G02_HW15

Group 02
HW 15
2019/12/24

ID	Name	Your works	Times you spend	Self score	TA
108202529	葉揚昀	PPT, Tracker, random theta fitting	7hr	7	
108202009	田家瑋	Tracker, modeling fitting	7hr	2	
108202016	張家菖	Purchase spring, stepper motor	4hr	7	

Coupled oscillation

1. Our progress

Device:

- Ensure the new stepper motor can push our device.
- Combine 3 different springs with two screws respectively.
- Combine 2 blocks with a screw .

  (Make 2 pendulums drop in the same time.)
- Dig a hole on the board to fix stepper motor .

Coupled oscillation

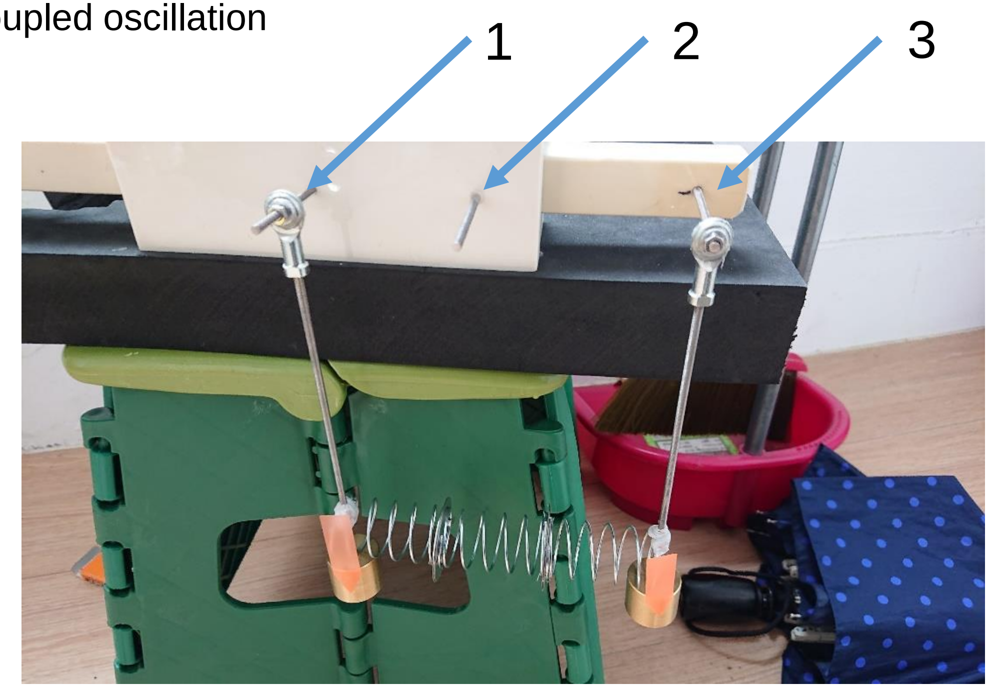


Fig.1 Three screws (axis) can fix pendulums.

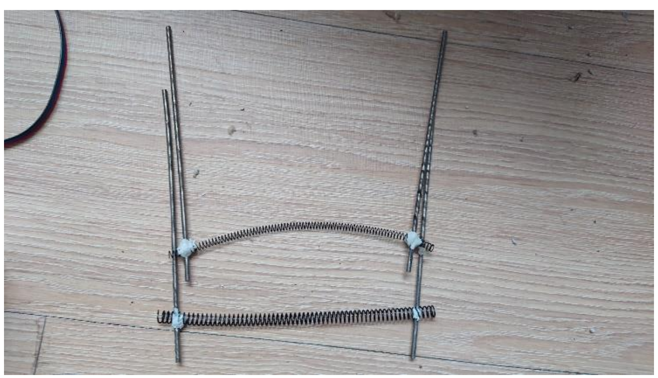
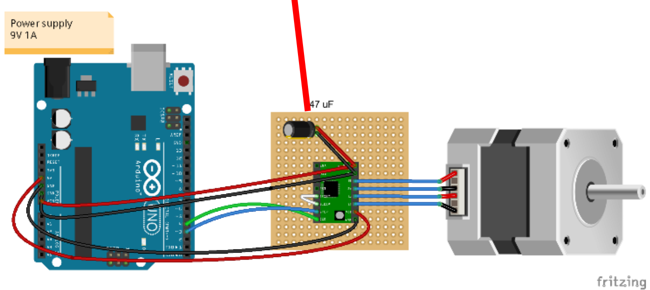


