Force reduction with a two-sided lever (Item No.: P6104100)

Curricular Relevance

Area of Expertise: Natural Sciences

Education Level: Age 11-14

Topic: Nature and technology

Subtopic: Mechanic devices in daily use

Experiment: Force reduction with a two-sided lever

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

Additional Requirements:

Experiment Variations:

- Digital measurement data recording with a tablet PC and Cobra4 sensor

Keywords:

lever (arm), load, weight, force reduction

Information for the teacher

Educational objective and competences

During this experiment, the students will observe the relationship between weight and the length of the lever arm of a two-sided lever. They will notice that the point of application of different masses affects the effort which is necessary in order to keep the lever in balance. In addition, they will see how the force, which needs to be applied, changes depending on the point of application of the spring balance or force sensor. They will conclude that force (or effort) can be reduced with the aid of a two-sided lever if the mass and spring balance or force sensor are positioned in a suitable manner.

Standard experiment set-up

Experiment set-up for measurements with a tablet PC

Competences

Process-related competences:

K: Knowledge gain
C: Communication
A: Assessment

The students can...

K02 – develop problem-related questions and formulate hypotheses.
K03 – describe relationships with sentences of the type "The more/less..., the more/less..." or "The greater/higher/smaller/lower..., the greater/higher/smaller/lower...".
K06 – execute simple experiments independently based on written instructions.
K08 – recognise technical concepts in examples from everyday life.
K09 – plan, execute and document simple experiments by themselves.
K12 – make assumptions about connections and causes.

C02 – describe the technical connections and relationships in everyday language.
C03 – acquire measurement data and extract them from age-appropriate representations.
C05 – present their results with the aid of specified media.
C06 – express and accept criticism.
C07 – work in groups on their own initiative.
C09 – read age-appropriate, relevant texts and relay the content thereof.

A01 – appraise their own results based on a comparison with other groups.
A02 – recognise the role of scientific phenomena in their everyday life.
A03 – evaluate arguments, take up a position and substantiate their point of view.
A06 – explain the areas of application in which scientific knowledge is of importance.

Content-related competences:

The students can...

S: Specialised knowledge

S13 – distinguish between weight and mass.
S14 – use the unit of force (1 N).
S16 – set up simple "machines" and "devices".
S17 – demonstrate, in an experimental manner, that simple machines can be used to reduce the required forces.

Equipment

Position No.	Material	Order No.	Quantity
1	Weight holder for slotted weights	02204-00	1
2	Slotted weight, black, 10 g	02205-01	9
3	Support base, variable	02001-00	1
4	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with	02035-00	1
5	Boss head	02043-00	1
6	Lever	03960-00	1
7	Holding pin	03949-00	1
8	Spring balance, transparent, 2 N	03065-03	1

Material for the standard set-up

Additional material for measurements with a tablet PC

In order to perform the experiment with digital measurement data recording via a tablet PC, the following additional material is required.

The spring balance is not required for this variant.

Position No.	Material	Order No.	Quantity
1	Fishing line, l = 20 m	02089-00	1
2	Cobra4 Wireless/USB-Link	12601-09	1
3	Cobra4 Sensor-Unit Force, ±10 N	12646-00	1
4	Apple iPad		1
5	PHYWE measure App		1

Download on the App Store

Material for measurements with a tablet PC

Safety information

- For this experiment, the general notes and instructions concerning safe experimentation in science classes apply.
- Prior to performing the experiment, you should warn the students that a loaded spring balance may rebound when it is unloaded.
- Inform the students that a high support stand can tip over easily when they pull on it high at the top.

Didactic notes

Procedure

- The mass object and spring balance or force sensor can be attached to the lever in 10 different positions. The slotted weights can be used to configure different masses. For a particularly detailed evaluation of the experiment, the students can try out all of the possible positions and masses. However, they will also achieve the objective of the experiment if they try out only 3 or 4 positions and masses.
- The students will realise that the effort (or force) that needs to be applied for transporting a load can be reduced if suitable devices are used. However, this is only possible if the distance over which the force must act is extended. This means that the resulting work is the same (if not more). Ask your students whether they realise this "disadvantage" of the new method.

