# Potential energy and span energy with Cobra SMARTsense

The pupils should understand the conversion of energy with the help of a spring. Tension energy is converted into kinetic energy and potential energy and vice versa.

Physics → Mechanics → Forces, work, power & energy

| Difficulty level | Group size | Preparation time | Execution time |
|---|---|---|---|
| easy | 2 | 10 minutes | 10 minutes |

This content can also be found online at:

http://localhost:1337/c/61237e12e3e7380003d486bb

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# Teacher information

## Application

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Test setup

### Potential energy and tension energy

Energy conversion is an everyday phenomenon.

In hydroelectric power plants, for example, potential energy is converted into kinetic energy. Electrical energy is then generated from kinetic energy.

In this experiment, the conversion of energy is reproduced with the aid of a spring. Tension energy is converted into kinetic energy and potential energy and vice versa.



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## Teacher information (1/2)

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**Prior knowledge**

Students should be familiar with the concepts of energy and work and the mechanical forms of energy.

**Scientific Principle**

The total energy of a closed system does not change with time. This fact is based on the law of conservation of energy. Although energy can be converted between various forms of energy, it is never lost. Additionally, energy can be brought into or taken out of a closed system.

The SI unit of energy $W$ (or $E$ ) is joules: $1\,J = 1\,Nm$

The tension energy of a coil spring is: $W = \frac{1}{2} \cdot D \cdot x^2 = \frac{1}{2} \cdot F \cdot x$

## Teacher information (2/2)

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**Learning objective**

In this experiment, the students should learn that energy can be converted into different forms of energy. As an example, this is examined in the case of span energy, kinetic energy and potential energy.

**Task**

Students:

1. Observe what force is required to lift a mass and what force is required to tension a coil spring.
2. Hang a mass on a helical spring and let it "fall" on the spring. They also observe the process and describe it using the concept of energy.
3. Determine the energy contained in a spring under tension using the energy theorem.



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## Safety instructions

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

Annotation:

A mass-spring system performs oscillations. In order to be able to determine the tension energy of the spring at the lower reversal point of the oscillation, it is necessary to select the height of the mass at the upper reversal point (relaxed spring) so that the mass at the lower reversal point of the oscillation just touches the table (preliminary experiment 1). To set this height safely, the extension $\Delta l$ of the spring by a mass at rest is determined (Hooke's law) and this distance is then doubled: $h = 2 \cdot \Delta l$.

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# Student Information



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## Motivation

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In hydropower plants, potential energy is converted into kinetic energy. Electrical energy is then generated from kinetic energy.

### Potential energy and tension energy

Energy conversion is an everyday phenomenon.

In this experiment you will learn about energy conversion with the help of a spring. Tension energy is converted into kinetic energy and potential energy and vice versa.

Test setup

## Task

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Test setup

1. Observe what force is required to lift a mass and what force is required to tension a coil spring.
2. Hang a mass on a helical spring and let it "fall" on the spring. Observe the process and describe it using the concept of energy.
3. Determine the energy contained in a spring under tension by applying the energy theorem



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# Equipment

| Position | Material | Item No. | Quantity |
|---|---|---|---|
| 1 | Cobra SMARTsense - Force and Acceleration, ± 50N / ± 16g (Bluetooth + USB) | 12943-00 | 1 |
| 2 | Support base, variable | 02001-00 | 1 |
| 3 | Support rod, stainless steel, l = 600 mm, d = 10 mm | 02037-00 | 1 |
| 4 | Boss head | 02043-00 | 2 |
| 5 | Weight holder, 10 g | 02204-00 | 1 |
| 6 | Slotted weight, black, 10 g | 02205-01 | 3 |
| 7 | Helical spring, 3 N/m | 02220-00 | 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 |
| 12 | measureAPP - the free measurement software for all devices and operating systems | 14581-61 | 1 |



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## Set-up (1/3)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows



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## Set-up (2/3)

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- Rotate the two-part tripod rod together.
- Assemble the tripod base and the tripod rod into a tripod.
- Clamp the tape measure into the glass tube holder.
- Then clamp the glass tube holder to the bottom of the tripod rod.