Fig.2 Combine the springs with two screws respectively. (Use plastic-soil.)

Coupled oscillation

Fig.3 We use a 9V battery as power supply.



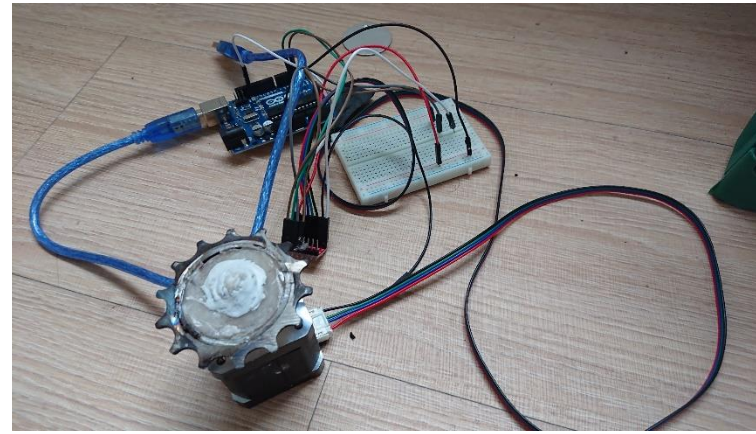


Fig.4 Entire stepper motor device.

Fig.5 The gear stuck on the stepper motor with plastic-soil.

Coupled oscillation

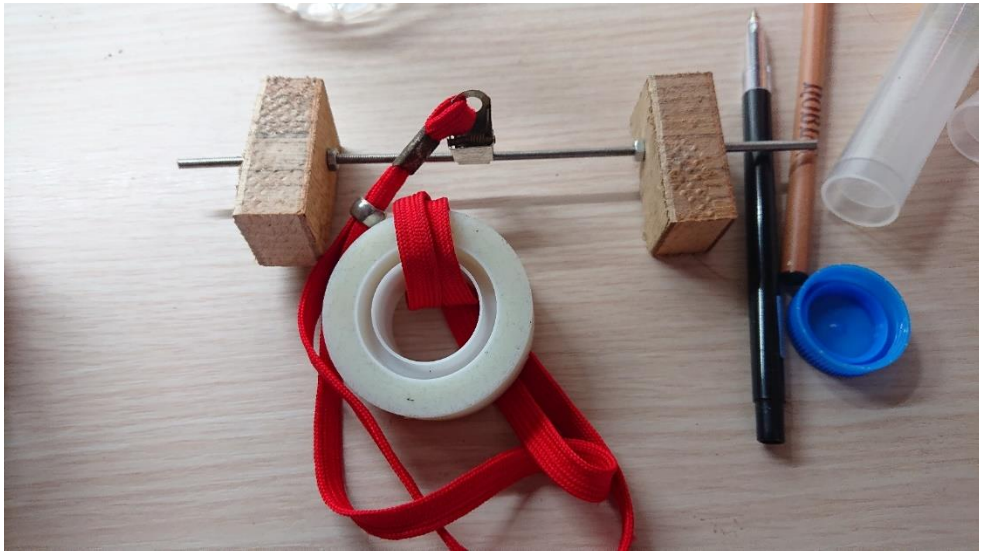


Fig.6 The two blocks with a screw to ensure 2 pendulums drop in the mean time.

