Ball and Beam Experiment Report

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A. Experiment Result

1. Calibration

Position	−30	0	30
Voltage	5.86	4.44	3.05
$\text{Position} = a \times Volt + b$ $\quad a = -21.532 \quad b = 95.01$			

$$\text{Angle} = a \times Volt + b \Rightarrow a = \frac{10}{V_0 - V_{-10}} = 51.02$$

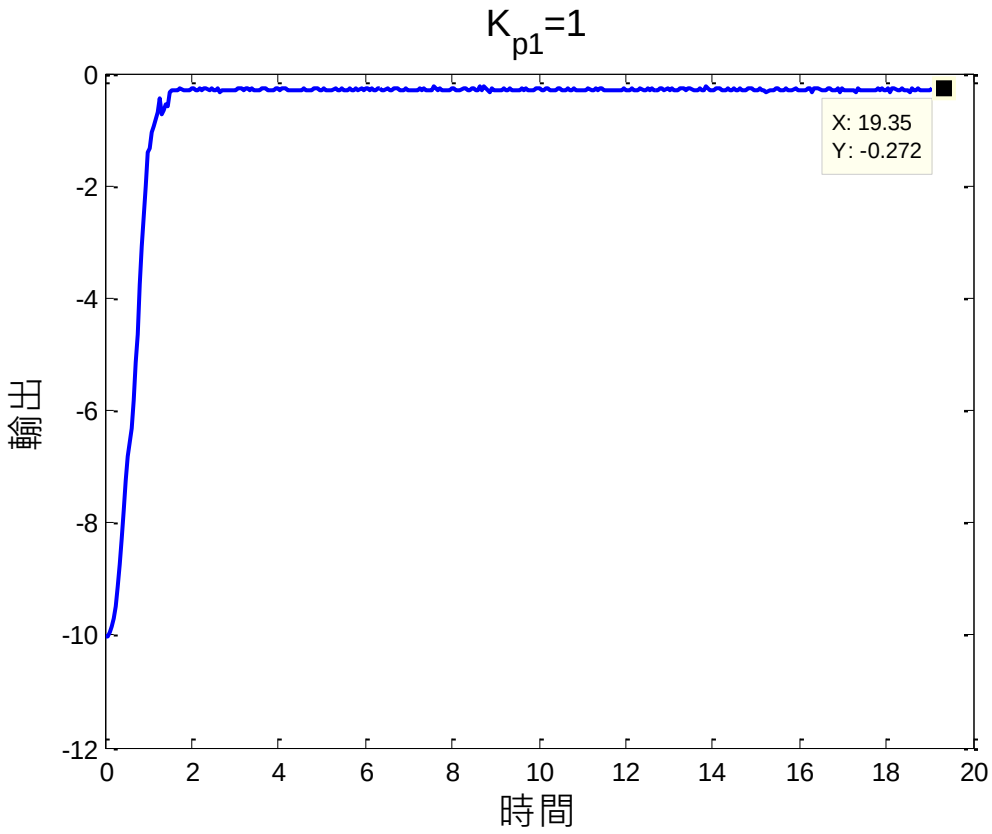
$$b = \frac{10V_0}{V_0 - V_{-10}} = -385.51$$

