Oxford Cambridge and RSA

A Level Physics A

H556/01 Modelling physics

Question Set 7

1 This question is about a simple pendulum made from a length of string attached to a mass (bob). For oscillations of small amplitude, the acceleration a of the pendulum bob is related to its displacement x by the expression

$$a = -\left(\frac{g}{L}\right)x$$

where g is the acceleration of free fall and L is the length of the pendulum. The pendulum bob oscillates with simple harmonic motion.

(a) (i) Show that the period T of the oscillations is given by the expression

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

$a = -\omega^2 x$ so $\omega^2 = \frac{g}{L}$

$\omega = \frac{2\pi}{T}$ so $\frac{4\pi^2}{T^2} = \frac{g}{L}$ $\rightarrow T^2 = \frac{4\pi^2}{g}L$ **[3]**

(ii) A student notices that the amplitude of each oscillation decreases over time.

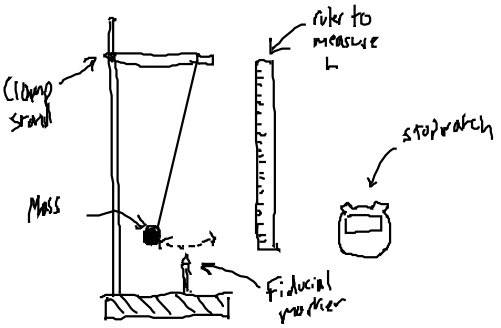
Explain this observation and state what effect this may have on T. **[2]**

– Transfer of energy to the air due to air resistance. No effect on T as an isochronous oscillator.

(b)* Describe with the aid of a labelled diagram how an experiment can be conducted and how the data can be analysed to test the validity of the equation

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

for oscillations of small amplitude. **[6]**



Set up the experiment as shown above. Measure L with ruler. Set mass oscillating. Use stopwatch to time multiple oscillations, then divide by no. oscillations to find T. Vary L, recording T for each. Each time, ensure that the oscillations are at small angles. Also, start and stop the stopwatch when the mass passes the fiducial marker in the centre of the oscillation. To analyse, plot T^2 against L. If $T^2 = \frac{4\pi^2}{g}L$ holds, points should lie on a straight line through the origin.

(c) Another student conducts a similar experiment in the laboratory to investigate the small amplitude oscillations of a pendulum of a mechanical clock. Each 'tick' of the clock corresponds to **half** a period.

(i) Show that the length of the pendulum required for a tick of 1.0 s is about 1 m. **[2]**

$L = \frac{g}{4\pi^2} T^2$ $\quad T = 2.0 \rightarrow L = 0.99 \approx 1\,M$

(ii) If the pendulum clock were to be used on the Moon, explain whether this clock would run on time compared with an identical clock on the Earth. **[2]**

It would not - g is lower on the moon, and $T^2 \propto \frac{1}{g}$ so T would be larger.

Total Marks for Question Set 7: 15