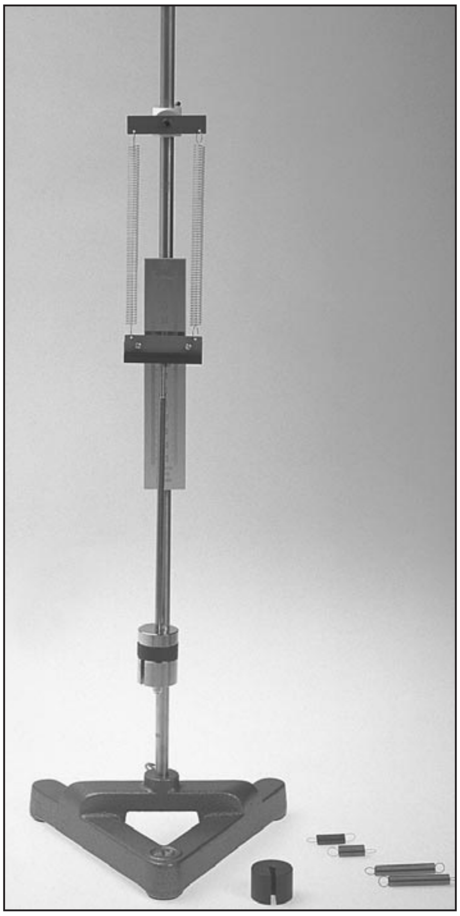
Prytz Oscillation Apparatus

14.12.10 Ae 2180.00



Mounting instructions

The stand rod is fixed to the stand base. The cm-scale is mounted to the vertical rod with the “0" at the top. Next the holder with the mounting bracket is attached to the rod, and the pair of (identical) springs selected for use are attached to the small holes in the bracket. The weight support is then mounted on the springs, and the apparatus is ready for use. The loading can be varied using the weights supplied.

Operation

Illustrating Hooke’s Law

Adjust the cm-scale so that the uppermost edge of the weight-holder is in line with “0" on the scale at the top. Next mount the holder with weights. Now measure corresponding values of the mass and the extension of the spring.

Measuring period of oscillation

The holder is loaded with weights, the system is adjusted to equilibrium. It can be easier to perform this experiment with the scale removed. Set the system in motion by pulling the weight support slightly downward and releasing it. Measure corresponding values of the period and the mass of the weights.

See the appendix for a more detailed description of the experiments.

Description

This apparatus is designed for experiments illustrating Hooke’s law. It can also be used to demonstrate the laws for the spring constants of springs in series and parallel and to find the period of harmonic oscillation of various spring and weight combinations. The apparatus consists of a rod for mounting of weights and pairs of springs. The springs in the pair must be identical. Springs as well as a selection of metal and plastic weights are included. A mirror scale with units marked in centimeters and with mounting brackets is included. See the illustration.

Accessories required

0006.00	stand base
0008.40	stand rod, 60 cm
1485.10	stopwatch, for measuring period of oscillation

Maintenance

There are no special maintenance requirement aside from keeping the apparatus clean and dry. It should be replaced in a safe storage box after use to avoid losing small parts.

Spare parts	Partnumber
Extra springs	
short spring	97790180
medium spring	97790220
long spring	97790260
Extra weights	
small PVC weight (10 g)	2180.0008
large PVC weight (20 g)	2180.0007
small metal weight (50 g)	2180.0006
large metal weight (100 g)	2180.0005

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EXPERIMENT 1: HOOKE'S LAW

Purpose:

The goal of this exercise is to demonstrate Hooke's law for the elongation of springs.

Equipment:

The Prytz apparatus should be mounted on a laboratory stand with no weights placed on the weight support so that the upper knife edge is aligned with the zero-value on the mirror scale.

Procedure:

Apply different forces to the springs by using different combinations of weights. Note the elongation of the springs corresponding to the various forces.

Typical data:

m(g)	0	10	20	30	50	60	70	80	100	120	150	180
x(cm)	0	0.25	0.50	0.75	1.30	1.55	1.80	2.10	2.60	3.15	3.95	4.70

Analysis:

