Potential energy and elastic energy (Item No.: P1001500)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physik	Klasse 7-10	Mechanik	Arbeit und Leistung	Potentielle Energie und Spannenergie

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

Preliminary experiment

In this experiment the students should discover that the expended energy - in this case the lifting work - is not lost. It can be transformed into other forms of energy, which in this case appear as tension and/or kinetic energy.
Through observations the students should establish that after the mass "falls" on the spring there is still energy in the system; this becomes evident when the mass is released at its lower reversal point.

Main experiment

By applying the laws of energy the students should determine the elastic energy of a helical spring as a function of its extension: $W_H = W_S$.
Through the evaluation of the measuring results in a diagram the students should recognize that the elastic energy of a helical spring is proportional to the square of its extension.

Remark

A mass-spring system oscillates. To determine the elastic energy of a spring at its lower reversal point, it is necessary to select the height of the mass at the upper reversal point (relaxed spring) so that the mass just touches the table at its lower reversal point (Preliminary experiment 2). To set this height correctly the spring's extension Δl is first established for a resting mass (Hooke's law); then this distance is doubled: $h = 2 \cdot \Delta l$.

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Task and equipment

Task

How much energy is contained in a stretched spring?

- Observe how much energy is required to lift a mass and how much to stretch a helical spring.
- Hang a mass on a helical spring and let it "fall" on the spring. Observe the process and describe it using the energy concept.
- Determine the energy that is contained in a stretched spring using the equations of energy.

Equipment

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
3	Boss head	02043-00	2
4	Weight holder for slotted weights	02204-00	1
5	Slotted weight, black, 10 g	02205-01	3
6	Helical spring, 3 N/m	02220-00	1
7	Spring balance,transparent, 2 N	03065-03	1
8	Holding pin	03949-00	1
9	Plate with scale	03962-00	1
10	Measuring tape, l = 2 m	09936-00	1
11	Glass tube holder with tape measure clamp	05961-00	1

Set-up and procedure

Set-up

Screw the splitt support rod together (Fig. 1). Set up a stand with the support base (Fig. 2). Put the support rod into the support base and lock it with the screw (Fig. 3).

Fig. 1

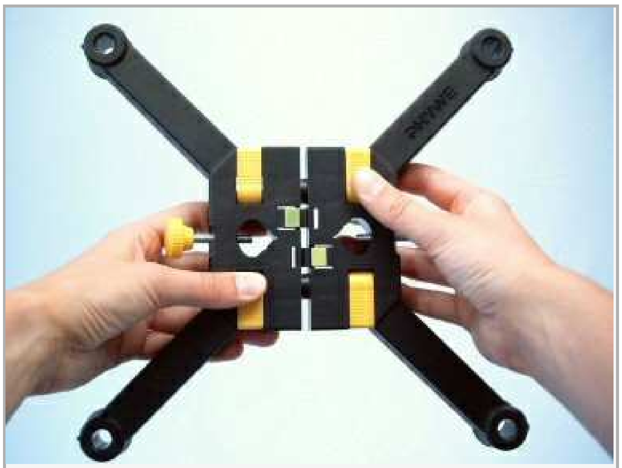

Fig. 2

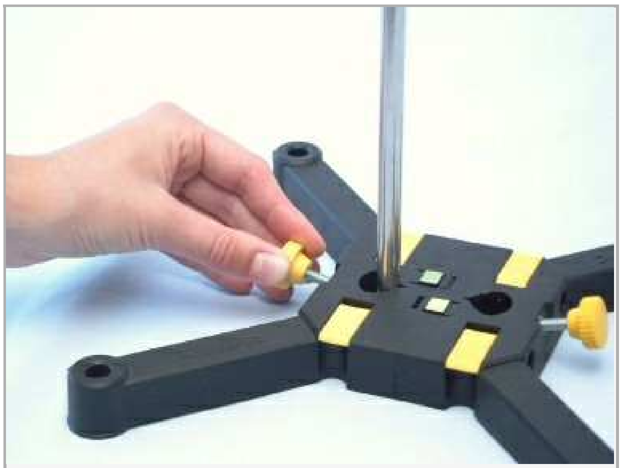

Fig. 3

Clamp the extended measuring tape in the glass tube holder and clamp both on the bottom of the support rod (Fig. 4). Fix the bosshead on the support rod and then fix the holding pin in the bosshead. Hang the helical spring in the hole of the holding pin (Fig. 5).