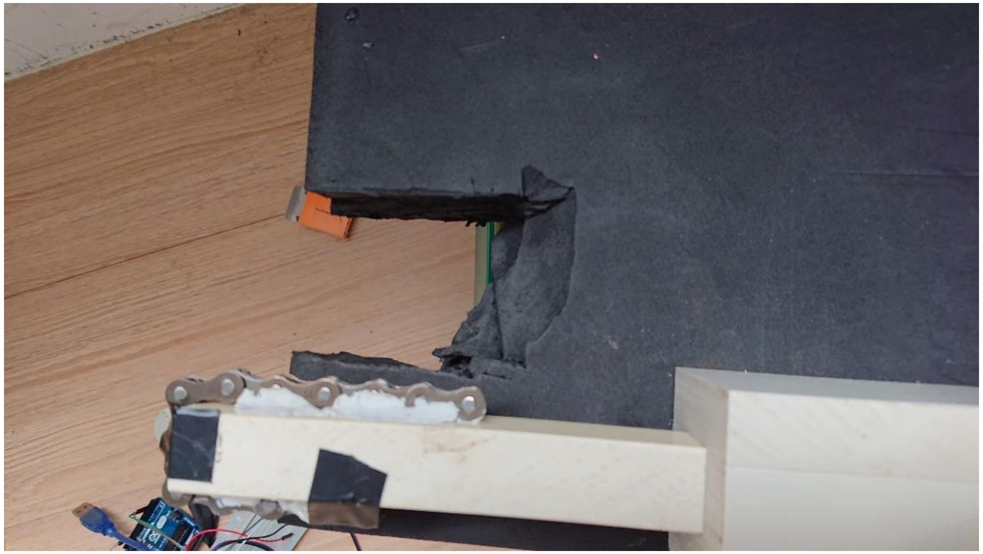


Fig.7 The hole on the board to fix stepper motor .

Coupled oscillation

2. Measure

- Mass of device (screws, pendulum and spring)
- Values of k (Apply Hooke's law)

Spring	x0 (m)	x' (m)	△x (m)	W (kgw)	F (Nt)	K (Nt/m)
1(3)	0.1372	0.1456	0.0084	0.089	0.8722	103.8333
2(1)	0.0448	0.0479	0.0031	0.089	0.8722	281.3548
3(粗)	0.15025	0.1542	0.00395	0.08526	0.835548	211.5311
4(細)	0.1498	0.161	0.0112	0.08526	0.835548	74.6025

Table.1 Measure the values of k (4 spring)

Coupled oscillation

Devices	Mass (g)
Pendulum_1	69.19
Pendulum_2	69.09
PVC_cylinder	228.48
Screw + Bearing (1)	13.39
Screw + Bearing (1)	13.38
Spring	26.65

Table.2 The mass of devices

Random theta fitting

Random theta (pendulums with different initial conditions)

