S.h.m. of mass on a helical spring

While conducting this experiment, you will be assessed for CPAC1: Following written instructions. Your lab report will be assessed for CPAC4: Correctly tabulating sufficient data and CPAC5: 'y=mx+c' analysis.

Theory

In this experiment you will be measuring the *Period* **T** of a mass on the end of a spring. The period is the time for one complete oscillation (up and down movement) of the mass.

The time period for small oscillations of a mass, **m** on a spring of *stiffness (*or *spring constant)* **k** is given by:

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

Interestingly the period of oscillation for a mass-spring system, unlike a pendulum, is independent of the acceleration due to gravity. It depends only on the mass **m** and the stiffness **k**.

squaring both sides $\mathbf{T^2 = 4\pi^2 m / k}$

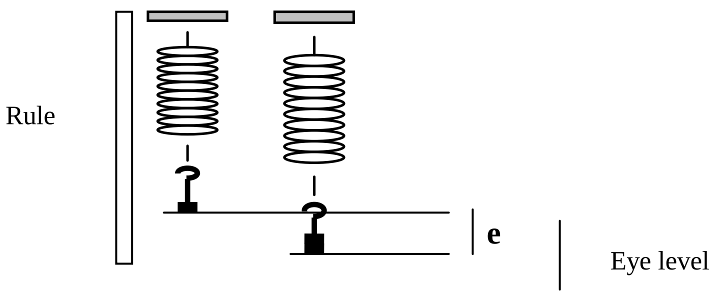
This can be compared with $y = m\ x + c$

and so by plotting $\mathbf{T^2}$ on the y–axis against **m** on the x–axis a straight line should be produced, and **k** can be evaluated from the gradient. (Think about this. The gradient is not simply equal to **k**.)

Apparatus required

A spring, clamp, stand, metre rule, set square, stop watch, masses.

Method



Find the average time period for several different masses suspended from the spring. Also record the equilibrium extension (**e** above) that corresponds to each mass. Think carefully about the number of readings you need to take to ensure accurate results – can you remember the experiment on the simple pendulum? Before you finish, record the mass of the spring itself.

Processing of results

Tabulate your results, converting to SI units, and include columns for average time for several oscillations, average time for one oscillation and $\mathbf{T^2}$. Now plot a graph of $\mathbf{T^2}$ on the y–axis against **m** on the x–axis. Measure the gradient of this graph and use it to obtain a value for **k**, giving it suitable units.

Discussion and second value for K

Firstly, how do you know if your value for **k** is acceptable? Can you think of another way of obtaining **k** for a spring? (Hint: Remember Hooke's Law?)

If you plot an additional graph of force v extension you can find the value of **k** from the gradient. This is why you were asked to record the equilibrium extension for each mass. N.B. Don't forget to convert to force units here (F = m g, where g = 9.81 m s^{-2}).

Are your two values of **k** consistent with one another? You may have used different units for your two values of **k**. If so, confirm that they are compatible with one another in terms of base units.

Secondly, did your original graph pass through the origin? Is this consistent with the value of 'c' according to our simple theory?

To explain the answer to these questions you need to realize that the mass of the oscillating system is not simply the mass of the load. The spring coils have a significant mass, and these oscillate to a variable extent depending on their position along the spring. The effective mass of the spring, $\mathbf{m_s}$, is approximately one third of the spring's total mass. Modifying our first equation, we now have:

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

Squaring gives $$\mathbf{T^2 = 4\pi^2 m / k + 4\pi^2 m_s / k}$$

Whilst the gradient is the same, we now have an intercept term. Using your value of **k**, evaluate $\mathbf{m_s}$ from the intercept of your first graph and compare it with the expected value found by weighing the spring. (Remember the factor of 3 above.)

N.B. Some of the springs available in the lab. are under permanent compressive forces. This means that they need a certain mass on them *before* they start to extend. This too can cause a non-zero intercept in both graphs, so don't be surprised if your result for the mass of the spring is inaccurate. Also, the intercepts are very small – what does this tell you about the uncertainties in the measurement? However, none of this should prevent you from getting good consistent values for the stiffness **k** itself.