## Set-up (3/3)

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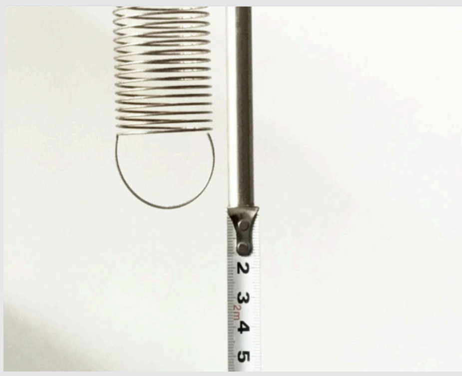
- Fix the force sensor in the double socket and hang the coil spring on it.
- Adjust the tape measure so that its zero mark coincides with the end of the coil spring.



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## Procedure (1/8)

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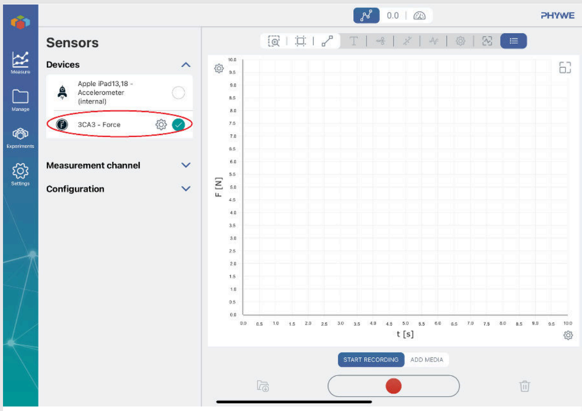
Switch on




Select sensor in measureAPP

- First remove the coil spring from the force sensor again.
- Switch on the force sensor by pressing the power button for several seconds. After successful switching on, you will see a flashing LED (left figure).
- Start the measureAPP. Tap on the tab "Devices" and select the force sensor (right figure).

## Procedure (2/8)

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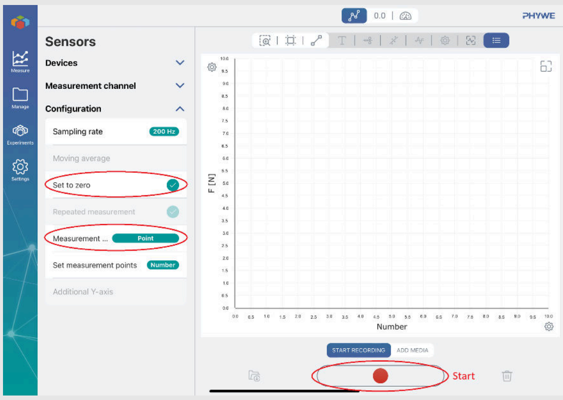
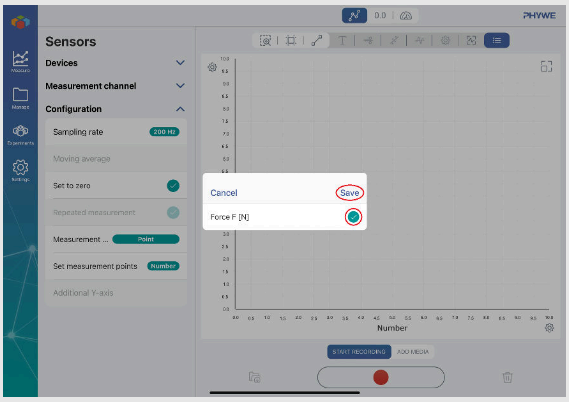
- Tap on the tab "Configuration" and select "Measurement on keystroke" (left figure). In the same tab, tap on "Set to zero" and select the force sensor in the following window.
- Exit the window by clicking on save (right image).



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## Procedure (3/8)

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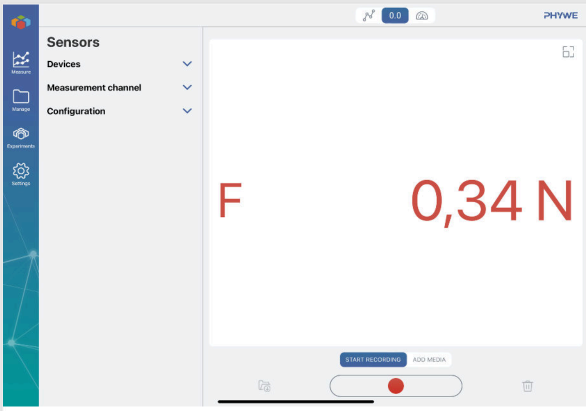


Implementation -**Preliminary test 1**

- Hang a mass of 30 g on the force sensor and observe the instantaneous value of the force in the measureAPP.
- Then hang the coil spring back on the force sensor and set it to zero again.
- Attach the force sensor with the coil spring as high as possible to the stand rod.
- Pull down on the coil spring with your hand and also observe the instantaneous force reading.