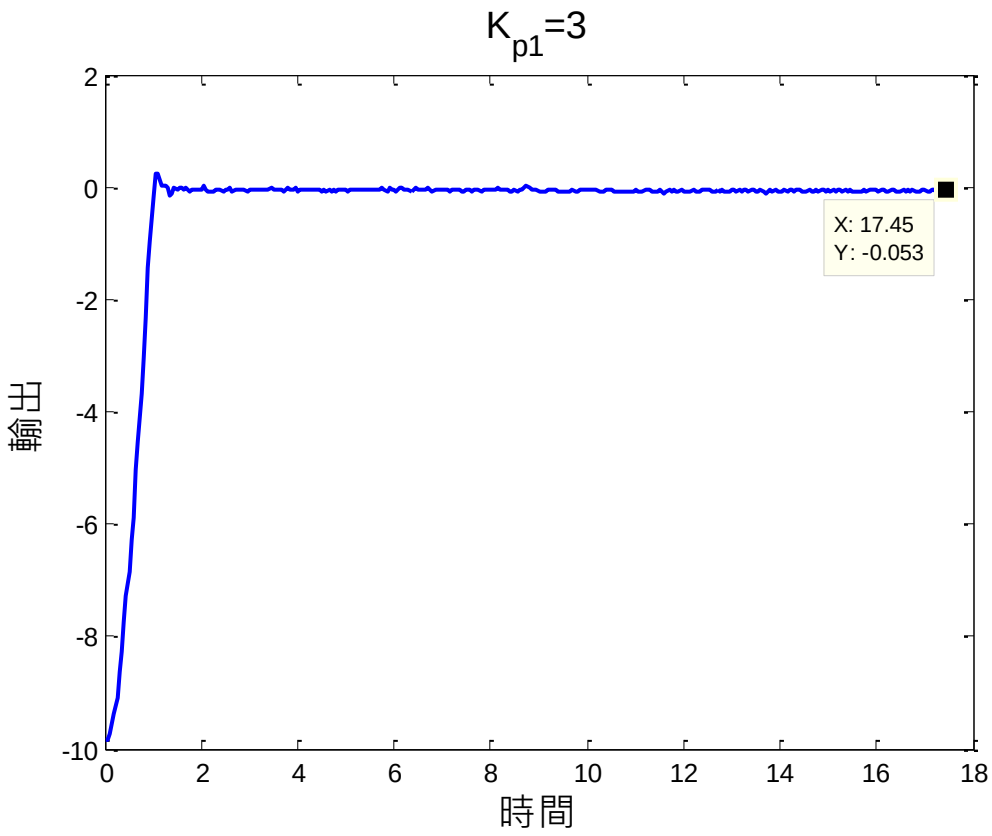
2. Beam Angle Control

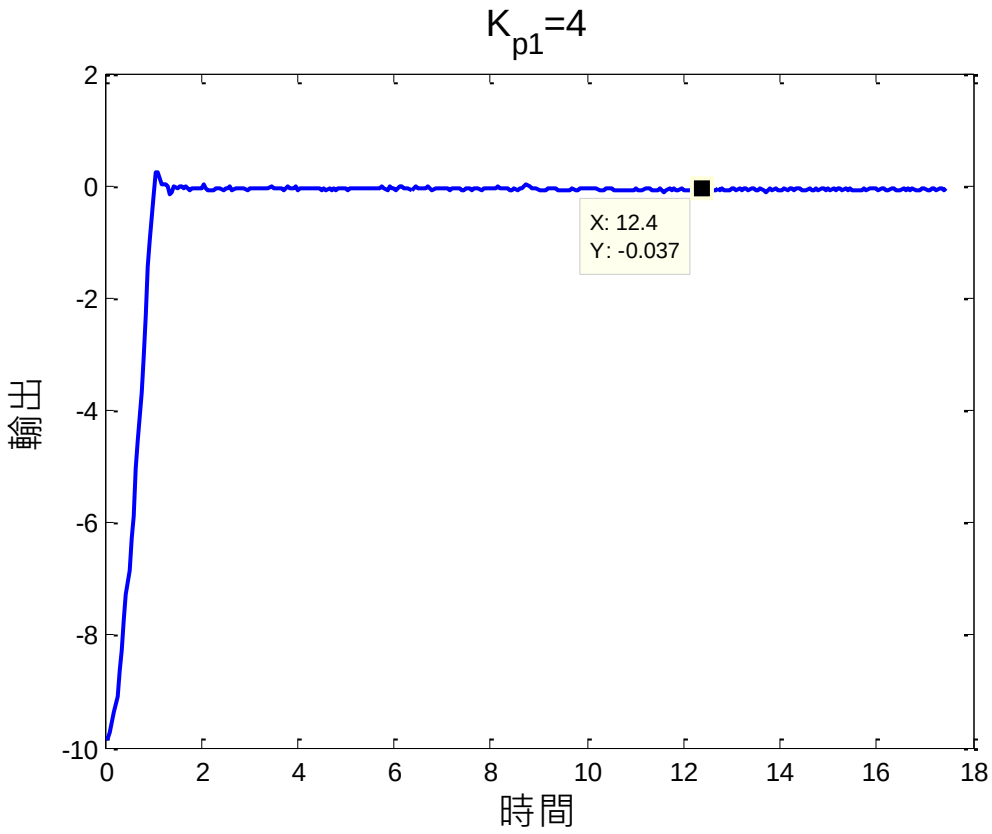
(1) Desired angle is 0. Please Record the Steady-error and the data in different K_{p1}

