Oscillating Paper Clips Investigation – the Planning section

Name…….. **Date**……..

You are going to plan and carry out an experiment that looks at how the period of oscillation of a paperclip chain varies with the number of paperclips in it.

You have available:

20 identical paper clips, 6 connected in a chain and 14 others

a ½ metre rule / a metre rule

a stopwatch timer

a nail to suspend the chain from

a fiducial marker (pin in a cork)

clamps, bosses, clampstand

Explain why it would be poor practice to try and time a single oscillation

A single oscillation would take a very short time ✓

It would be difficult to start / stop the stopwatch at exactly the right times ✓

(2 marks)

You should time a number of oscillations e.g. 10T (ten oscillations), 15T (fifteen oscillations), etc.

Explain why this is much better practice. There are 2 major reasons.

1. Timing multiple oscillations reduces the percentage uncertainty in the time ✓

2. Your reaction time for starting / stopping the stopwatch becomes less significant ✓

(2 marks)

It is suggested that the period, T, of small oscillations of a chain of paperclips is given by

$$T = 2\pi\sqrt{\frac{kxl}{g}}$$

x = number of paperclips in chain, l = length of each link of chain, k = a constant, g = 9.8 m s^{-2}

By creating chains of different lengths you are going to investigate whether k is independent of x.

Explain clearly how you would determine the link length, l. (NOTE that it is a link length not an individual paperclip length that you need to determine).

Measure the length of the whole chain ✓

And divide by the number of clips ✓

(l = 2.995 cm i.e. 3.00 to 3 sf sample result to be used later)

(2 marks)

In order to more fully investigate the relationship between T and x, we can square the original equation to give:

$$T^2 = \frac{4\pi^2 kxl}{g} \qquad \textbf{or} \qquad T^2 = \frac{4\pi^2 kl}{g} \times x$$

Sketch a clearly labelled diagram of the apparatus set-up you would use.

Clear sketch showing the chain freely suspended from the nail ✓

Clear labelling of the diagram ✓

(2 marks)

Explain below how you are going to use the apparatus to obtain the data required for your graph. Remember to state the variable you are going to change and how you are going to take the measurements including steps taken to improve the reliability of the timings beyond timing nT.
From the equation for a straight line graph ('y = mx + c') state the graph you should plot to show the relationship between T and x. State clearly what belongs on the y axis, x axis, the expected gradient and how you can obtain a value for k from the graph.

Use a fiducial marker to mark the position of the centre of the oscillations (rest position) ✓

Change the number of links in the chain ✓

For each number of links time n oscillations ✓

Repeat the timings ✓

At least 15 oscillations timed (3 x 5T or 2 x 10T for example) ✓

Obtain at least 8 sets of data ✓

Plot a graph with T^2 on the y axis ✓

and x on the x axis ✓

The graph should be a straight line through the origin ✓

With gradient = $\frac{4\pi^2 kl}{g}$ ✓

So k can be calculated from k = $\frac{gradient \times g}{4\pi^2 l}$ ✓

(11 marks)

Check your method and modify it as necessary from the answer given.

(Total 19 Marks)