Topic 4 – Practical 4

Relationship between a mass suspended by a spring and the period of oscillation of the spring–mass system

Safety

Wear safety glasses/ goggles.

Apparatus and materials

- stand and two clamps
- steel spring (of known spring constant)
- ruler
- plumb line
- mass hanger (100 g) and slot masses (100 g)
- fiducial mark (long pin)
- adhesive putty
- stopwatch

Introduction

In this practical, you will use measurements of the period of oscillation of a spring to determine its spring constant.

The period T of the oscillations of a small point mass m suspended from an ideal spring of spring constant k is given by:

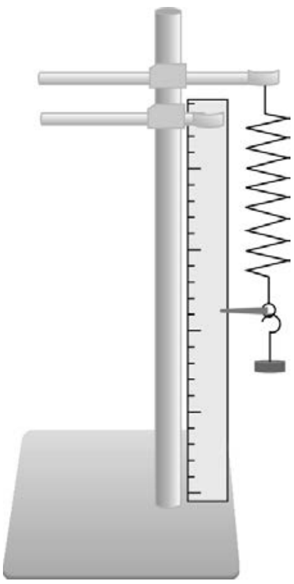
$$T = 2\pi\sqrt{\frac{m}{k}}$$

The equation above can be written as:

$$T^2 = \frac{4\pi^2}{k}m$$

so that the gradient of a T^2 vs m graph is equal to $\frac{4\pi^2}{k}$

Procedure



1 Attach one end of the spring to the clamp and stand securely.

2 Use a small piece of adhesive putty to attach the fiducial mark at the end of the spring.

3 Place the ruler next to the spring. Use the plumb line to check that both spring and ruler are vertical. Place a mass hanger at the other end of the spring and mark on the ruler the equilibrium position.

4 Displace the mass from its equilibrium position by a certain distance. This distance will be the amplitude of the oscillations and should remain constant throughout the experiment.

5 Release the mass and measure the time for the system to complete 20 full oscillations. (Note: the time it takes the end of the spring to go from the equilibrium position to the next equilibrium position is half a period. One full period is the time it takes to return to the equilibrium position **from the same side**.)

6 Repeat four more times for this mass.

7 Record your measurements in an appropriate table.

Raw data table

mass *m* / kg ± ….	Time for 20 full oscillations / s ± . . .				
	#1	#2	#3	#4	#5

8 Repeat the process (steps **3**–**7**), each time adding a slot mass of 100 g.

9 For each mass calculate:

a the average time for 20 oscillations and the uncertainty of repeated measurements

b the period of one oscillation and the relevant uncertainty

c the square of the period and the relevant uncertainty.

Record these calculations in a separate table.

Processed data table

Mass, *m* / kg ± ….	Average time for 20 oscillations / s	Uncertainty from repeated measurements of *t* / s	Period, *T* /s	Uncertainty of *T* / s^2	T^2 / s^2	Uncertainty of T^2 / s^2

10 Plot a graph of the square of the period T^2 against mass *m*. Use the values of uncertainty of T^2 to draw error bars.

11 Draw a best-fit line for your points and calculate its gradient.

12 From the value of the gradient, calculate the experimental value of *k* $\left(=\frac{4\pi^2}{\text{gradient}}\right)$.

13 Determine the gradient uncertainty and use it to calculate the uncertainty of the experimental value of *k*. Compare the known value of *k* with the experimentally determined one.

Questions

1 Is there another way of plotting your data in a linear graph? How would you re-arrange the equation $T = 2\pi\sqrt{\frac{m}{k}}$ to allow you to do this?

2 In this case, how would you determine the value of *k* from the gradient of your graph?