Technical terms

It is important that the students are familiar with the concept of "mass" and that they use this term in science classes instead of "weight" when they talk about mass. Mass is a material property while weight is a force. In a simplified manner, "mass" is what can be measured in kg or g by way of a scale.

Tablet PC option

In addition to the classic variant, you can also let the students perform the experiment with the Cobra4 equipment and tablet PCs. The digital measurement data recording method enables the students to quickly acquire the measurement data, understand them more readily and to evaluate them in a particularly comfortable way.

- Remove the spring balance from the set-up and replace it with the Sensor-Unit "Force" connected to the Cobra4 Wireless/USB-Link. The students perform the same measurements with the Sensor-Unit. They record the values directly in the form of a diagram, which immediately demonstrates the relationship between the individual points of measurement. If the students save their measurement series for each part of the experiment, they can retrieve the exact values from the stored measurements and use them for the questions in the experiment report.
- In order to ensure that the hook of the Sensor-Unit "Force" can apply force to the load points of the lever, the students need to take a piece of string and tie a loop which must then be suspended from the lever. We recommend preparing small pieces of string of approximately 10 cm and tying the loops in advance.

Force reduction with a two-sided lever (Item No.: P6104100)

Standard experiment

Introduction

You have surely already seen or even played on a see-saw on a playground. In addition, you may have noticed that your position on the see-saw leads to different results.

If you sit right at the end of the board, your side of the see-saw goes down quickly. If you sit closer to the centre, you remain longer up in the air.

This means that your position determines the direction in which the see-saw tips more easily.

See-saw on a playground

Application

In your everyday life, you often encounter two-sided levers in cases in which you want to perform certain things with less force:

- A pair of scissors: Thanks to their long handles, you can cut through paper and other materials more easily.
- Pliers: They can be used to cut through thick wire or to loosen screws with less effort.
- A boom barrier in the forest: It has a counterweight at one end so that the heavy pole can be raised and lowered more easily.

Task

In earlier experiments, you have already learned that the spring balance or force sensor indicates a force of 1 N (1 Newton) if you use it to directly lift a mass of 100 g.

During this experiment, you now want to find out with how much force you need to pull the lever so that it is horizontal if a mass is suspended from the other side of the lever.

In addition, you want to study the change in force when you change the suspended mass or when you change the position of the mass on the lever.

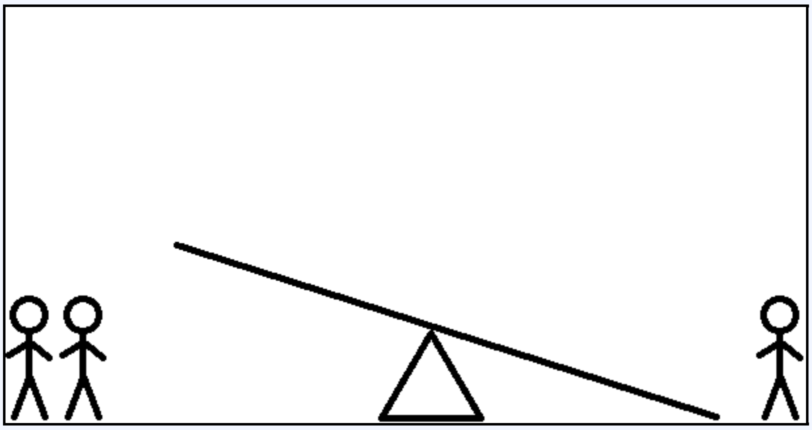
Experiment set-up

Assumption

Can you sit alone on one side of the see-saw on the ground if two of your classmates sit on the other side of the see-saw?

Initial question

Your two classmates are on the left and you are on the right. You all have approximately the same mass. Where do you sit and where do your classmates have to sit?



