Helical spring pendulum

Physics → Mechanics → Vibrations & waves

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

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Teacher information

Application

Test setup of the coil spring pendulum

As already shown in previous experiments, each spring has its own spring constant k which can be adjusted by means of the spring force F and the deflection of the spring y can be described as follows:

$$F = k \cdot y$$

If the spring is connected to a mass m is weighted down and deflected from its rest position, the mass is re-accelerated according to the spring force:

$$m \cdot \ddot{y} = -k \cdot y \quad \Rightarrow \quad \ddot{y} + \frac{k}{m} \cdot y = 0$$

Solving the linear homogeneous differential equation with the exponential approach then yields the undamped natural angular frequency ω_o or the oscillation period T.

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Other teacher information (1/2)

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Prior knowledge

Students should have acquired basic knowledge of the determination of spring rates and Hooke's law, as well as experience with vibrating systems.

Scientific principle

A spring with spring constant k which is connected to a mass m is weighted and deflected, oscillates with a natural angular frequency ω_0 or a period duration T:

$$\omega_0 = \sqrt{\frac{k}{m}} \quad \Leftrightarrow \quad T = 2\pi \cdot \sqrt{\frac{m}{k}}$$

Other teacher information (2/2)

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Learning objective

Using a coil spring pendulum, the students should determine the extent to which the period of oscillation T depends on the mass to be loaded m and the spring constant k of the feather.

Tasks

The students should:

1. The oscillation period T of a spring pendulum for different masses m on two springs with different spring constants k investigate.
2. A relationship between the three variables T, m and k manufacture.

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Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

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Student Information

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Motivation

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Coil Springs

Have you ever had a close look behind the tyres of a car? Then you have most likely seen a spring like the one shown in the picture.

These springs are installed in vehicles to compensate for the unevenness of the road and thus increase the driving comfort. However, when such a spring is excited, it tends to oscillate. This duration of the oscillation should be kept as short as possible.

But how can this period of oscillation be influenced? You will examine this aspect more closely in the following experiment.

Tasks

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In this experiment you will investigate the oscillation period of a coil spring pendulum.

To that end, you will:

1. The oscillation period T of a spring pendulum for different masses m on two springs with different spring constants k investigate.
2. The relationship between the three variables T, m and k manufacture.

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Equipment

Position	Material	Item No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
3	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
4	Boss head	02043-00	1
5	Weight holder, 10 g	02204-00	1
6	Slotted weight, black, 10 g	02205-01	4
7	Slotted weight, black, 50 g	02206-01	3
8	Helical spring, 3 N/m	02220-00	1
9	Helical spring, 20 N/m	02222-00	1
10	Spring balance,transparent, 1 N	03065-02	1
11	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
12	Holding pin	03949-00	1

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Set-up (1/2)

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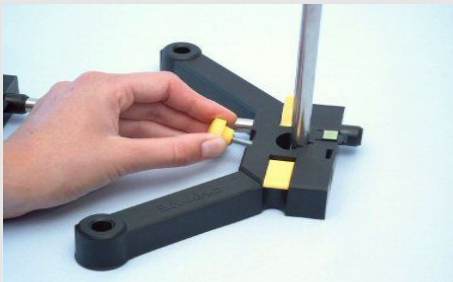
Connect the two halves of the tripod foot to the tripod rod (25 cm) and lock the locking levers. Screw the two-part tripod rod into a long tripod rod (60 cm), insert it into the front half of the tripod foot and fasten it with the screw.

Assembling the tripod base

Screwing the support rods



Fastening with the aid of the screw plug

Set-up (2/2)

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Hook the coil spring into the retaining bolt

- Clamp the double sleeve to the long stand rod.
- Fasten the retaining bolt in the double socket and hang the coil spring $(3\ N/m)$ into the bore of the retaining bolt.

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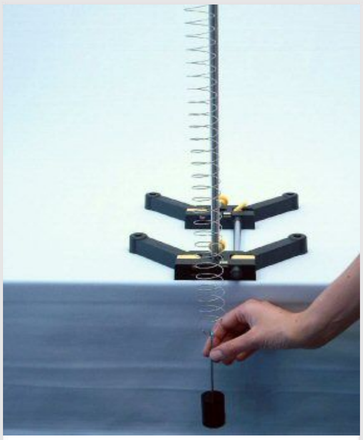
Procedure (1/3)

Spring with different masses m burden

- Load the spring successively with masses m from $20, 40, 60, ..., 140\,g$ including weight plate ($m = 10\,g$).
- To hang the slotted weights on the weight plate, slide them over the upper end of the plate.

