# Simple Pendulum

## Purpose

Observe single pendulum motion and calculate acceleration of gravity from experiments.

## Theory

Theoretically, a single pendulum is one which can be considered to be a point mass suspended from a string or rod of negligible mass. However, in this experiment, we will use a small ball with high density and hang it with string. The weight of rope can be neglected here but the length must exceed the radius of ball's diameter. Only under this condition will the mass of system focus on the centre of the ball. (The centre of the ball is also the pendulum bob).

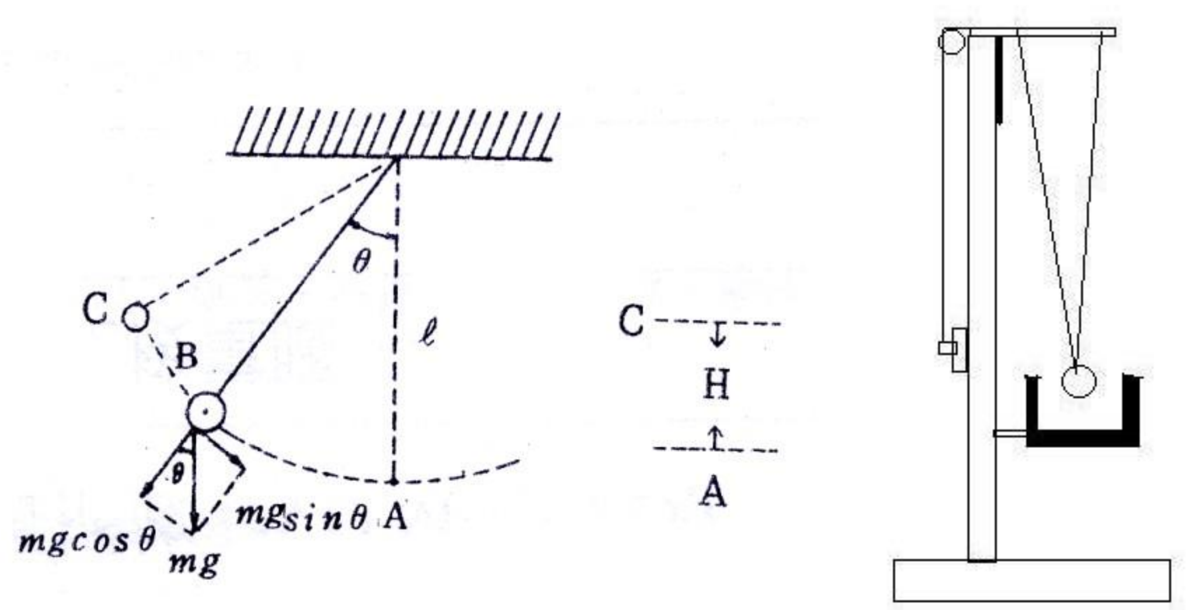


**Figure 1** The figure is for reference only. The actual amplitude angle is larger than the figure.

As shown in **Figure 1**, when the pendulum bob is still at point A, it is influenced by a pulling force (gravity) W and a pulling up force (string) P. When the bob moves to point B, the gravity W can be decomposed to two vectors, normal component n and tangential component f. When the swing angle gets larger, f will become larger and n will becomes smaller. Their relationship can be observed from point B and C in figure 1.

It is very interesting to observe the transformation of potential energy into kinetic energy in a single pendulum. When pendulum bob swings back from point B, it generates potential energy (mgh). When it swings to point A, its potential energy decreases and its velocity increases so the kinetic energy increases $1/2mv^2$.

A single pendulum motion includes three basic components:

1. String length L- From hanging point O to the centre of pendulum bob.

2. Period T- The time it takes to complete one swing.

3. Amplitude- There are two calculation methods. First, use the angle θ between OA and OB. Second, use the arc of AB (swing from point B). When (rad) is small, $BA \fallingdotseq BA$ =S

Thus, $\sin\theta \fallingdotseq \theta = \frac{S}{L}$ $so\ \mathrm{f} = mg \cdot \sin\theta = mg\frac{S}{L} = k \cdot S$, $and\ k = \frac{mg}{L}$

Consider the motion as a simple harmonic motion, the relationship between length L and period T can be written as

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m}{mg/L}} \qquad \therefore T = 2\pi\sqrt{\frac{L}{g}}$$

Thus the acceleration of gravity is g= $\frac{4\pi^2 L}{T^2}$

[Note：θ does not exceed 5° so the errors will be small. ]

# Instrument


**Instrument picture**

| No. | Accessory | Qty | No. | Accessory | Qty |
|---|---|---|---|---|---|
| 1 | Aluminum base ( including adjustable feet) | 1 | 2 | Aluminum support rod ( including scale) | 1 |
| 3 | Fixed pulley | 1 | 4 | Fixed arm of pendulum bob | 1 |
| 5 | String adjustable base (including indicator) | 1 | 6 | Pendulum bob and string | 2 |
| 7 | Semi-circular angle disk | 1 | 8 | Photogate holder | 1 |
| 9 | Photogate (indlucing iron rod *1) | 1 | 10 | Photogate electronic timer ( including DC power supply *1) | 1 |

## Procedure

1. The experimental setup is shown in above figure. Tie the bob on the string and then tie the string on the support stand.

2. Adjust the length (from the support point to the centre of bob) to 20cm. Swing the bob. Keep the angle below $5^{\circ}$. Record the time of 50 swings. Repeat four times and calculate the average value. The period is $T = \frac{t(\sec ond)}{n(\sec ond)}$

3. Adjust the length to 30, 40, 60 and 80 cm accordingly and repeat procedure 2.

4. Change the bob and repeat above procedure.

## Experiment record and analysis

I. Pendulum Bob

| Trail | Length ℓ | Times to complete 50 swings | | | | | | Period T | Acceleration of gravity g |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Average time t | | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| | | | | | | | | Average | |

II. Light ball

| Trail | Length ℓ | Times to complete 50 swings | | | | | | Period T | Acceleration of gravity g |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Average time t | | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| | | | | | | | | Average | |

## Questions:

1. Analyze the relationship between length and g.

2. Analyze and compare the weight of bob and g.

3. What is the definition of pendulum cycles? and describe the relationship of pendulum length?

4. When doing the experiment at sea level and mountains, will the g be different?

Atis Scientific Instruments Co.,Ltd
Address：1F., No.18, Nanming St., South Dist.,
Tainan City 702, Taiwan (R.O.C.)
E-mail:atis@atissi.com.tw
Tel: (886) -6-2925201
Fax: (886)-6- 2611476
Mobile:+886-9-8006-1128
Website: www.atis.com.tw