Equipment and procedure

Position No.	Material	Order No.	Quantity
1	Weight holder for slotted weights	02204-00	1
2	Slotted weight, black, 10 g	02205-01	9
3	Support base, variable	02001-00	1
4	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with	02035-00	1
5	Boss head	02043-00	1
6	Lever	03960-00	1
7	Holding pin	03949-00	1
8	Spring balance, transparent, 2 N	03065-03	1

Set-up

First screw the two parts of the support rod together (Fig. 1). Set up a support system like the one shown in Figs. 2 and 3 with the aid of the support base and support rod.

Fig. 1

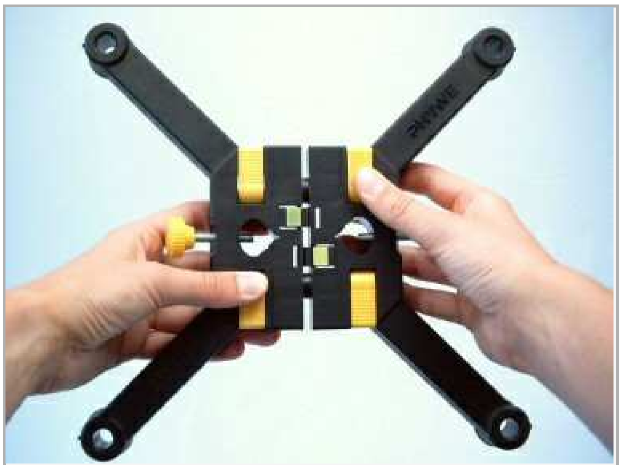


Fig. 2

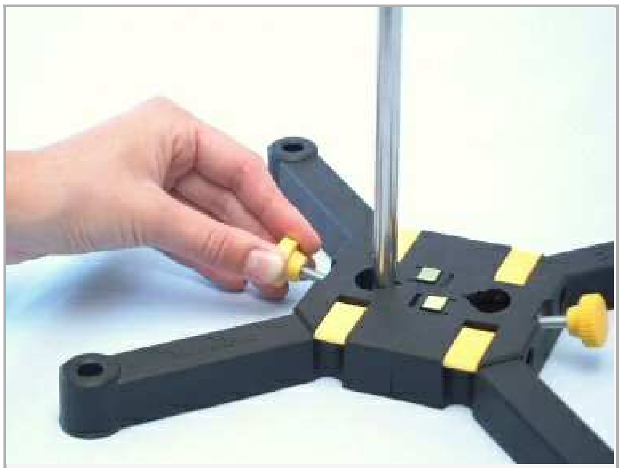


Fig. 3

Fasten the right-angle clamp to the support rod.

Push the holding pin through the upper hole in the middle of the lever and then secure the holding pin in the right-angle clamp (Figs. 4 and 5).