Weight plate provided with slotted weights

Procedure (2/3)



Deflecting the spring with the spring constant $3\,N/m$

- Pull the coil spring and let it swing for each mass attached.
- Determine the time required for 10 oscillations for each mass t with the stopwatch.
- Enter all measured values in Table 1 in the protocol.

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Procedure (3/3)

Deflecting the spring with the spring constant $20\,N/m$

- Now use the coil spring $20\,N/m$ and perform the measurements described above again.
- Also enter the measured values obtained in Table 1 in the protocol.

Report

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Table 1

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Carry your readings from the test with the $3\,N/m$ spring on the left in the table. The measured values of the $20\,N/m$ you enter in the table on the right. Calculate from the values t for 10 oscillations the respective oscillation period T and its square T^2 and enter the values as well.

$m\,[g]$	$t_3\,[s]$	$T_3\,[s]$	$T_3^2\,[s^2]$	$t_{20}\,[s]$	$T_{20}\,[s]$	$T_{20}^2\,[s^2]$
20						
40						
60						
80						
100						
120						
140						

Task 1

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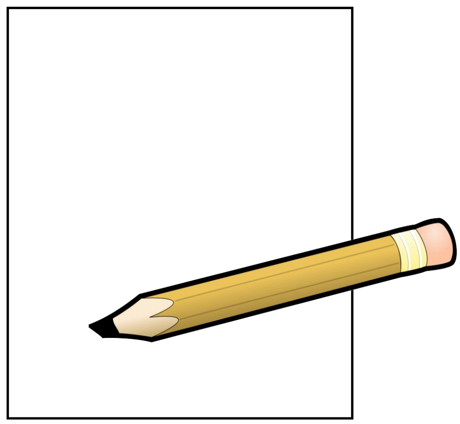
- Now take a piece of paper and create a diagram on it. In this diagram you set the oscillation period T (y-axis) depending on the mass m (x-axis). Generate the curve for both the $3\,N/m$ spring, as well as for the $20\,N/m$ Feather.
- Afterwards also carry the square of the oscillation periods T^2 (y-axis) depending on the mass m (x-axis). Create the curve as before for both springs.



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Task 2

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Look at the first diagram. It shows T as a function of mass m and the spring constant k. What can you tell about the influence of m and k on the period of oscillation?

- [ ] The greater the spring constant k the greater the period of oscillation T.
- [ ] The smaller the spring constant k the greater the period of oscillation T.
- [ ] The smaller the mass m the greater the period of oscillation T.
- [ ] The greater the mass m the greater the period of oscillation T.

Check

Task 3

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Test setup of the coil spring pendulum

What knowledge do you get from the application of the squares of the period of oscillation T^2 as a function of mass?

- [ ] $m^2 \sim T$
- [ ] $T^2 \sim m$
- [ ] $m \sim \sqrt{T}$
- [ ] $T \sim \sqrt{m}$

Check

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Task 4

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Test setup of the coil spring pendulum

What knowledge do you get from the application of the squares of the period of oscillation T^2 as a function of mass, taking into account the influence of the spring constant?

- [ ] $T \sim \sqrt{m \cdot k}$
- [ ] $T \sim \sqrt{m/k}$
- [ ] $T^2 \sim m \cdot k$
- [ ] $T^2 \sim m/k$

Check

Task 5

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Do the curves in diagrams 1 and 2 go through the coordinate origin? Can you imagine what cause is responsible for this?

- ○ The curve for the small spring constant goes through the origin.
- ○ The curves in both diagrams do not go through the zero point. The reason for this is the neglect of the spring mass m_f which is also proportionally included in the period duration.
- ○ The curve for the large spring constant goes through the origin.

Check

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Slide	Score / Total
Slide 18: influence of \(m\) and \(k\) at \(T\)	**0/2**
Slide 19: Application of the squares \(T^2\) (1)	**0/2**
Slide 20: Application of the squares \(T^2\) (2)	**0/2**
Slide 21: Coordinate origin	**0/1**

Total amount 0/7

Solutions Repeat Exporting text

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