## Implementation (4/8)

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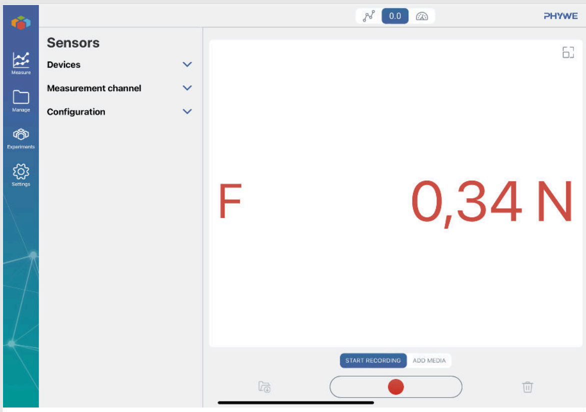


Implementation -**Preliminary test 2**

- Now hang a mass of 30 g on the coil spring and let it "fall". Observe the process.
- Lower the suspension point so that the mass just touches the table at the lower reversal point of the oscillation.
- Then hold the mass when it touches the surface of the table, release it afterwards and observe the further course of the experiment.



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# Procedure (5/8)

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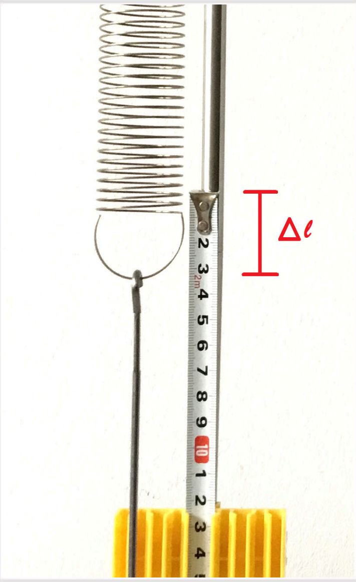


- Hang the weight plate ( $m = 10g$ ) to the coil spring and determine the extension of the spring.
- Increase the mass by each $10g$ up to max. $40g$ and determine for each mass the extension $\Delta l$(Illustration).
- Enter the values for $\Delta l$ in Table 1 in the log.
- Calculate the height $h$from $h = 2 \cdot \Delta l$and enter these values in Table 1 as

# Procedure (6/8)

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- Remove the glass tube holder with the tape measure and fix the second double socket together with the plate in the lower part of the stand rod.
- Set the plate at the lower double socket to the height $h$ ...that you've been using for... $m = 10g$ ...you've been investigating.
- Measure the weight force of the mass $m = 10g$(weight plate) with the force gauge. To do this, you can briefly remove the coil spring again. Remember to reset the sensor to zero beforehand.
- Then place the weight back on the plate and reattach the coil spring to the force sensor. Enter the result of the weight force in Table 1 in the log.



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## Procedure (7/8)

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- Move the suspension point for the spring so that its lower eyelet is just at the height of the hook on the weight plate.
- Remove the plate, hang the weight plate ( $m = 10g$ ) to the feather and let it fall. Observe the process.
- Repeat the experiment (2 times) in the same way for the masses $m = 20g$and $m = 30g$.

## Procedure (8/8)

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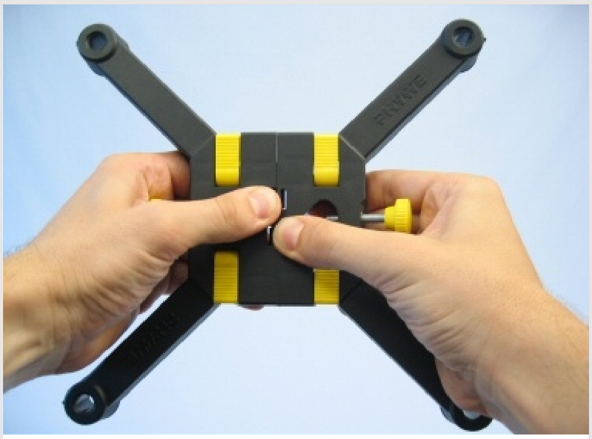

Feedthrough - Tripod base

- To disassemble the tripod base, press the buttons in the middle and pull both halves apart.