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Fig. 4

Fig. 5

Adjust the length of the measuring tape so that its zero mark is exactly at the same level as the lower end of the helical spring (Fig. 6).

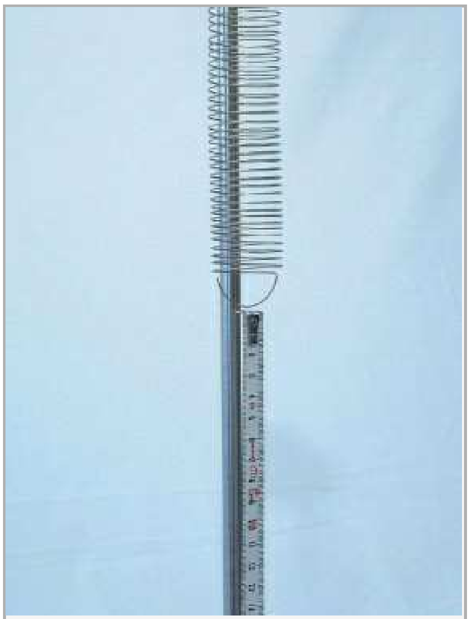


Fig. 6

Procedure

Preliminary experiment 1

- Lift a 40 g mass with the spring balance and observe the balance's indicator (Fig. 7).
- Attach the helical spring as close to the top of the support rod as possible.
- Pull down on the helical spring with the spring balance and observe the indicator at different extensions (Fig 8).


Fig. 7


Fig. 8

Preliminary experiment 2

- Now hang a 40 g mass on the helical spring and let it "fall". Observe the process (Fig. 9).
- Lower the suspension point far enough that the mass just touches the table top at the lower reversal point of its oscillation.
- Hold the mass against the table top so that it touches the table, then release it again and observe the continued course of its movement (Fig. 10).


Fig. 9


Fig. 10

Main experiment

- Hang the weight holder (m = 10 g) on the helical spring and determine the spring's extension.
- Increase the mass in increments of 10 g to max. 40 g and determine for each mass the extension Δl (Fig. 11).
- Record the values for Δl in Table 1 in the report.
- Calculate the height h from $h = 2 \times \Delta l$ and record this value in Table 1, too.

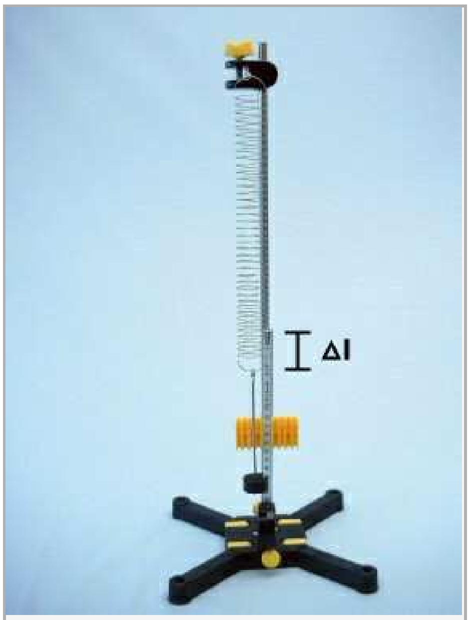


Fig. 11

- Attach the plate on the lower bosshead at height *h* which you determined for *m* = 10 g (Fig. 12).
- Lift the mass (*m* = 10 g; the weight holder) with the spring balance onto the plate and read the weight (force) F_g while you are lifting.
- Record its value in Table 1 in the report.
- Shift the suspension point of the spring so that its bottom hook is just at the height of the weight holders hook (Fig. 12).

Fig. 12

- Now hang the weight holder (*m* = 10 g) on the spring and let it "fall". Observe the process (Fig. 13)!
- Repeat the experiment the same way (3 times) for the masses *m* = 20, 30 and 40 g.

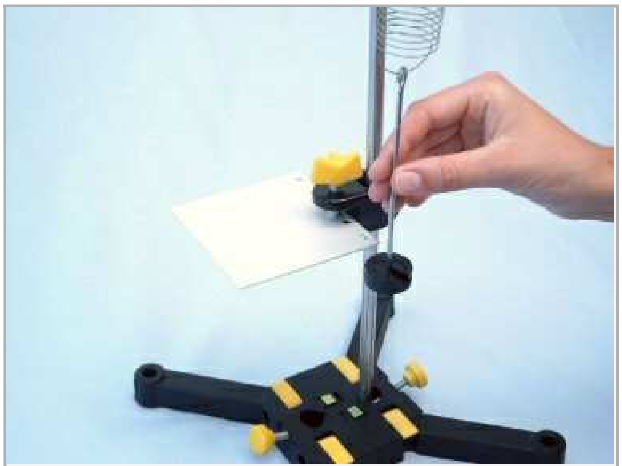


Fig. 13

In order to disassemble the support base you should press the yellow buttons (Fig. 14).

