SHM: Practicals

For both experiments:

Safety:

- place soft surface directly below equipment to prevent damage caused by falling equipment
- (mass-spring) only pull down a small amount as large oscillation will damage/dislodge equipment
- (pendulum) end of string needs to be securely attached to prevent it falling.

Resolution of equipment:
- stop watch = $\pm 0.01 s$
- meter ruler = $\pm 1 mm$
  $1 \times 10^{-1} m$

equipment	Purpose
clamp stand	to hold spring, mass and pendulum vertically
string	to calculate spring constant and provide oscilations
marker (eg. needle)	to mark equilibrium
mass hanger with mass	To hang from spring and vary the mass
stop watch	to measure time for oscillations
ruler (meter)	(spring) to check all oscillations have same amplitude (pendulum) measure length of pendulum
pendulum on string (mass)	to provide oscillations

Reducing errors:

Systematic Errors:

- **Reduce parallax error by viewing the marker at eye level**

Random Errors:

- **Record the time taken for 10 full oscillations, then divide by 10 for one period, to reduce random errors**
- **The equation for the time period of a pendulum bob only works for small angles, sin(x) $\approx$ x**
- **A motion tracker and data logger could provide a more accurate value for the time period and reduce the random errors in starting and stopping the stopwatch (due to reaction times)**

The practical went incredibly well with my accuracy < 1%. to further my experiment's accuracy I would use a motion tracker for more accurate time readings. as the uncertainty stems from parallax error and my reaction speed when starting/stopping the stop watch.

Mass-spring:

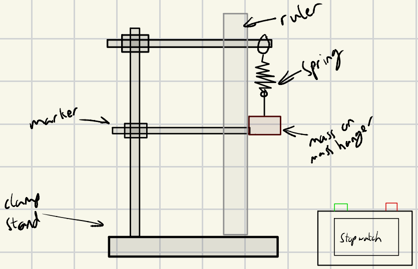
Method:

1. **Set up the apparatus, with no masses hanging on the holder to begin with**
2. **Pull the mass hanger vertically downwards between 2-5 cm as measured from the ruler and let go. The mass hanger will begin to oscillate**
3. **Start the stopwatch when it passes the nail marker**
4. **Stop the stopwatch after 10 complete oscillations and record this time. Divide the time by 10 for the time period (mean)**
5. **Add a 10 g mass to the holder and repeat the above between 8-10 readings. Make sure the mass is pulled down by the same length before letting go**

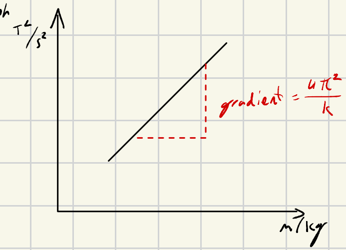
Variables:

independent: mass, m
Dependent: time period, T
Control: spring constant, k, number of oscillations

apperatus set-up:



example graph



equation:

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

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

$y = mx$

gradient = $\frac{4\pi}{k}$

$k = \frac{4\pi}{\text{gradient}}$

T = time period
m = mass
k = spring constant

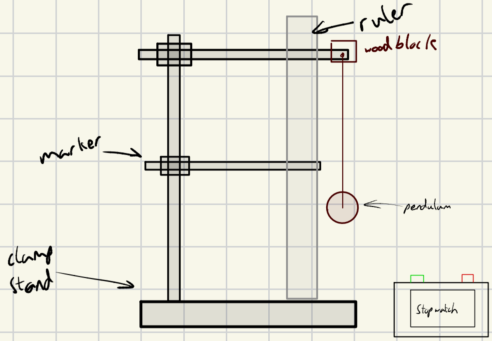
resulting gradient can be compared with Hooke's Law $F = k(\text{extension})$

mass / kg	T_{10} / s	T / s	T^2 / s^2

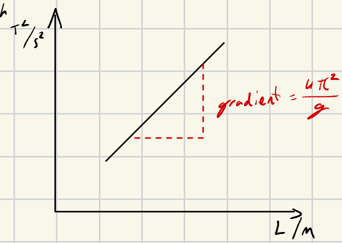
1 g = 0.001 kg

pendulum:

apperatus set-up



example graph:



Variables:
independent: length, L
Dependent: time period, T
Control: mass of pendulum, m
number of oscillations

Method:

1. Set up the apparatus, with the length of the pendulum at 0.2 m
2. Make sure the pendulum hangs vertically downwards at equilibrium and inline directly in front of the needle marker
3. Pull the pendulum to the side at a very small angle (10*) then let go. The pendulum will begin to oscillate
4. Start the stopwatch when the pendulum passes the needle marker in its equilibrium.
5. Stop the stopwatch after 10 complete oscillations and record the total time. Divide the time by 10 to obtain the time period (mean)
6. Adjust the string to increase the length of the pendulum. Repeat the above for 8-10 readings. The ruler is used to measure the string. Ensure it is measured from the start of block to the centre of mass of the bob.

equation:

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

$$T^2 = 4\pi^2 \frac{L}{g}$$

$$y = mx + c$$

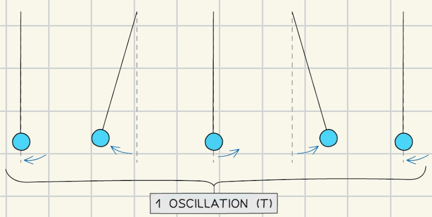
$$\underbrace{m = \text{gradient} = \frac{4\pi^2}{g}}$$

$$g = \frac{4\pi^2}{\text{gradient}}$$

compare with accepted value 9.81

Length/	R1 T_{10}/s	R1 T/s	R1 T^2/s^2	R2 T_{10}/s	R2 T/s	R2 T^2/s^2	R3 T_{10}/s	R3 T/s	R3 T^2/s^2	mean T^2/s^2
0.2	8.95	0.895	0.801	9.09	0.909	0.826	8.98	0.898	0.806	0.809
0.4	12.68	1.268	1.607824	12.65	1.265	1.600225	12.71	1.271	1.615441	1.61
0.6	15.50	1.55	2.4025	15.46	1.546	2.390116	15.59	1.559	2.430481	2.41
0.8	17.90	1.79	3.2041	17.93	1.793	3.214849	17.91	1.791	3.207681	3.22
1	20.16	2.016	4.064256	20.18	2.018	4.072324	20.02	2.002	4.008004	4.03

← 3 sig fig



gradient = 4.024

$$\frac{0.809 + 1.61 + 2.41}{0.2 + 0.4 + 0.6}$$

$$\frac{x_1 + x_2 + x_3}{y_1 + y_2 + y_3}$$

$$\frac{4\pi^2}{4.024} = g = 9.8107$$

$$\% \text{ uncertainty} = \frac{9.8107 - 9.81}{9.81} \times 100\%$$

$$= 0.0000754\ \%$$