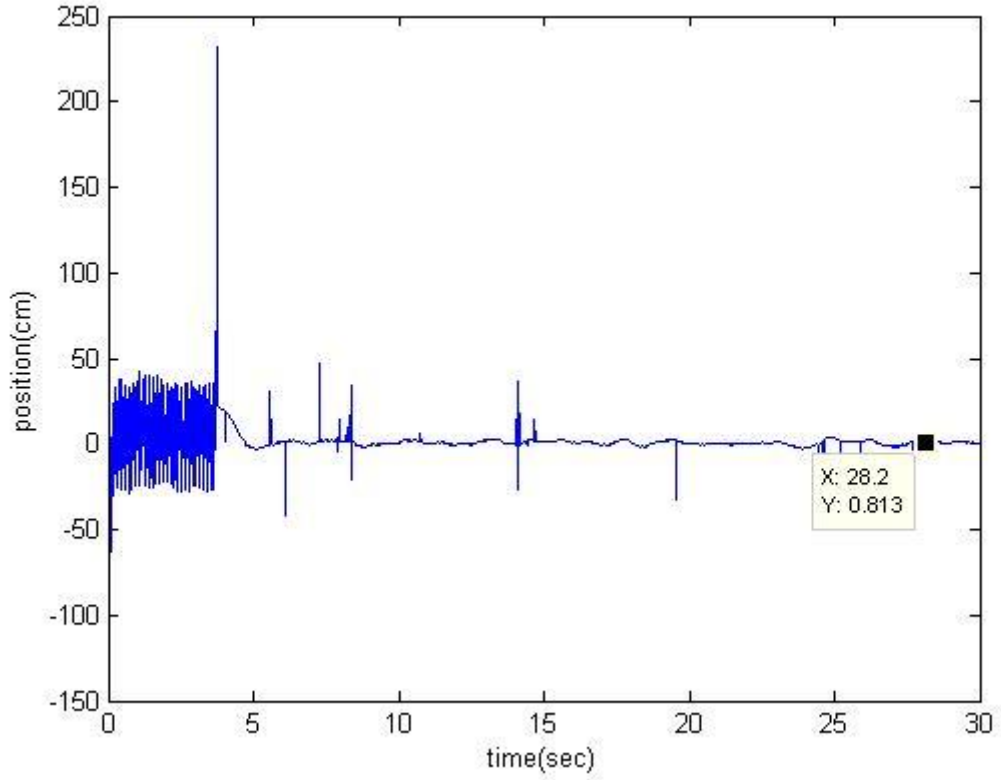
$$K_p = 0.92 \quad K_d = 0.433$$



$$K_p = 0.1 \quad K_d = 0.1$$



$$K_p = 0.92 \quad K_d = 0.31$$



4. BALL AND BEAM EXPERIMENT - PART II

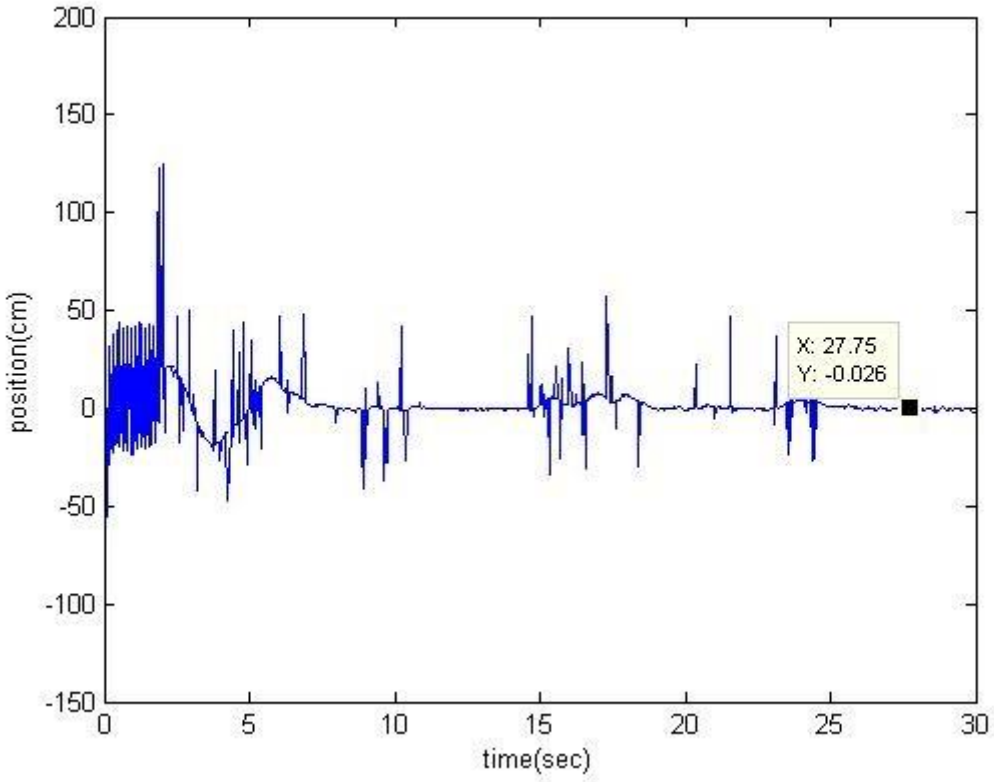
(1) Find the parameter K_p, K_d, K_i of the control ,with different damping ratio ξ and natural frequency ω_n, decay rate a