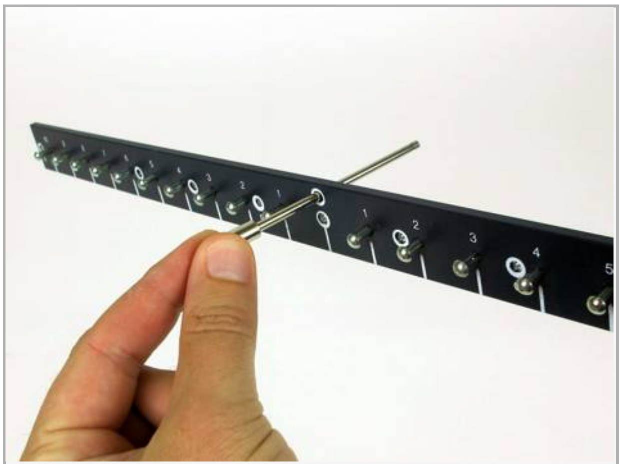


Fig. 4

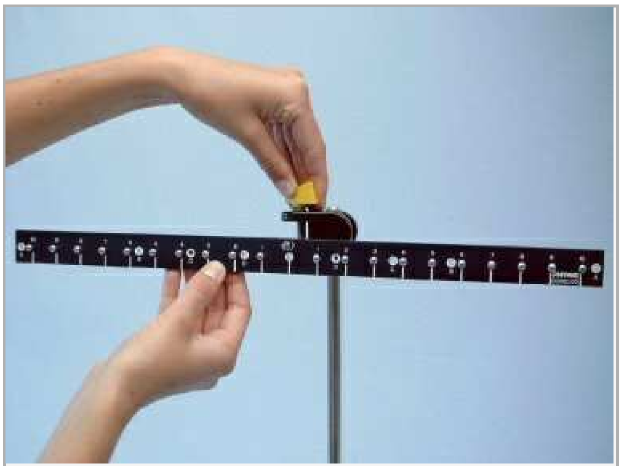


Fig. 5

Before the measurements, hold the spring balance upside down and adjust it to zero (Fig. 6).

Fig. 6

Robert-Bosch-Breite 10
D - 37079 Göttingen

Tel: +49 551 604 - 0
Fax: +49 551 604 - 107

info@phywe.de
www.phywe.com

Procedure

1. Suspend the weight holder and the spring balance from the lever at opposite ends. Ensure that both are suspended from a point with the same mark, e.g. both from the mark "10".

   Pull the spring balance down until the lever is horizontal as shown in Fig. 7. Read the value that is indicated by the spring balance.

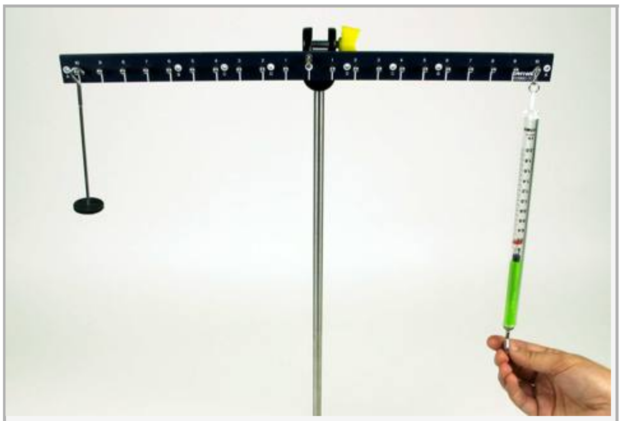


Fig. 7

   Add more slotted weights one after the other to the weight holder. For each step, adjust the lever so that it is horizontal and read the value that is indicated by the spring balance. Continue until all of the weights are placed on the weight holder as shown in Fig. 8.

   Observe how the force changes when you add a new weight to the weight holder.

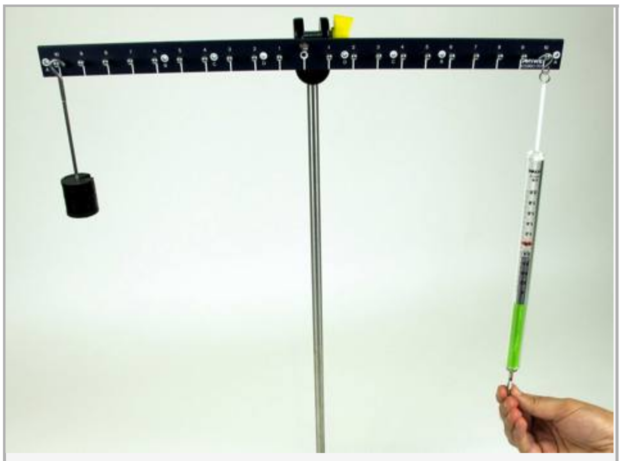


Fig. 8

2. Then, take the weight holder with all of the 9 weights and suspend it from the lever in different positions (Fig. 9).

   Start with a position far at the end of the lever and then move the weight holder step by step closer to the middle until you reach position "1". For each step, measure the force with the spring balance suspended from position "10" on the other side of the lever.

   Observe whether the force changes.

