UE1050101

HARMONIC OSCILLATION OF A STRING PENDULUM

OBJECTIVE

Measuring the period of oscillation of a string pendulum with bobs of various masses.

EXPERIMENT PROCEDURE

- **Measure the period of oscillation *T* of a string pendulum as a function of the length of the pendulum *L*.**
- **Measure the period of oscillation *T* of a string pendulum as a function of the mass of the pendulum bob *m*.**
- **Determine the acceleration due to gravity *g*.**

SUMMARY

The period of oscillation *T* for a string pendulum is dependent on the length of the pendulum *L*, but does not depend on the mass of the bob *m*. This is to be verified by a series of measurements in which the period of oscillation of such a pendulum is measured by means of a photoelectric sensor connected to a digital counter.

REQUIRED APPARATUS

Quantity	Description	Number
1	Set of 4 Pendulum Bobs	1003230
1	Cord for Experiments	1001055
1	Tripod Stand 185 mm	1002836
1	Stainless Steel Rod 1500 mm	1002937
1	Stainless Steel Rod 100 mm	1002932
1	Clamp with Hook	1002828
2	Universal Clamp	1002830
1	Photo Gate	1000563
1	Digital Counter (230 V, 50/60 Hz)	1001033 or
	Digital Counter (115 V, 50/60 Hz)	1001032
1	Pocket Measuring Tape, 2 m	1002603
1	Electronic Scale 200 g	1003433

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BASIC PRINCIPLES

A string pendulum with a bob of mass m and a length *L* will exhibit simple harmonic oscillation about its rest point as long as the angle of deflection is not too great. The period *T*, i.e. the time it takes for the pendulum to swing from one end of its motion to the other end and back, is dependent solely on the length of the pendulum *L* and not on the mass *m*.

If the pendulum is deflected from its rest position by an angle φ, the restoring force is as follows:

(1a) $$F_1 = -m \cdot g \cdot \sin\varphi \,.$$

For small angles φ, this closely approximates to the following:

(1b) $$F_1 = -m \cdot g \cdot \varphi$$

The moment of inertia of the accelerated mass is given by

(2) $$F_2 = m \cdot L \cdot \ddot{\varphi}$$

Both these forces are equal, thus the result is equivalent for the equation of motion for simple harmonic oscillation:

(3) $$\ddot{\varphi} + \frac{g}{L} \cdot \varphi = 0$$

For the period of oscillation *T* the following applies:

(4) $$T = 2\pi \cdot \sqrt{\frac{L}{g}} \,.$$

In this experiment the period of oscillation will be measured for various lengths of pendulum and masses of bob with the help of a photoelectric sensor connected to a digital counter. The digital counter's internal programming is such that it halts the time measurement after each complete swing of the pendulum.

EVALUATION

The measurements are plotted on a graph of *T* against *L* and another one of *T* against *m*. These graphs will show that the period of oscillation depends on the pendulum's length and not on the mass of the bob, as expected.

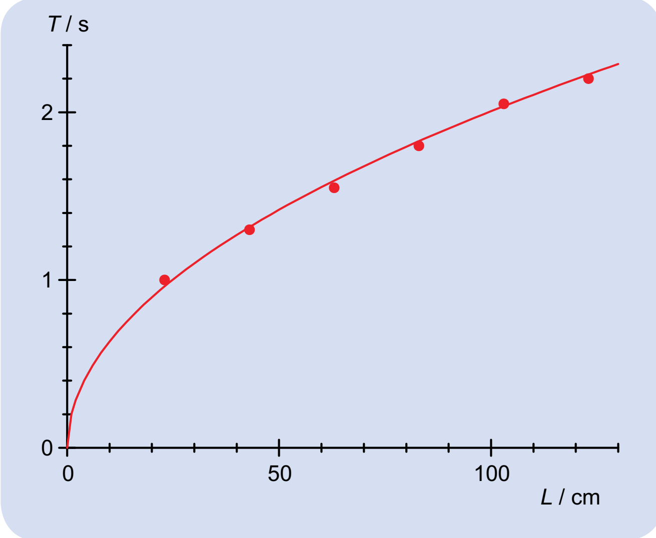

Fig. 1: Period of oscillation *T* as a function of the pendulum length *L*

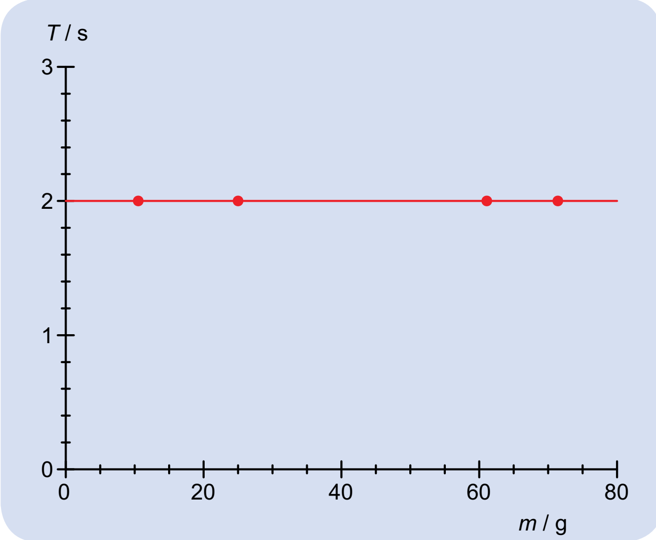

Fig. 2: Period of oscillation *T* as a function of the pendulum mass *m*