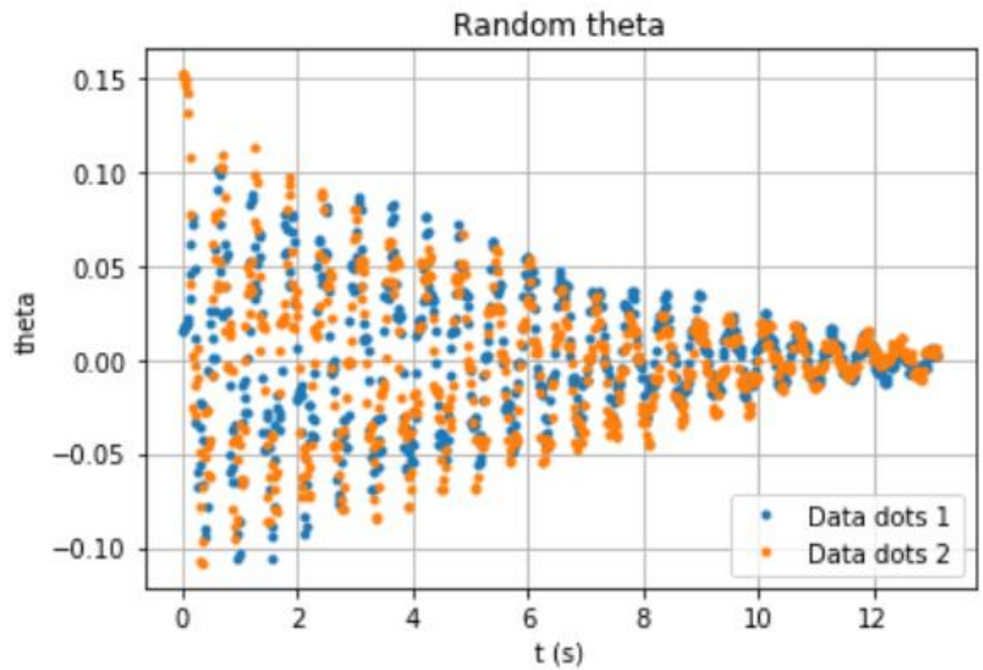


Fig.8 Random initial theta1 & theta2

Random theta fitting

Try1.

1. RK4 fitted coefficient of air resistance.

- Problem: It would decay too fast.