Compute the applied force on the springs by using Newton's second law:

$$F = m \cdot g$$

using SI units and where *F* is the magnitude of the applied force, *m* is the mass of the weights and *g* is the acceleration of gravity. The elongation should be measured in meters. The resulting graph (as shown in Figure 2) can be used to find the effective spring constant of the pair of springs using Hooke's law:

$$F = k \cdot x$$

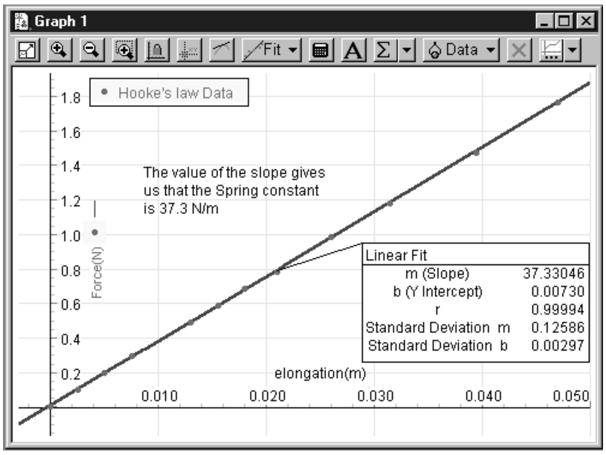

Figure 2: Applied force vs. elongation for Prytz apparatus using the 45 mm spring pair.
The graph is made with DataStudio from Pasco.

A similar experiment can be performed using e.g. the 32 mm spring pair. In this experiment we find that the spring constant *k'* = 17.08 N/m.

Supplementary Experiment:

If we ignore the mass of the springs and consider the situation when the two pairs of springs previously considered with spring constants *k* and *k'* are mounted in series, one pair above the other, we can find a simple expression for the effective spring constant *k"* of the combination. If a force *F* is applied to the combined spring, the tension *F* will be present at all points in the spring system. I.e. each spring will be subjected to the force *F*.

Due to the force *F* acting on the first spring, an-elongation $\Delta x = F/k$ will occur, and due to the force acting on the second spring, the elongation $\Delta x' = F/k$ will occur. The total elongation $\Delta x'' = \Delta x + \Delta x' = F/k + F/k' = (1/k + 1/k') \cdot F$. The effective spring constant k" of this combination is therefore given by the formula:

$$^{1}/_{K''} = (^{1}/_{K}) + (^{1}/_{K'}) <=> k'' = ^{(K \cdot K')}/_{(K + K')}$$

Using the data mentioned above, the series combination of the two spring pairs with *k* = 37.08 N/m and *k'* = 17.08 N/m yields an effective spring constant for the combination *k"* = 11,69 N/m. Using this high quality apparatus you should be able to confirm this relationship with an uncertainty of less than 1%.

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EXPERIMENT 2: HARMONIC OSCILLATION

Purpose:

The goal of this exercise is to illustrate the equations of simple harmonic oscillation using the Prytz apparatus. The experiment will permit confirmation of the equation for the period T of a spring-mass combination.

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

where *k* is the spring constant in N/m, and m is the mass of the weight in kilograms.

Equipment:

The Prytz apparatus should be mounted on a laboratory stand with the 45 mm spring pair and with a mass of 50 g initially placed on the weight holder. Adjust the apparatus so that the knife edge is aligned with the 50 mm position on the mirror scale. Note that the mass of the weight holder is 60 grams, and that the mass of the springs can be neglected in this experiment. A stopwatch or timer will also be required.

Procedure:

Set the system in motion so that a stable vertical oscillation with an amplitude of about 1 cm is achieved. Use a timer to find the total time for 50 complete (up and down) oscillations. Repeat the experiment using masses of 100 grams and 150 grams on the holder. Adding the mass of the weight holder we find the following results:

Typical data:

m(g)	110	160	210
T(s)	0.326	0.410	0.460

Analysis:

The equation for *T* can now be confirmed by graphing *T* against $\sqrt{m}$ as shown in Figure 3. Note that a linear relationship results with a slope which should be equal to $2\pi/\sqrt{k}$. Recalling the value of the spring constant *k* = 37.32 N/m found in Experiment 1, we expect a slope equal to 1.03 in SI units. The slope in Figure 3 is equal to 1.05 $s/m^{1/2}$.

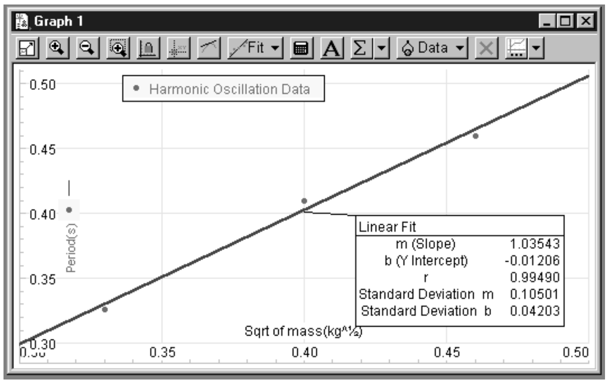

Figure 3: Harmonic motion with Prytz' apparatus. The graph is made with DataStudio from Pasco.

Supplementary Experiment:

As a final experiment it can be instructive to try observing oscillations with the combination of the 45 mm spring pair and the 32 mm spring pair in series (as in Experiment 1). Use a mass of e.g. 100 grams measure the period of oscillation and find the spring constant. Compare this result with the value found for k" in Experiment 1.

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