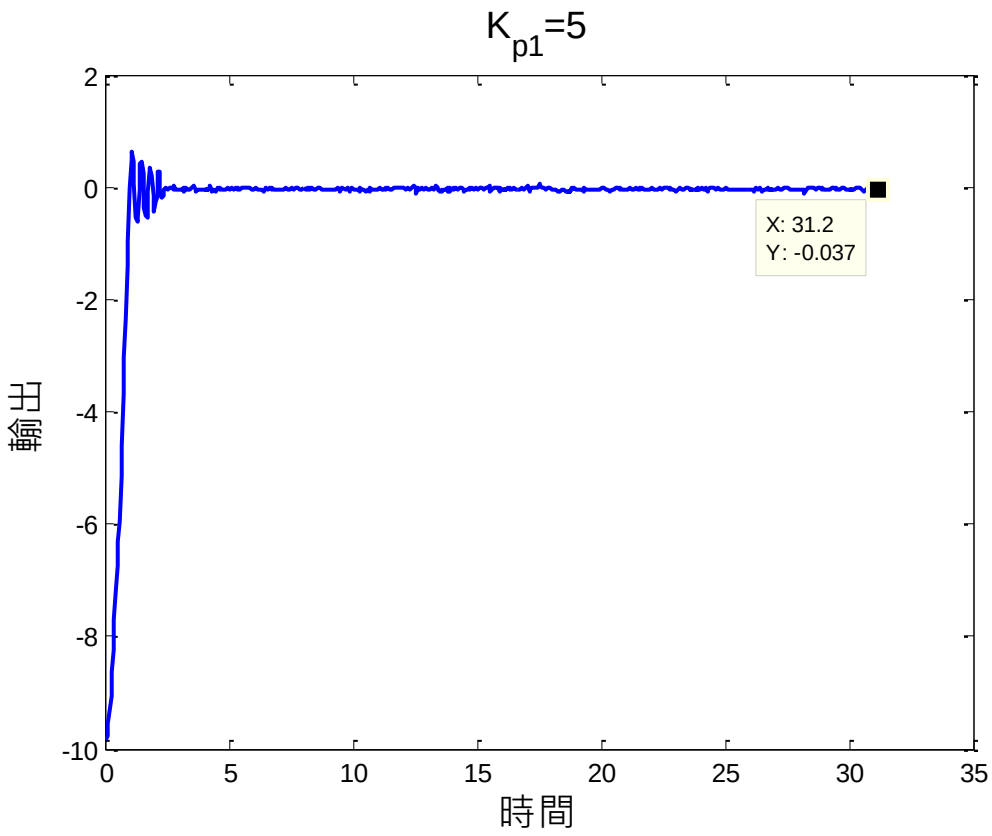
K_{p1}	1	3	4	5	7
Steady-error	0.272	0.053	0.037	0.037	0.668

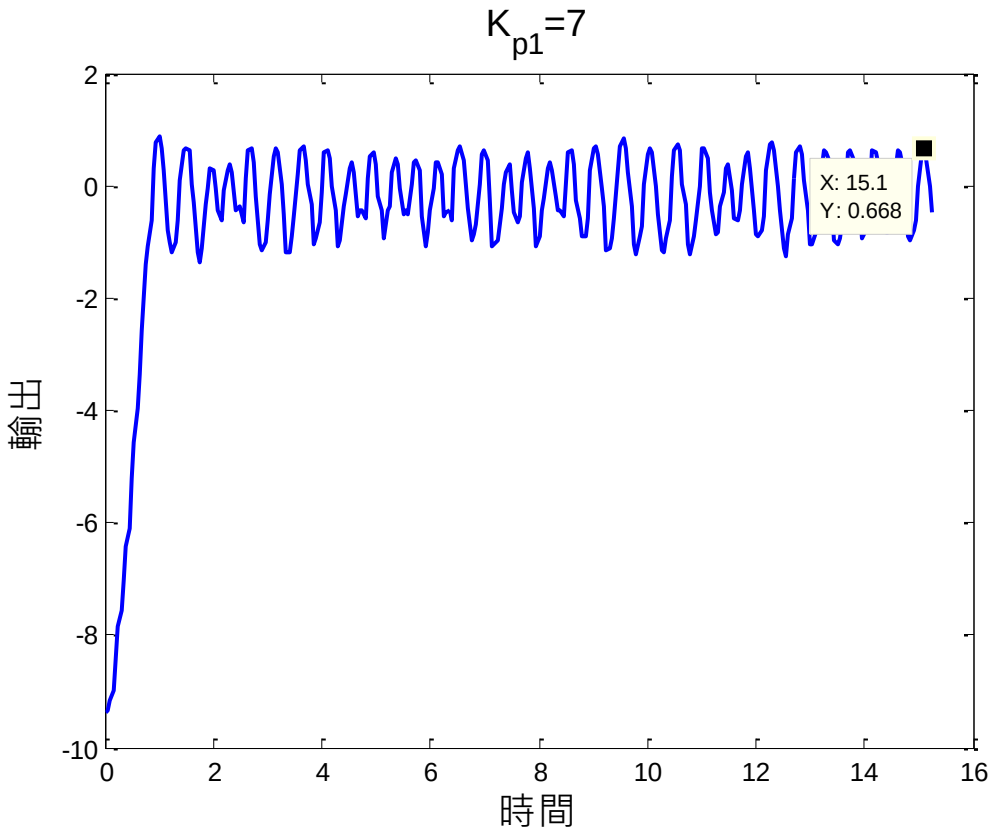
(2)Data Plot


K_{p1}=1
X: 19.35
Y: -0.272
輸出
時間
0
-2
-4
-6
-8
-10
-12
0
2
4
6
8
10
12
14
16
18
20