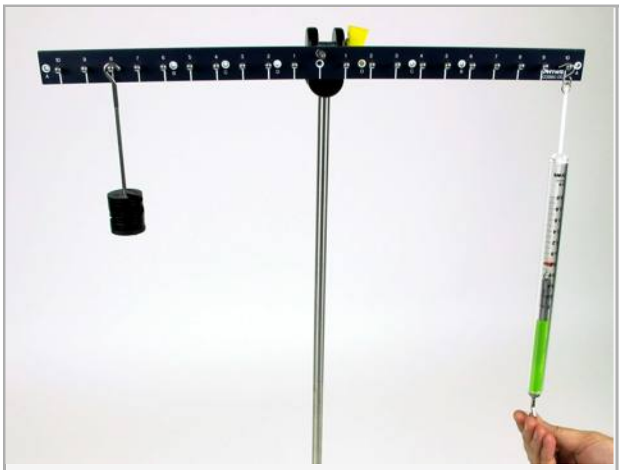


Fig. 9

3. Then, suspend the weight holder with 3 weights from a position closer to the middle (position "5") (Fig. 10).

   Measure the force acting on the lever at different positions on the other side of the lever.

   Observe whether the force changes.

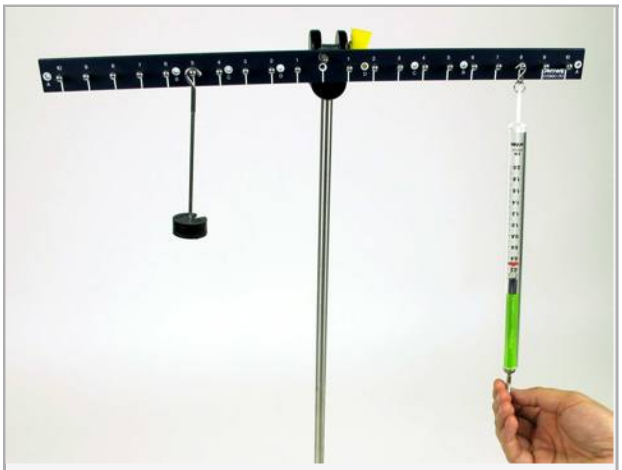


Fig. 10

Evaluation

The weight holder and each of the slotted weights have a mass of 10 g. If you suspend them directly from the spring balance, it indicates 0.1 N for the empty weight holder. With each slotted weight, the value increases by 0.1 N.
During the experiment, you have explored how the value indicated by the spring balance changes when you hold the weights with the aid of the two-sided lever.

Go to the experiment report and answer the questions about the experiment.

Experiment (with a tablet PC)

Introduction

You have surely already seen or even played on a see-saw on a playground. In addition, you may have noticed that your position on the see-saw leads to different results.

If you sit right at the end of the board, your side of the see-saw goes down quickly. If you sit closer to the centre, you remain longer up in the air.

This means that your position determines the direction in which the see-saw tips more easily.

See-saw on a playground

Application

In your everyday life, you often encounter two-sided levers in cases in which you want to perform certain things with less force:

- A pair of scissors: Thanks to their long handles, you can cut through paper and other materials more easily.
- Pliers: They can be used to cut through thick wire or to loosen screws with less effort.
- A boom barrier in the forest: It has a counterweight at one end so that the heavy pole can be raised and lowered more easily.

Task

In earlier experiments, you have already learned that the spring balance or force sensor indicates a force of 1 N (1 Newton) if you use it to directly lift a mass of 100 g.

During this experiment, you now want to find out with how much force you need to pull the lever so that it is horizontal if a mass is suspended from the other side of the lever.

In addition, you want to study the change in force when you change the suspended mass or when you change the position of the mass on the lever.

