Experiment: Hooke's Law Apparatus

Purpose

1. Measure the spring coefficient and verify Hooke's law.
2. Observe the spring simple harmonic motion, and calculate the spring elastic coefficient.

Theory

1. Hooke's Law:

When a spring is elongated by external forces, the elongation of the length does not exceed the elastic limit of the spring and is direct proportional to the external force. This is called Hooke's Law. If an object M hangs under a spring, the spring will be imposed by external forces F=Mg and elongate X, as shown in **Figure 1**.

According to Hooke's law, we know that

$$F = -kX$$

k :Spring coefficient

F: Restoring force

X: Elongation.

Negative sign -: The direction of elasticity is opposite to the direction of deformation.

Therefore, we can calculate the elastic coefficient k by measuring the external forces and the elongation.

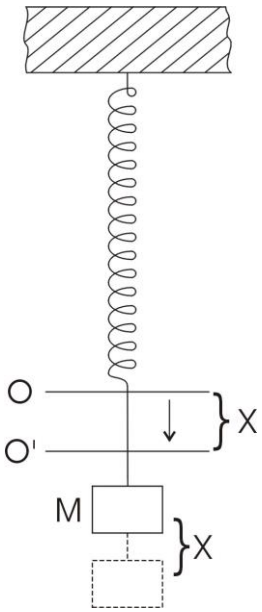


Figure 1. Elongation X

2. Simple Harmonic Motion:

Simple harmonic motion which is the most common and important motion can be found in many physical phenomena. According to Newton's second law of motion, we know,

$$F = ma = m\frac{d^2x}{dt^2} \quad (1)$$

$$\therefore \quad m\frac{d^2x}{dt^2} = -kx \quad (2)$$

From the above equations, we obtain

$$x(t) = A\cos\omega t \quad (3)$$

And we know

$$\omega = \sqrt{\frac{k}{m}} \quad (4)$$

t : Time

A: Amplitude, the largest displacement in the motion

x (t) : The location of object after time t.

ω: The angular frequency of the object in simple harmonic motion.

$$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{k}{m}} \quad (5)$$

We obtain $T = 2\pi\sqrt{\frac{m}{k}}$ (6)

$$\Rightarrow k = \frac{4\pi^2 m}{T^2} \quad (7)$$

f: Frequency

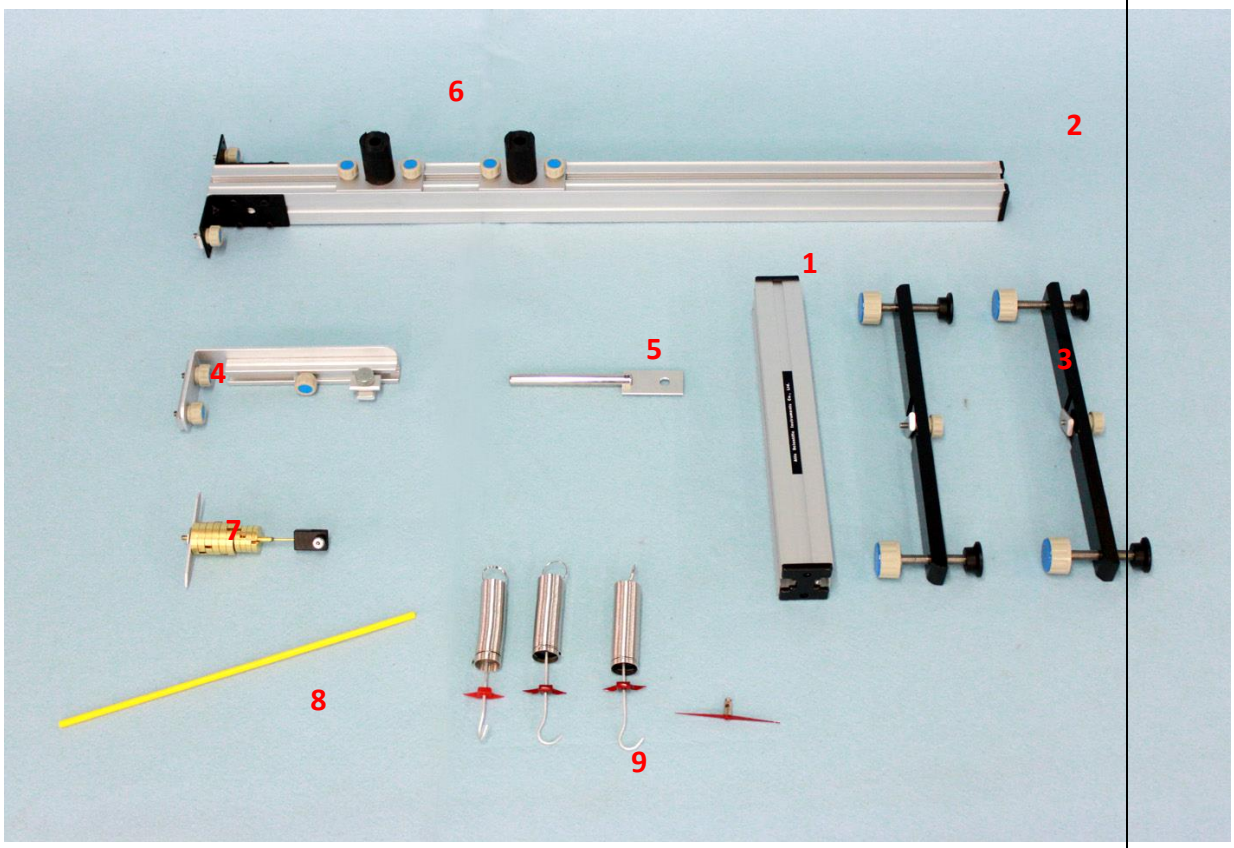
T: Period

From equation (6), we know period is only relevant to the mass of object and the coefficient of elasticity k so in this experiment, we will verify equation (6).

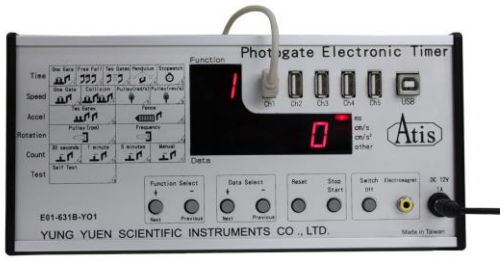
Instrument

NO	Accessory	Qty	NO	Accessory	Qty
1	Experimental base (aluminum base)	1	**2**	Hook experimental stand (aluminum support stand)	1
3	Experimental base (two-point adjustable feet)	2	**4**	L-shaped Hook	1
5	Plumb stabilizing device	1	**6**	Movable magnetic base	2
7	Weight set (weight 20g*6, 10g*4, weight holder and photogate indicator)	1	**8**	Plumb indicator	1
9	Spring set (2N、3N、5N)	1	**10**	Photogate Additional purchase	
11	Photogate electronic timer (E01-631B-Y01) Additional purchase				

Instrument picture



Additional purchase

	
Photogate Electronic Timer E01-631B-Y01	Photogate