ξ	ω_n	a	K_p	K_i	K_d
1	3	10	0.574	16	0.44
0.707	3	10	0.6448	14.242	0.368
0.707	3	20	0.7577	24.242	0.395
0.5	3	20	0.7986	23	0.306

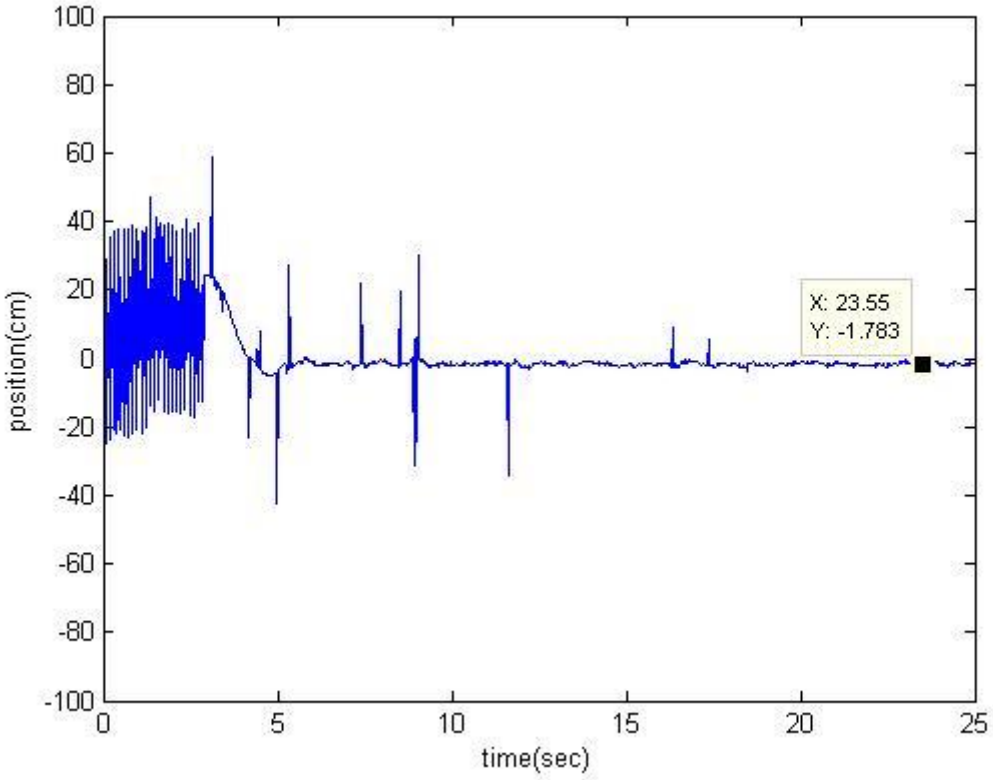
$$\begin{cases} K_i = 2\xi\omega_n + a \\ K_p = \dfrac{a\omega_n^2}{gK_i} \\ K_d = \dfrac{\omega_n^2 + 2a\xi\omega_n}{gK_i} \end{cases}$$

(2) Desired position is 0 cm. Set up all the parameter and plot the performance data.

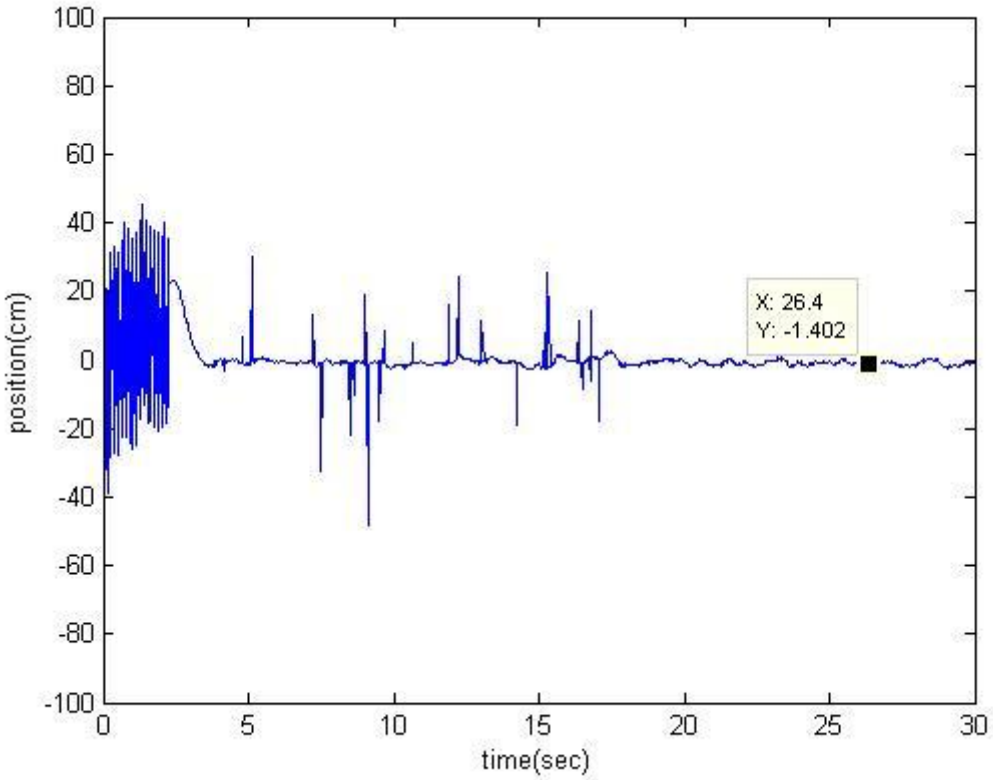
$$K_p = 0.574 \quad K_i = 16 \quad K_d = 0.44$$