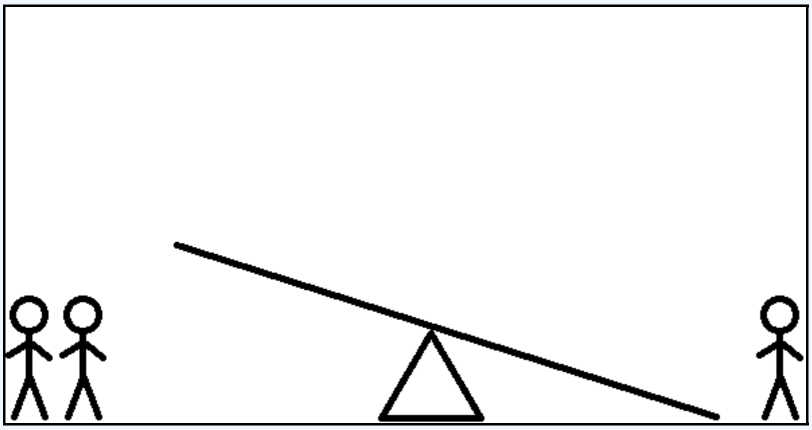
Experiment set-up

Assumption

Can you sit alone on one side of the see-saw on the ground if two of your classmates sit on the other side of the see-saw?

Initial question

Your two classmates are on the left and you are on the right. You all have approximately the same mass.
Where do you sit and where do your classmates have to sit?



Equipment and procedure

Position No.	Material	Order No.	Quantity
1	Weight holder for slotted weights	02204-00	1
2	Slotted weight, black, 10 g	02205-01	9
3	Support base, variable	02001-00	1
4	Support rod, l = 600 mm, d = 10 mm, split in 2 rods with	02035-00	1
5	Boss head	02043-00	1
6	Lever	03960-00	1
7	Holding pin	03949-00	1
8	Fishing line, l = 20 m	02089-00	1
9	Cobra4 Wireless/USB-Link	12601-09	1
10	Cobra4 Sensor-Unit Force, ±10 N	12646-00	1
11	Apple iPad		1
12	PHYWE measure App		1

Set-up

First screw the two parts of the support rod together (Fig. 1). Set up a support system like the one shown in Figs. 2 and 3 with the aid of the support base and support rod.

Fig. 2

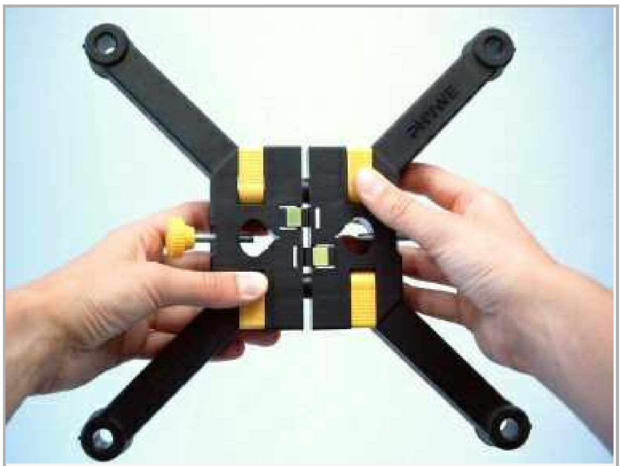


Fig. 2

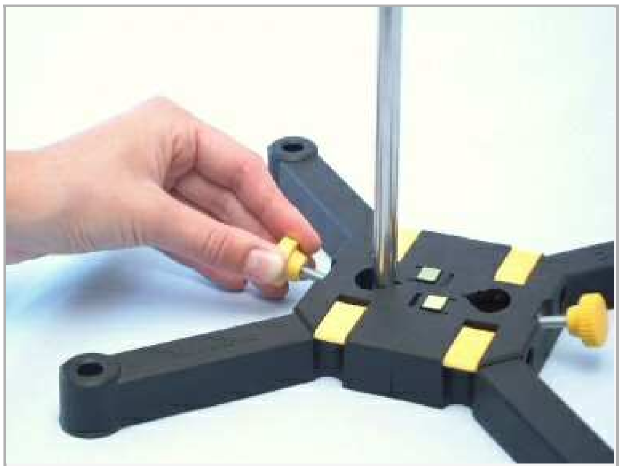


Fig. 3

Fasten the right-angle clamp to the support rod.

Push the holding pin through the upper hole in the middle of the lever and then secure the holding pin in the right-angle clamp (Figs. 4 and 5).

