Experiment 1: To determine the acceleration due to gravity using the simple pendulum.

APPARATUS REQUIRED

- brass weight on a thread about 2 m in length
- wooden block with a slit or two pieces of thin wood for clamping the pendulum thread
- retort stand, boss and clamp
- optical pin and Plasticine
- metre rule
- stopwatch reading to 0.1 s
- protractor

PRINCIPLES INVOLVED

a The period of an oscillation T is the time taken for the pendulum to make one complete swing past a fixed point O in one direction and back and then through O again in the first direction (O → A → B → O in Fig. 5.3).

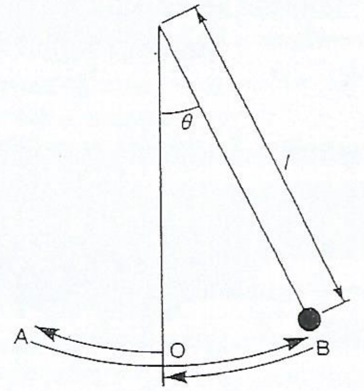

Fig. 5.3 The simple pendulum.

T depends on the length l of the pendulum and the strength of the gravitational field g. T is independent of the angle of the swing θ provided that θ is small and the approximation $\sin\theta = \theta$ in radians is valid; this approximation is valid to within 1 part in 1000 for θ less than 5° (0.0873 radians).

b The theoretical relationship is $T = 2\pi\sqrt{l/g}$ or $T^2 = 4\pi^2 l/g$. l should be measured from the top of the pendulum thread to the centre of gravity of the pendulum bob, but this is often difficult to measure for a large irregular bob such as a brass weight. It is then preferable to measure the distance from the top of the pendulum (at the support) to a *small* knot tied about 2 cm above the bob.

PROCEDURE

c Assemble the apparatus as shown in Fig. 5.4, setting the pendulum length so that the period of oscillation is about 2 s (take g to be approximately 10 N kg^{-1}). Ensure that the pendulum thread is clamped firmly in the wooden block or between the two pieces of wood and that the pendulum is well clear of the edge of the bench. A G-cramp may be needed to keep the stand rigid. Tie a knot in the thread about 2 cm above the bob. Make a reference mark using an optical pin either mounted horizontally on the stand or fixed vertically on the bench with Plasticine, and in line with the undisplaced position of the pendulum.

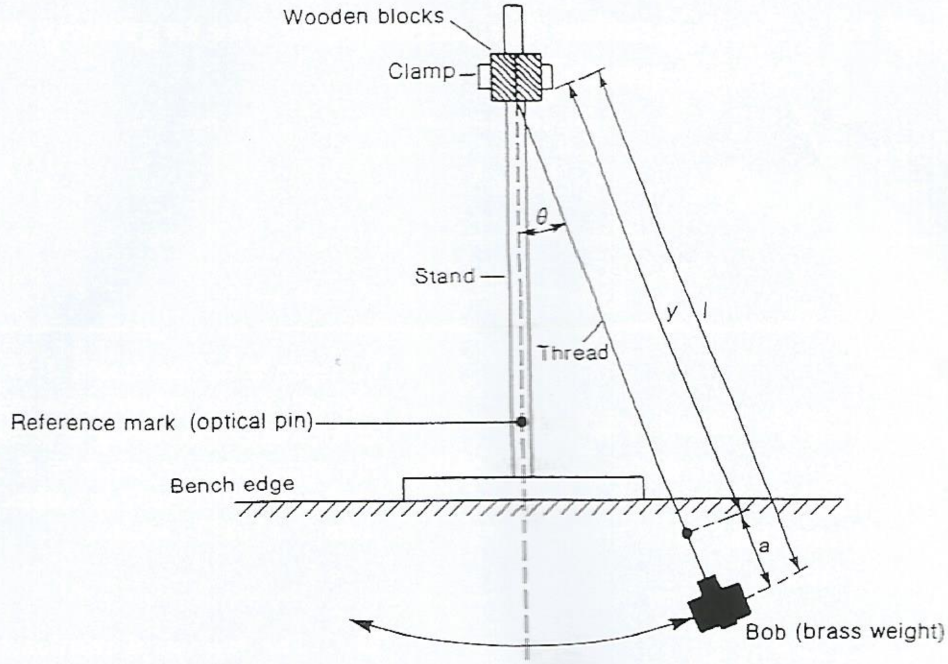

Fig. 5.4 Apparatus for simple pendulum experiment.

d Displace the pendulum a few centimetres to one side and release it. The pendulum should oscillate in one plane and not in a cone or ellipse. As the pendulum passes the reference mark start the stopwatch, count zero and determine the time for twenty oscillations. Measure the length y from the bottom of the wooden block to the knot.

e Repeat this procedure for five further values of y to give a reasonably large range of T values (about 1.4 to 2.8 s). You may have to move your reference mark further up the stand for small values of y.

f Plot a graph of the time for twenty oscillations against y as the experiment proceeds so as to identify any doubtful points. The graph should be a smooth curve.

g Tabulate your values for the times for 20 oscillations, the period T, T^2 and y (in metres).

h The equation for the period of oscillation of the pendulum is $T = 2\pi\sqrt{(y + a)/g}$, where a is the distance of the knot from the centre of gravity of the bob. Hence $T^2 = 4\pi^2 y/g + 4\pi^2 a/g$.

i From your results plot a suitable graph in order to obtain a straight line. From the slope determine a value for g and from an appropriate intercept determine a value for a. Estimate from your graph uncertainties in these two quantities.

j Compare your value of g with the accepted value and the value of a with that measured using a metre rule.

NOTES

k Your record should include a diagram of the apparatus, a table of results, graphs and analysis leading to values for g and a, together with their uncertainties.

FURTHER WORK

l The equation for the simple pendulum period $T = 2\pi\sqrt{l/g}$ is derived assuming that the angle of oscillation is small. Investigate how the period of the pendulum varies for a fixed length l of about 1 m for a range of values of θ from about 10° to 50°. You will need to determine the period of oscillation to an accuracy of ± 0.01 s to see any effects. Damping will also occur, decreasing θ as you make your timings; you will therefore need to take an average value for θ. Comment on whether you would have expected the change in T observed.

m In (d) you were instructed to ensure that the pendulum oscillates in one plane. Compare T for a conical oscillation and for a vertical plane oscillation. Is there a significant difference?