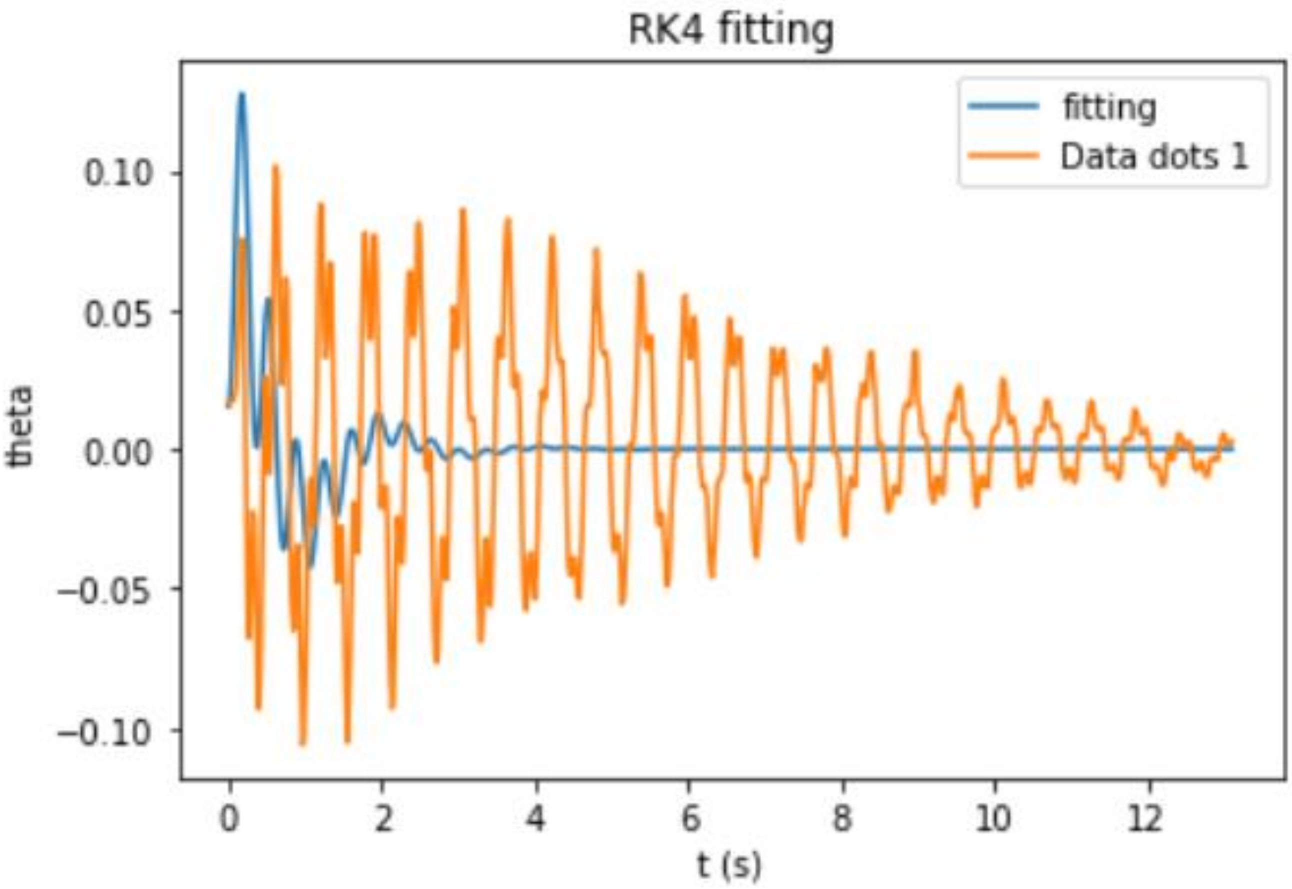


Fig.9 RK4 fitting theta1 (original time partition of data)

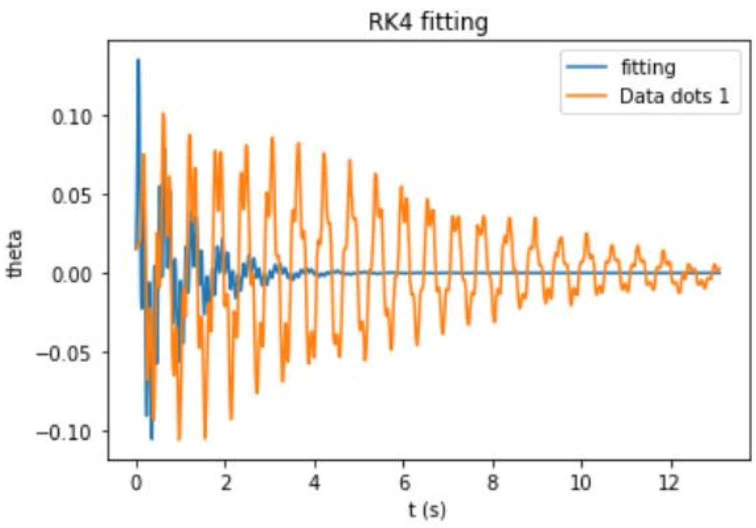
Random theta fitting

Try2.

- Try solve Try1.: Slice each time interval into smaller tree parts.

(Make norm of time partition into 1/3 times : $\| p' \| = \frac{1}{3} \| p \|$)

- Problem: It also decayed too fast.




```
for i in range (0, num):
    if i % 3 == 0:
        i_prime = int(i/3)
        tp.append(t[i_prime])
    else:
        i_prime = int(i/3)
        div = t[i_prime] + 1/3 * (i % 3) *
(t[i_prime + 1] - t[i_prime])
        tp.append(div)
```

Fig.9 RK4 fitting theta1 (New time partition of data)

Random theta fitting

Try3. (Two normal modes superposition)

- Normal mode 1 ($\theta_1 = \theta_2$ all the time):

Set $(\theta_1)\ q_1 = \frac{\theta_1+\theta_2}{2} = A_1 e^{i\omega_1 t} \rightarrow damped\text{: } q_1 = A_1 e^{-\alpha_1 t} e^{i(\omega_1 t+\varphi_1)}$ (1)

- Normal mode 2 ($\theta_1 = -\theta_2$ all the time):

Set $(\theta_1)\ q_2 = \frac{\theta_1-\theta_2}{2} = A_2 e^{i\omega_2 t} \rightarrow damped\text{: } q_2 = A_2 e^{-\alpha_2 t} e^{i(\omega_2 t+\varphi_2)}$ (2)