K_{p1}=3
X: 17.45
Y: -0.053
輸出
時間
2
0
-2
-4
-6
-8
-10
0
2
4
6
8
10
12
14
16
18


K_{p1}=4
X: 12.4
Y: -0.037
輸出
時間
2
0
-2
-4
-6
-8
-10
0
2
4
6
8
10
12
14
16
18


K_{p1}=5
X: 31.2
Y: -0.037
輸出
時間
2
0
-2
-4
-6
-8
-10
0
5
10
15
20
25
30
35



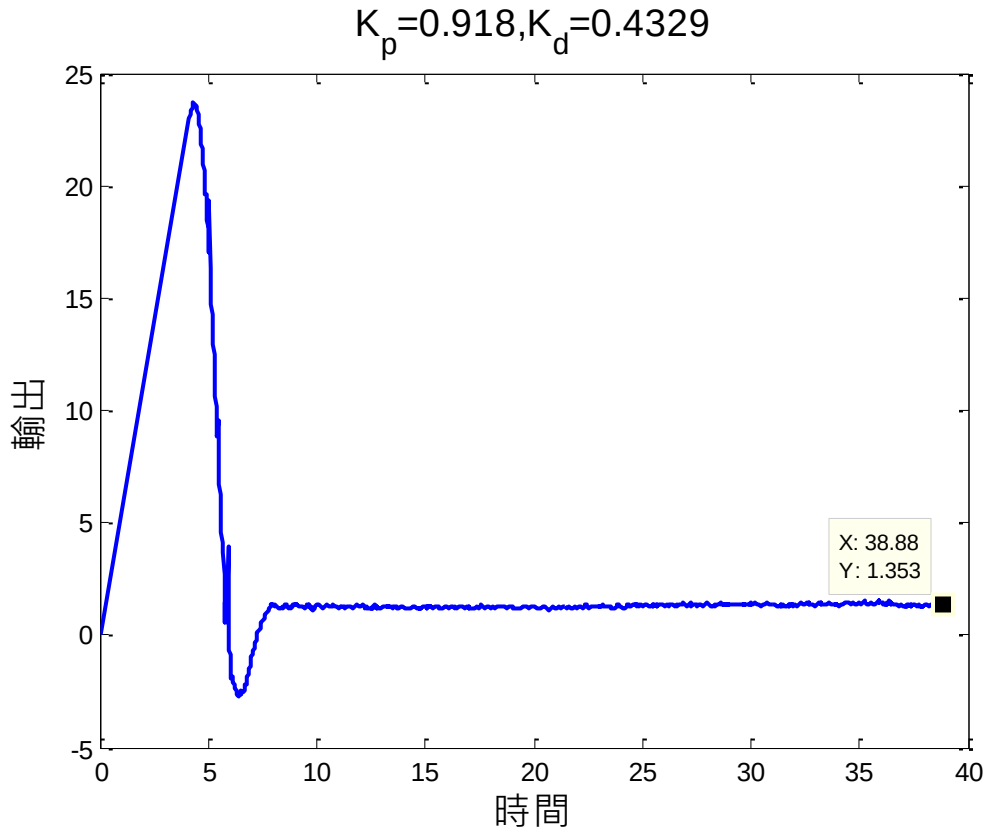
3. BALL AND BEAM EXPERIMENT - PART I

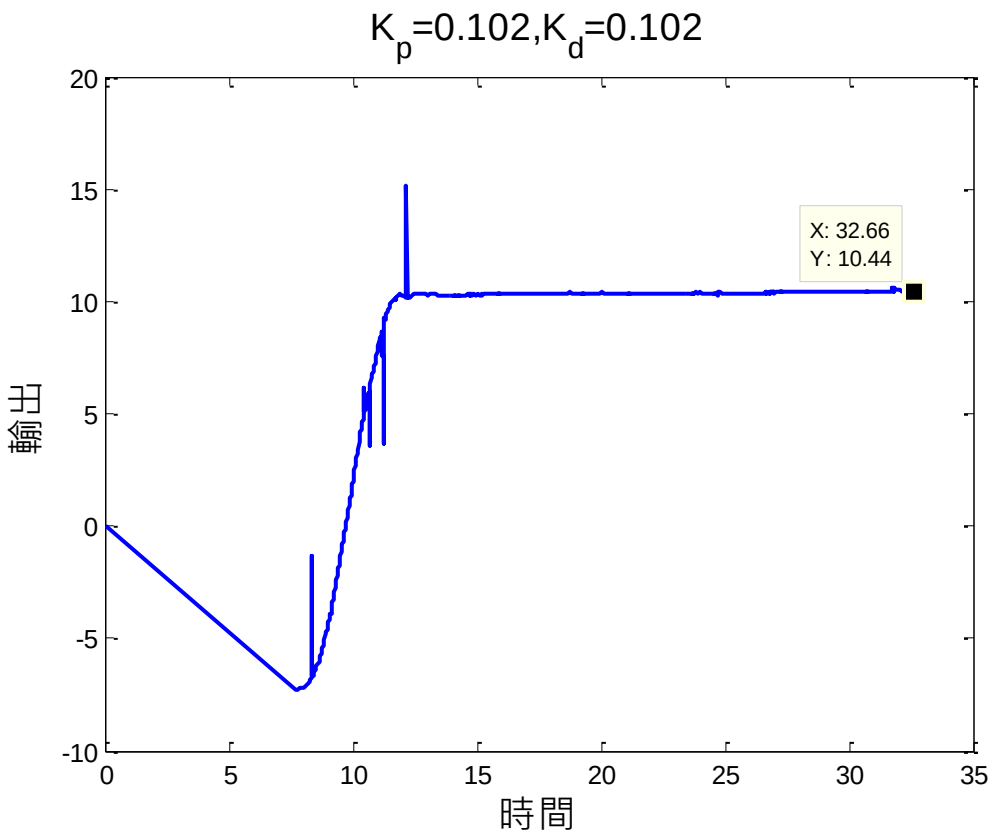
(1) Find the parameter K_p, K_d of the control ,with different damping ratio ξ and natural frequency ω_n

