**Measurement of “g” using a ruler pendulum**

**h**

**θ**

**x**

**mg**

This is a simple version of Kater’s pendulum. A metre stick or a 30cm wooden ruler can be used for this experiment, both work equally well. The metre stick or ruler has holes drilled at 2cm intervals. The metre stick is pivoted on a knitting needle, or something similar, mounted in a cork and place a cork on the other end of the needle for safety. Make sure the ruler oscillates in one plane only and does not wobble.

The distance along the metre stick from the point of suspension to the centre of mass of the ruler is the length “h.”

For small displacements, the restoring turning effect, force multiplied by the perpendicular distance to the pivot. The restoring force is the weight of the ruler, mg, acting at its centre of mass. The perpendicular distance to the pivot, x, is given hsinθ, which for small angles simplifies to hθ.

Giving I(d2θ/dt2)= -Mghθ where I is the moment of inertia of the metre rule. For small displacements, the motion is simple harmonic motion, SHM.

Remembering for SHM the acceleration is given by: -ω2x, the restoring force is therefore given by m ω2x.

For rotational motion I ω2θ = Mghθ (1)

The period is then: T = 2π√(I/Mgh) (2)

The moment of inertia of a metre rule about its centre of gravity is IG = Mk2

where k is the radius of gyration about the centre of gravity. To get the moment of inertia about the pivot point use the theory of parallel axes. This gives the moment of inertia about the pivot point as: I = Mk2 + Mh2 = M(k2 + h2 )

Substituting (1) into (2) gives:

 T = 2π√(k2+h2)/gh comparing this equation with the equation for the period of a

simple pendulum given by T = 2π√l/g gives the length (l) of the simple equivalent pendulum as:

 l = (h2+k2 )/h

This is a quadratic equation, h2 –hl + k2 = 0, so there are two values of h for which the metre rule has the same period of oscillation.

Using a ruler that has small holes drilled in it at 2 cm intervals down its length, suspend the ruler using a knitting needle passed through one of the holes with its end mounted in a cork that is held firmly in a clamp stand. For safety please place the other end of the knitting needle in a cork too once it has been passed through the hole in the ruler. For each hole the ruler is suspended from along the length of the ruler find the period of oscillation (T) of the ruler.

Plot a graph of period T against the distance the point of suspension is from one end of the ruler.

The graph has two minima at points x1 and x2 corresponding to the period Tm. Finding these values from your graph calculate a value for “g”

g=4π2(x2 – x1)/(Tm)2

From the graph identify the position xc where the ruler will balance perfectly and the period of oscillation tends to infinity.

In general the period of oscillation T is given by the equation:

 glT2 = 4 π2l2 + k2

where l =( x – xc)and k is a constant.

Plot a suitable graph for x > xc and find a second value for g.