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# Report

## Table 1

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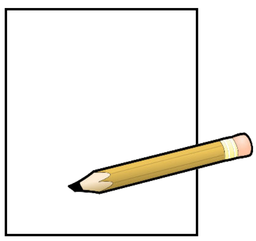
Carry the deflections $\Delta l$ and the calculated total swing height $h = 2 \cdot \Delta l$and the corresponding weight force $F_G$ and the associated stroke energy $W_{Hub} = F_G \cdot h$ in the table.

| $m$ $[g]$ | $\Delta l$ $[cm]$ | $h$ $[cm]$ | $F_G$ $[N]$ | $W_{Hub}$ $[Ncm]$ |
|---|---|---|---|---|
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 40 | | | | |

Sketch on a sheet of paper a diagram with the total deflection $h$ on the X-axis and the energy $W_{hub} = W_{spann}$ on the Y-axis.





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## Table 2

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| $m$ in [g] | $s$ in [cm] | $W_s$ in [Ncm] | $C$ |
|---|---|---|---|
| 10 | | | |
| 20 | | | |
| 30 | | | |
| 40 | | | |

- Carry the deflections $s = h$and the span energy $W_s = W_h$in the table.
- Calculate the factor $C$from the stress energies by dividing the higher value by the value for $10g$dividing, so $\frac{W_S(20g)}{W_S(10g)}$ etc.

## Task 1

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What differences do you observe in the force gauge reading when lifting a mass and stretching a spring?

- The force in lifting a mass is independent of the displacement, while in deflecting a spring the force increases with the deflection.
- The force in lifting a mass depends on the displacement, while in deflecting a spring the force increases with the deflection.
- The force in lifting a mass is independent of the displacement, while in deflecting a spring the force decreases with the deflection.



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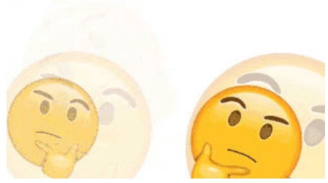
## Task 2

How can you explain this phenomenon?

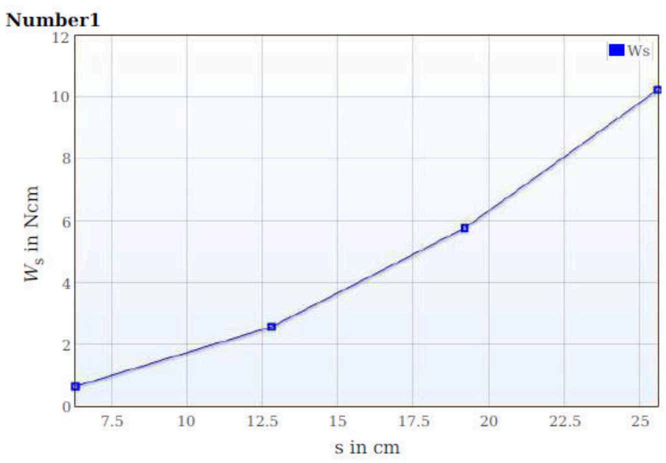
The energy put into it - the energy generated by the ______ supplied potential energy - is converted into ______ is converted. On the table surface, the potential energy again corresponds to the ______. The tension energy ______ is released when the mass is released again. It is transformed into kinetic energy (kinetic energy $E_{kin}$) and ______ of the mass: $E_{pot} = W_H$.

- stored in the system
- potential energy
- initial energy
- voltage energy $E_S$
- stroke work $W_H$

Check



## Task 3




You see the measured values for $W_S$ as a function of $s$.

What is the shape of the curve you get after connecting the measuring points?

- The curve in the diagram corresponds to a straight line, it has a linear course.
- The curve in the diagram corresponds to a parabola, it has a quadratic course.



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