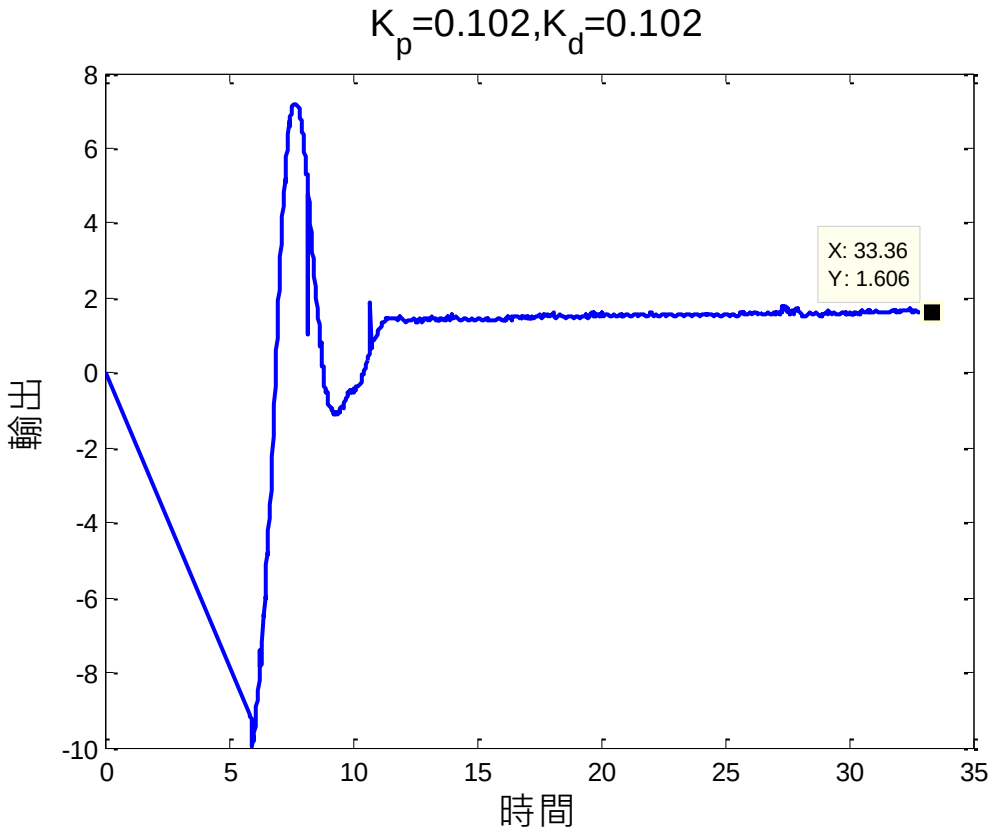
	K_p	K_d
$\xi = 0.707, \omega_n = 1$	0.102	0.144
$\xi = 0.707, \omega_n = 3$	0.918	0.433
$\xi = 0.5, \omega_n = 1$	0.102	0.102
$\xi = 0.5, \omega_n = 3$	0.918	0.306

