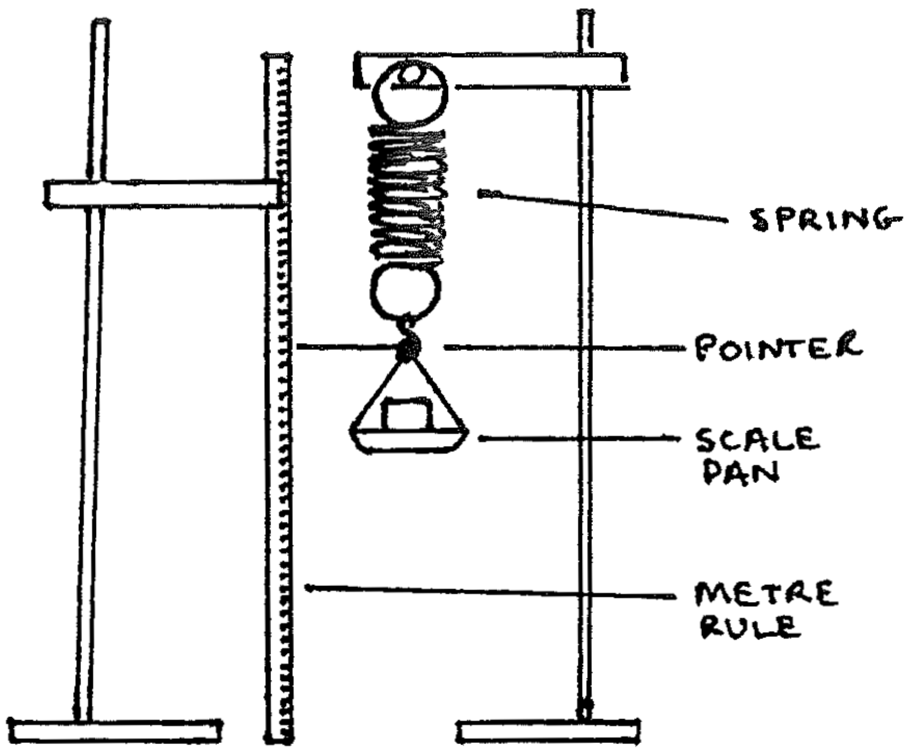
B5-2: Experiments Using a Spiral Spring

Apparatus

2 stands with clamps; metre rule; spiral spring; scale pan with attached pointer; stopwatch; assorted masses 5g to 100g; 2 sheets of graph paper; triple beam balance



Procedure

1. Measure and record the mass of the scale pan and attached pointer. Attach the pan and pointer to one stand and place the metre rule in the other stand such that the end of the pointer moves lightly over it. Read and record the pointer position. This

is the zero position.

2. Put 5g in the pan and record the total load (including the mass of the pan and pointer) and the pointer position.

3. Put 10g more into the pan and record the position of the pointer and the total load on the spring. Continue adding 10g increments of mass until 95g has been added. Record the total load and pointer position each time.

4. Once you have reached 95g remove 10g at a time and record the total load and the pointer position each time. This will give you two readings for every load except at 95g.

5. Use the readings in your data table to find the total mean extension for each load by subtracting the zero position pointer reading (from 1.) from the average pointer reading for each load. Write this in your table.

6. Put 50g into the scale pan then set it in vertical oscillations by lifting it slightly above the equilibrium position then quickly letting go. Time 20 complete oscillations to find the periodic time, T, where $T = \frac{\text{time for 20 oscillations}}{20}$.

7. Repeat procedure (6.) with 100, 150, 200, and 250g. Be certain to include the mass of the pan and pointer in your tabulation of total load on the spring.

Observations

Mass of scale pan and pointer = ______ g

Zero position of pointer = ______ cm (also record in data table)

Tabulate:

Load	Pointer reading load increasing	Pointer reading load decreasing	Average pointer reading	Total mean extension

Total load	Time for 20 oscillations	T	T^2

Theory

Hooke's Law predicts that when the spring experiences elastic deformation due to a load the extension is linearly proportional to the load: $F = -kx$. When a mass, M, attached to the spring extends the spring by a distance, x, there is a restoring force $Mg = \frac{x}{n}g$, where $n = \frac{\text{extension}}{\text{load}}$ (n is the slope of the first graph you will draw), and g is the acceleration due to gravity.

The oscillations of the spring are simple harmonic and obey the equation of motion $Ma = -\frac{x}{n}g$ or, $a = -\frac{g}{Mn}x$. Using calculus, $-\frac{a}{x}$ can be expressed in terms of the angular frequency ω such that:

$$\omega^2 = \frac{g}{Mn} \text{ and, } T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{Mn}{g}}$$

The above assumes that the spring is weightless. In reality the spring has an effective mass, m, which changes the equation for T:

$$T = 2\pi\sqrt{\frac{(M+m)n}{g}}$$

From a graph (you will draw) of T^2 vs. load, g and m can be found:

$$\frac{T^2}{\text{load}} = \frac{4\pi^2 n}{g} = (\text{slope of the second graph})$$

$$g = 4\pi^2 n \frac{1}{(\text{slope of the second graph})}$$

The x-intercept of the T^2 vs. load graph gives the effective mass, m, of the spring.

Analysis

1. Plot a graph of total mean extension vs. load. Find the slope, n, of the graph and the x - intercept. Use SI units.
2. Does this first graph verify Hooke's Law?
3. Plot a graph of T^2 vs. load. Fine the slope and the x - intercept.

4. Use the slope of your graph to solve for g. Does the value you obtain for g agree with your expected value of nearly 9.8 ms^2? If there are differences try to explain them.

5. What is the value you predict for the effective mass, m, of the spring?