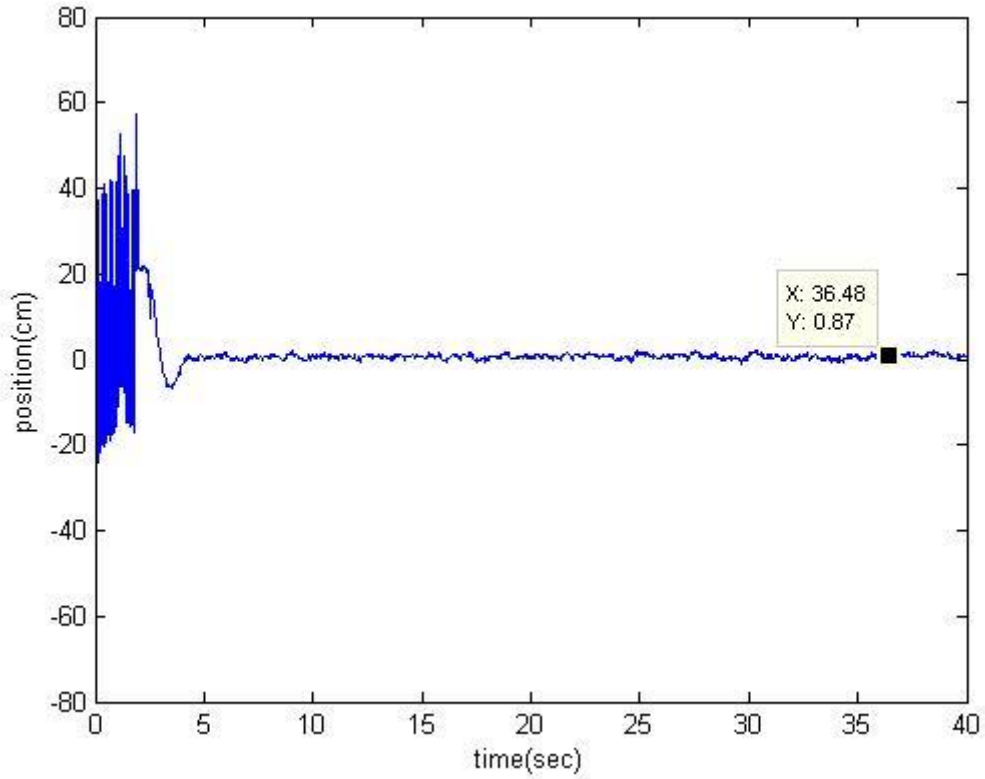
$$K_p = 0.6448 \quad K_i = 14.242 \quad K_d = 0.368$$



$$K_p = 0.7577 \quad K_i = 24.242 \quad K_d = 0.395$$



$$K_p = 0.7986 \quad K_i = 23 \quad K_d = 0.3061$$



Discussion

1. Why we use a Cam to drive the beam to change angle but not use motor to drive the beam to change the angle ?

   Ans： 因為使用凸輪可使平衡桿的轉動角度限制在一定的範圍內。

2. Explain when we were at beam angle experiment, why not we can make $e_{SS}=0$ only with K_{p1}?

   Ans： 因為本實驗伴隨著各種誤差，而使用K_{p1} 無法直接改善穩態響應，所以只要系統有微量的變化，都無法讓穩態誤差恆為零。

3. Explain when we were at beam angle experiment, what reason cause the different phenomena with different K_{p1}?

   Ans： K_{p1}是比例控制參數，可以發現增加此參數有助於系統接近到平衡點,但從圖中也可以發現太大的K_{p1} 會使得系統不斷的振盪，反而造成系統不穩定。

4. Do you think this system is a stable system? What is your reason?

   Ans: 系統的穩定性會根據不同的控制參數而有不同的結果，因此設計出好的控制參數，輸出的響應也會比較好，但實驗

上會因為導線的鬆緊、球的形狀或有無生鏽，而影響實驗的控制結果。