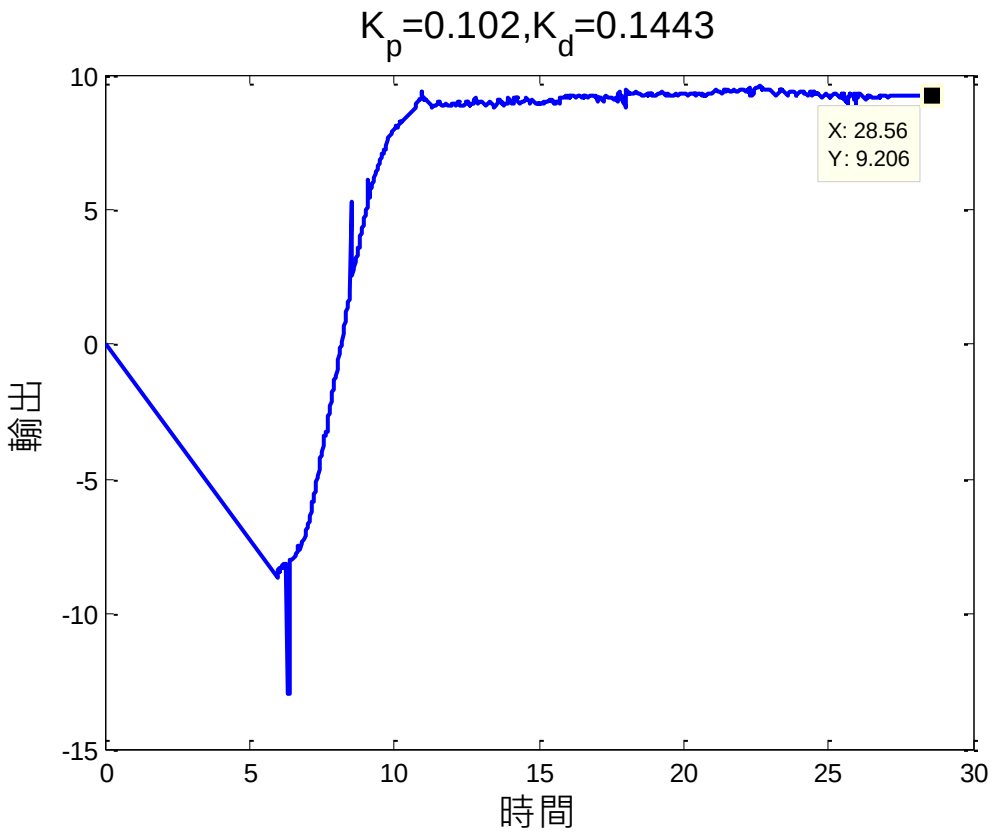
$$\begin{cases} gK_d = 2\xi\omega_n \\ gK_p = \omega_n^2 \end{cases}$$

