6.3.1 Applications of simple harmonic motion

The spring pendulum

There are two factors that affect the period of oscillation of a mass-spring system; the spring constant ('stiffness' of the spring) $k$ and the mass $m$.

Have a go at changing each in the following simulation: https://tinyurl.com/yv9atno9

1. How would the period change if you increased the spring constant?

2. How would the period change if you increased the mass?

Provided the spring is not stretched beyond its elastic limit is will obey Hooke's Law:

$$F = -kx$$

The minus sign is there because the restoring force $F$ is always in the opposite direction to the displacement (from equilibrium).

3. Using $F=ma$, substitute for $F$ in the equation, above, and rearrange to make $x$ the subject.

We know that the mass-spring system will oscillate with SHM, and a defining feature of SHM is:

$$a = -(2\pi f)^2 x,$$

where $A$ is the amplitude, $x$ is the displacement and $f$ is the frequency.

4. Substitute for $x$, using the previous equation and rearrange this equation to make $f$ the subject.

5. The period $T = \frac{1}{f}$. Substitute for $f$ and rewrite the equation to make $T$ the subject.
You should have found the period of the spring pendulum is given by:

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

(6) How would you show experimentally that this relationship is correct?

The Simple pendulum

There are two factors that affect the period of a pendulum; the length of the pendulum $l$ and the gravitational field strength $g$.

The period of a pendulum is given by:

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

Systems will oscillate with SHM if the restoring force is proportional to the displacement from the equilibrium position.

(7) For a pendulum, where does the restoring force come from?

(Note: This is tricky.)

(8) Show that for small angles (Hint: use small angle approximation), the restoring force is proportional to the displacement $s$. 