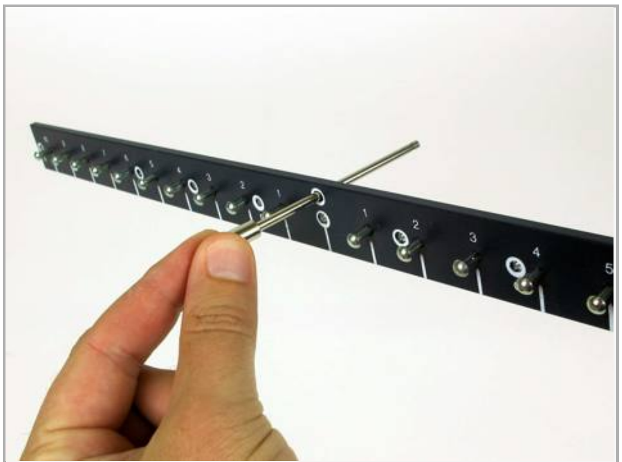


Fig. 4

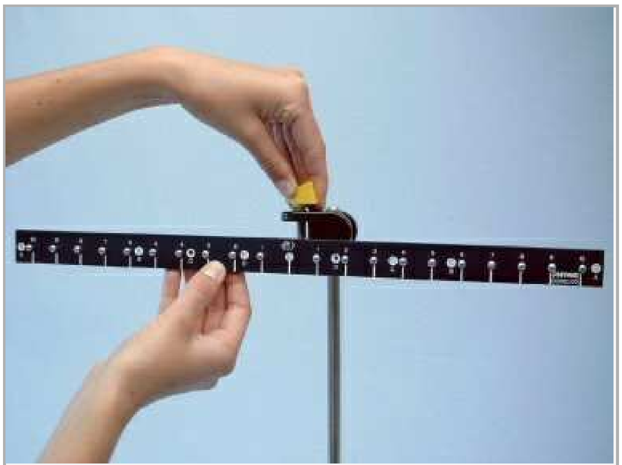


Fig. 5

Procedure

Connect the ''Wireless/USB-Link" and the sensor and switch the device on.

Connect your tablet PC with the "Wireless/USB-Link" and open the "measure" app.

Select the connected sensor.

Hold the force sensor with the hook up and select "Set to zero".

Open the diagram window.

Select "Repeated measurement".

In order to fasten the Sensor-Unit "Force" to the lever by its hook, you must take a piece of string, tie a small loop and attach it to the pins of the lever.

1. Suspend the weight holder and the force sensor from the lever at opposite ends. Ensure that both are suspended from a point with the same mark, e.g. both from the mark "10".

   Pull the force sensor down until the lever is horizontal as shown in Fig. 6. Perform a measurement for one measuring point.

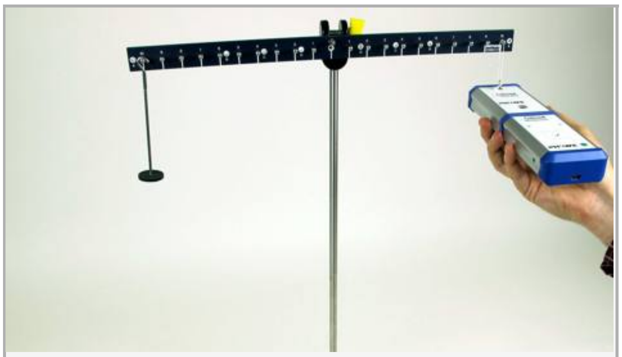


Fig. 6

   Add more slotted weights one after the other to the weight holder. For each step, adjust the lever so that it is horizontal and perform a measurement. Continue until all of the weights are placed on the weight holder as shown in Fig. 7.

   Observe how the force changes when you add a new weight to the weight holder.

   Then, stop the measurement.

Fig. 7

2. Then, take the weight holder with all of the 9 weights and suspend it from the lever in different positions.

   Start with a position far at the end of the lever and then move the weight holder step by step closer to the middle until you reach position "1". For each step, measure the force with the force sensor suspended from position "10" on the other side of the lever.

   Perform a measurement each time and observe whether the force changes.

   Then, stop the measurement.