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


K_p=0.918,K_d=0.4329
輸出
時間
X: 38.88
Y: 1.353


K_p=0.102,K_d=0.102
輸出
時間
X: 32.66
Y: 10.44





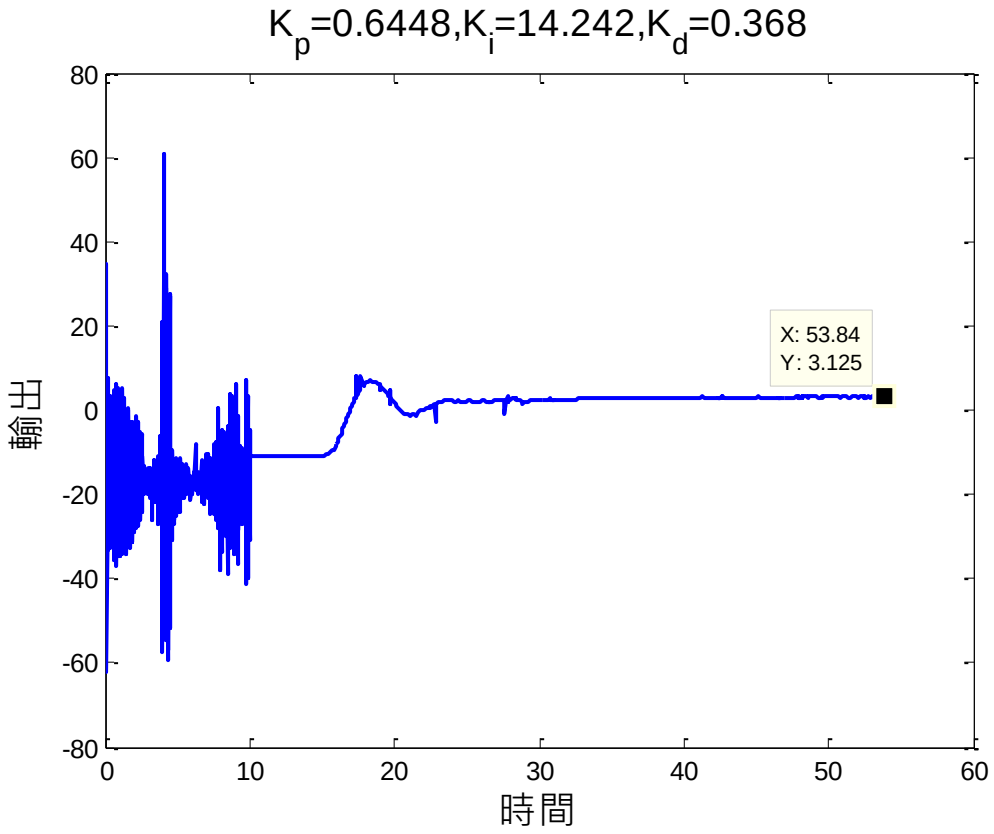
4. BALL AND BEAM EXPERIMENT - PART II

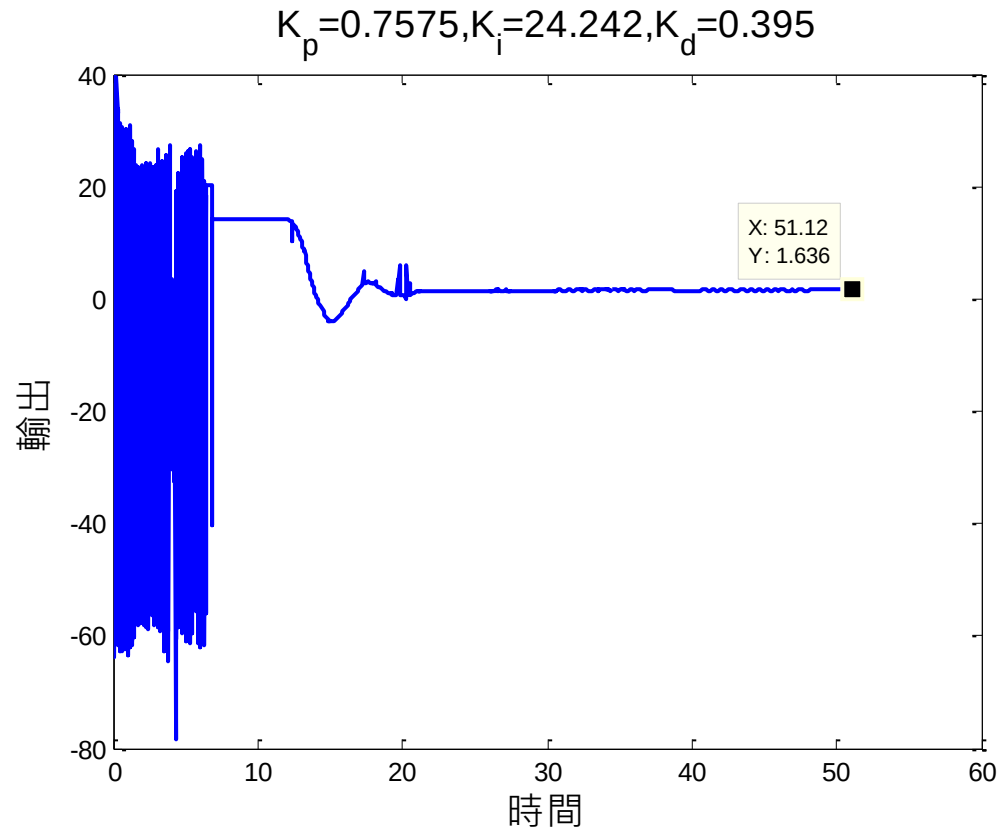
(1) Find the parameter K_p, K_d, K_i of the control ,with different damping ratio ξ and natural frequency ω_n, decay rate a

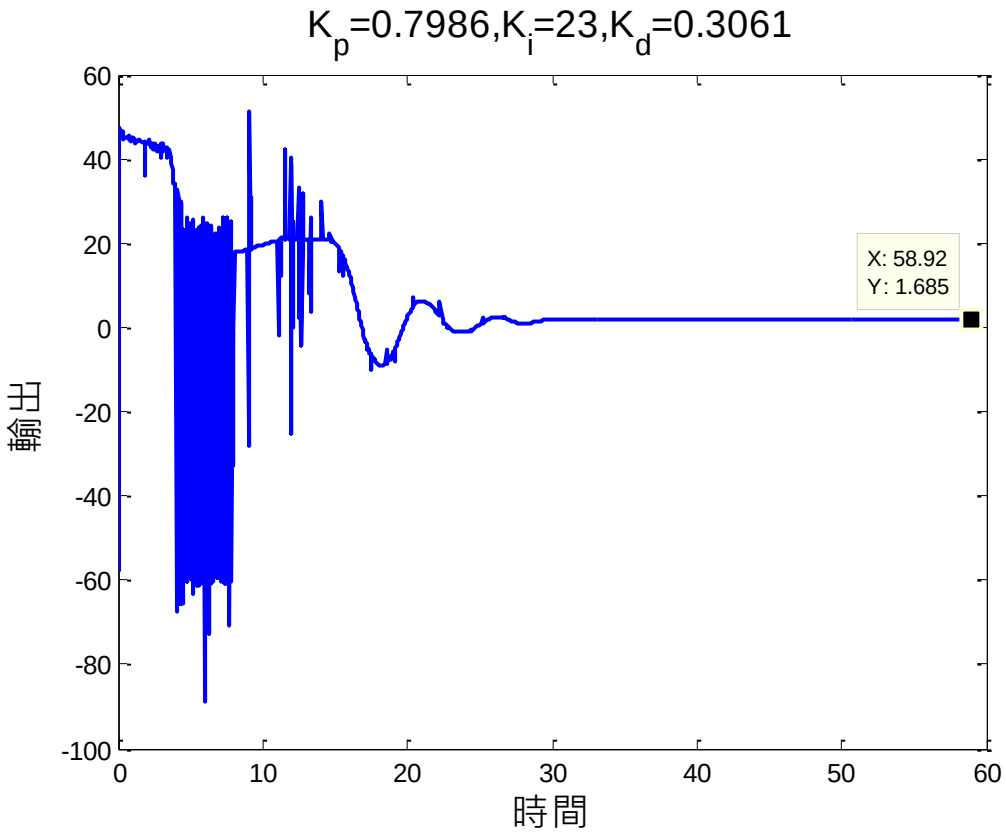
ξ	ω_n	a	K_p	K_i	K_d
1	3	10	0.573979592	16	0.44005102
0.707	3	10	0.644830324	14.242	0.368413058
0.707	3	20	0.75766632	24.242	0.394996708
0.5	3	20	0.798580302	23	0.306122449