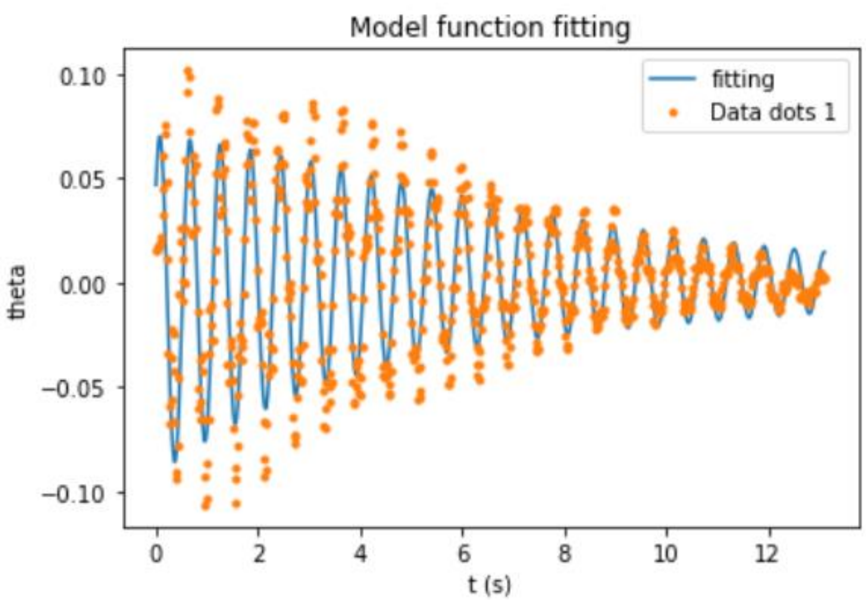
Combine (1) & (2), we get:

$$\left[\begin{array}{l} \theta_1 = q_1 + q_2 \\ \theta_2 = q_1 - q_2 \end{array}\right.$$

Where ω_1 is normal mode 1 frequency and ω_2 is normal mode 2 frequency.

Random theta fitting

Try3. Use it as model function to fit:



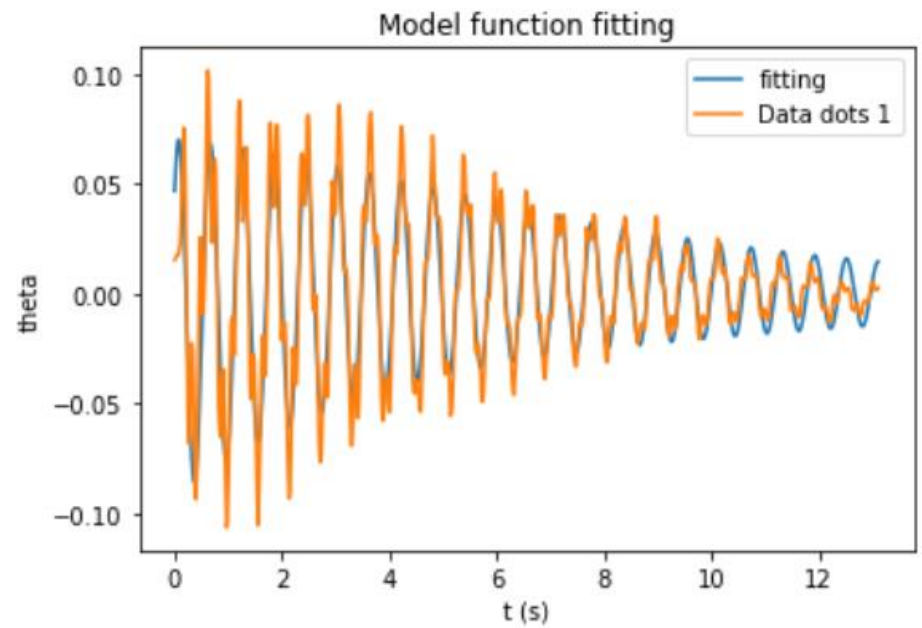


Fig.10 Model function fitting theta1 (New time partition of data)