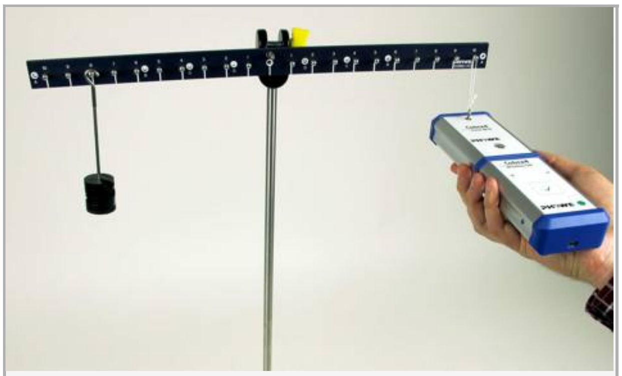


Fig. 8

3. Then, suspend the weight holder with 3 weights from a position closer to the middle (position "5").

   Measure the force acting on the lever at different positions on the other side of the lever.

   Perform a measurement each time and observe whether the force changes.

   Then, stop the measurement.

Fig. 9

Evaluation

The weight holder and each of the slotted weights have a mass of 10 g. If you you suspend them directly from the force sensor, it indicates 0.1 N for the empty weight holder. With each slotted weight, the value increases by 0.1 N.
During the experiment, you have explored how the value indicated by the force sensor changes when you hold the weights with the aid of the two-sided lever.

Go to the experiment report and answer the questions about the experiment.

Report: Force reduction with a double-sided lever

Observation - question 1

You have placed different slotted weights on the weight holder. The weight holder and the spring balance or force sensor were suspended from two identical positions.

Does the value that is indicated by the spring balance or force sensor change when the weights are placed on the weight holder? If so, what was the cause of this change?

The weight holder and spring balance or force sensor have the same distance to the pivot point (fulcrum). The measured force equals the weight of the suspended mass (weight holder + slotted weights). This means that the measured force is the same force that would be measured if the mass was lifted directly.

Observation - question 2

The more slotted weights are placed on the weight holder, the greater,higher is the indicated force.

The change of force is the same,equal for every additional weight.

Observation - question 3

You have suspended the weight holder with the same number of weights from the lever at different positions. The spring balance or force sensor for measuring the force was always located at the same position.

Does the indicated force change?

- [x] yes
- [ ] no

Observation - question 4

How does the indicated force change if the mass is suspended from a position closer to the middle of the lever?

- [x] The force decreases.
- [ ] The force increases.
- [ ] The force does not change.

Observation - question 5

You have suspended the weight holder from a fixed position. Then, you have measured the force at different positions of the lever.

The further the force is measured at the end of one side of the lever, the...

- [ ] greater the indicated force is.
- [x] smaller the indicated force is.

Evaluation - question 6

How can a two-sided lever help to reduce force? There are two correct answers!

- [ ] When the mass is suspended at the far end of the lever.
- [x] When the mass is suspended close to the middle of the lever.
- [x] When the lever is held at the far end.
- [ ] When the lever is held close to the middle.

Evaluation - question 7

Why is the lever, which is used for this experiment, referred to as a "two-sided" lever?

The lever is suspended at its centre and there is a force acting on both sides of the lever.

On the one side, this is the weight of the mass and, on the other side, this is the force that is needed for holding the spring balance or force sensor.

Evaluation - question 8

What is your advantage when you use a two-sided lever for lifting a mass?

With a two-sided lever, you can reduce the force that is needed for lifting a mass.

To do so, the mass must be suspended close to the pivot point (fulcrum) of the lever and you must pull at the far end of the other side of the lever.

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

Evaluation - question 9

Name objects or devices from your everyday life which can be used for force reduction with a two-sided lever.

Scissors

Pliers

Boom barrier

See-saw

Catapult

Oar

Beam balance

Spade

Shovel

Crowbar

Initial question (repeated)

Can you sit alone on one side of the see-saw on the ground if two of your classmates sit on the other side of the see-saw?

Your two classmates are on the left and you are on the right. You all have approximately the same mass.

Where do you sit and where do your classmates have to sit?