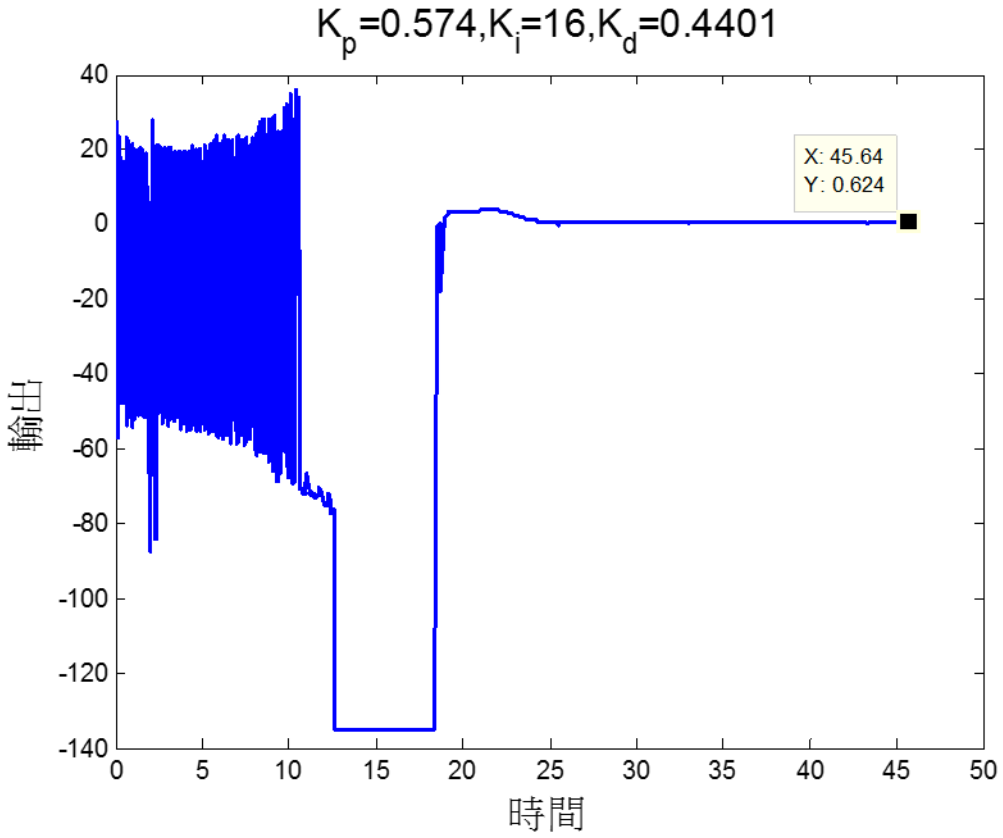
$$\begin{cases} K_i = 2\xi\omega_n + a \\ K_p = \dfrac{a\omega_n^2}{gK_i} \\ K_d = \dfrac{\omega_n^2 + 2a\xi\omega_n}{gK_i} \end{cases}$$

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




K_p=0.7575,K_i=24.242,K_d=0.395
X: 51.12
Y: 1.636
40
20
0
-20
-40
-60
-80
0
10
20
30
40
50
60
時間
馬達


K_p=0.7986,K_i=23,K_d=0.3061
X: 58.92
Y: 1.685
60
40
20
0
-20
-40
-60
-80
-100
0
10
20
30
40
50
60
時間
馬達



B. 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 ?

   使用此方式可使平衡稈的角度轉動限制在一定範圍，不會因馬達轉動而導致平衡桿損毀。

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

   誤差會隨著輸出的值變化，然而到達穩定後的值其實還是有微小的變化，其中的絕對值稱為穩帶誤差，而此系統是一個實際系統，因此會有各種的干擾，因此微小的變化量是永遠存在的，因此穩態誤差也不可能恆為零，若以系統的階數來觀察，答案也是相同的。

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

   由圖可以知道K_{p1}增加，則峰值越高，是因為增加比例控制器值時，會造成E(S)的值變大，而經過負回授後則訊號會變小，而穩態誤差也變小了，但也由於比例控制器增大，所以一開始的響應也會變大。

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

這系統的穩定性可由不同的控制器造成的結果來觀察，經由調整控制器適當的參數，則輸出的響應也會越好，反之，若參數並不適當則系統也會有不穩定的結果。

C. Feedback

經由此實驗可以了解現性回歸的最基本的意義與用途，並應用在實務上，藉由調整比例控制器了解與穩態誤差之間的關係，PD 與 PID 控制器實務上的應用與用途都可藉由此實驗而驗證。