Fig. 14

Report: Potential energy and elastic energy

Results – Table 1

Record all the measured values in table 1.

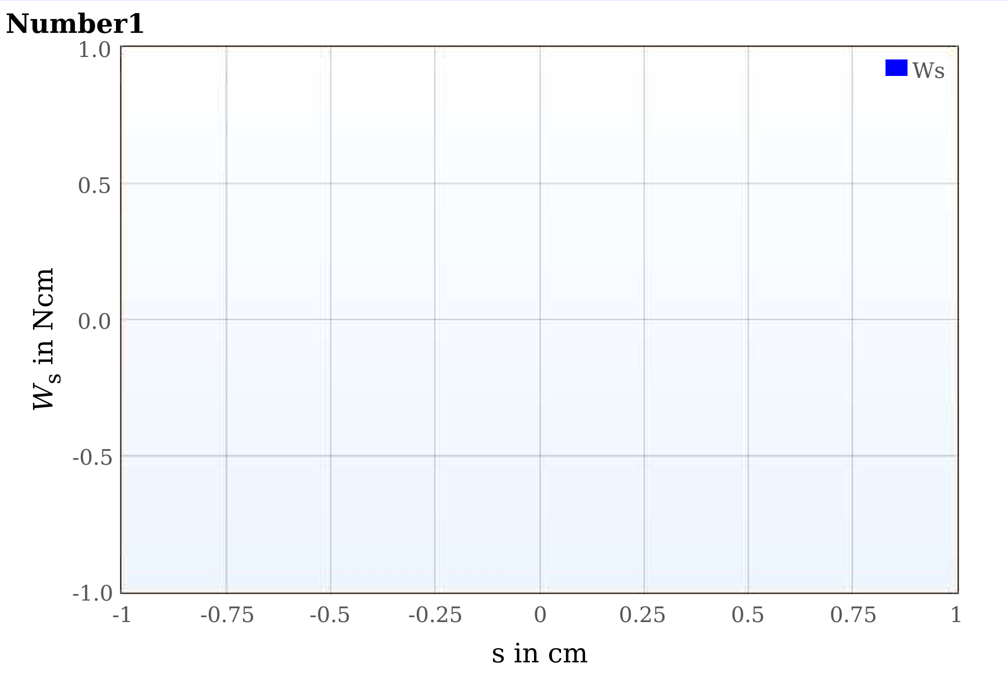
Calculate the lifting work W_H from the values determined for h and m, and from F_g; record the results in table 1.

m in g	Δl in cm	h in cm	F_g in N	W_H in Ncm
10	1	1	1	1
20	1	1	1	1
30	1	1	1	1
40	1	1	1	1

Results – Table 2

Record the extensions $s = h$ and the elastic energy $W_S = W_H$ in table 2.

m in g	*s* in cm	W_S in Ncm	*C*
10	1	1	1
20	1	1	1
30	1	1	1
40	1	1	1



Evaluation – Question 1

What differences do you observe on the spring balance's indicator when lifting a mass and stretching a spring?

Evaluation – Question 2

A mass *m* at height *h* has a potential energy W_p which is equal to the invested lifting work W_h. When you "drop" this mass while it is hanging on the spring, the potential energy is again transformed. How does this become apparent in preliminary experiment 2 which you have just completed?

Evaluation – Question 3

When the mass which is falling on the spring is held against the table top - i.e., at its lowest point - it should have already released the lifting work invested during lifting. What happens when you release the mass again?

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Evaluation – Question 4

How can you explain this phenomenon?

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Evaluation – Question 5

Calculate the factor C from the elastic energies by dividing each higher value by the value for 10 g, i.e. W_S (20 g)/W_S (10 g) etc. Record the values for C in Table 2. What do you notice when you examine the values?

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Evaluation – Question 6

Create a chart with data of table 2. You can see the measured values for W_S as a function of *s*.
What does the course of the curve obtained by joining the lines look like?

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Evaluation – Question 7

What correlation between s and W_S can be seen in the measurements and calculations?