Weight with SMARTsense (Item No.: P0999069)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Mechanics
Subtopic: Forces, simple machines
Experiment: Weight with SMARTsense

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

Additional Requirements:

Experiment Variations:

Keywords:

weight, gravity, gravitation, weight force

Teachers information

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Goal:
The students should be brought to understand the difference between a mass and the weight of it here – the force of weight, i.e. the weight is dependent on the gravitational field, but the mass is not. The use of a force meter that shows forces and not a common balance should help to make the difference clear.

Notes on set-up and procedure:

Attention should by given to the zeroing of the force sensors – without this a linear dependence between weight and mass is given at constant gravitational field, but no proportionality; zero mass should be zero force.
It is more accurate to talk of pieces of mass rather than slotted weights. The students should be told that the slotted weights represent pieces of mass.

Generally, a "point by point measurement" is used. Since the mass is increased in fixed steps, the graph shows a linear dependency. Here, clarification might by useful. There is a big difference between the plot of the force against number of measurement and force against acutal mass. This can be shown by increasing the mass in different steps. Here, no linear plot appears on the tablet but after analysing and plotting mass against force the linear dependency becomes obvious again (can be seen in the report). This can also be used to obtain intraclass variance by allowing students with high performance to choose their own step size.

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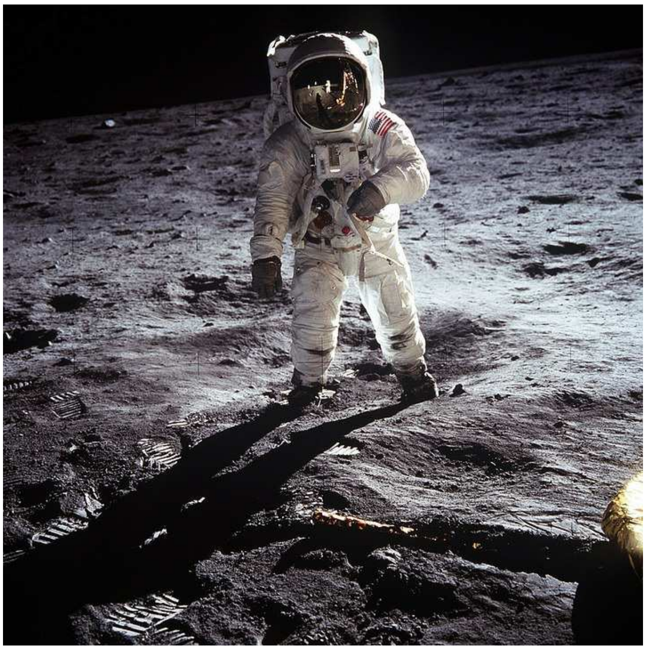
Overview

Introduction

Why can't we fly and jump like an astronaut in space?



An astronaut in space has difficulties to move around like we do on earth. He seems to be weightless and has to be careful not to fly away. But an astronaut does not magically loose all his mass. So how comes, we can't jump as easily as an astronaut on the moon? The blame lies with gravity and the force that it proposes to mass. This force is called weight and it was already discovered by Newton who found that every single object falls down towards earth. Within this experiment, you should measure this weight.

Equipment

Position No.	Material	Order No.	Quantity
1	Cobra SMARTsense-Force	12904-00	1
2	Support base variable	02001-00	1
3	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
4	Support rod with hole, stainless steel, 10 cm	02036-01	1
5	Boss head	02043-00	1
6	Weight holder for slotted weights	02204-00	1
7	Slotted weight, 10 g, black	02205-01	4
8	Slotted weight, 50 g, black	02206-01	3
9	Fishing line, l = 20 m	02089-00	1
Additional materials:			
10	Tablet PC with "measure" App		1

Android iPad

Tasks

- Use the force sensor to measure the force of weight (weight) that the slotted weights experience in the gravitational field of our planet.
- Determine the connection between the mass of the slotted weights and the force of weight that is exerted on them.

Setup and procedure

Setup

- Set up the stand as shown in Fig. 1 by fitting the support base together and fastening the support rod. Attach a boss head on the rod.
- You need the Cobra SMARTsense-Force.

  Turn on the Cobra SMARTsense-Force sensor. Open the „measure“ app and select the force sensor.
- Make a loop from fishing line that is to hold the weight holder to the small hook of the force sensor.

Fig.1: Setup

Procedure

- At first, the sensor has to be tared by hanging the loop but no weights on the force sensor hook.
- Select “Set to zero” in your "measure" app . Choose the force parameter and save the changes.
- The display should now show a force of 0.000 N.
- Choose "Point-by-point measurement". And start the recording for the 0 g.
- Hang the weight holder (10 g) with two 10 g slotted weights, i.e. a mass of 0.030 kg, in the loop. Take down the next data point.
- Increase the hanging mass in steps of 0.030 kg up to 0.180 kg and complete Table 1. Save your measurement.

Fig. 2: Examplary measurement

Results and evaluation

Your data should resemble fig. 2. Open the report for further evaluation.

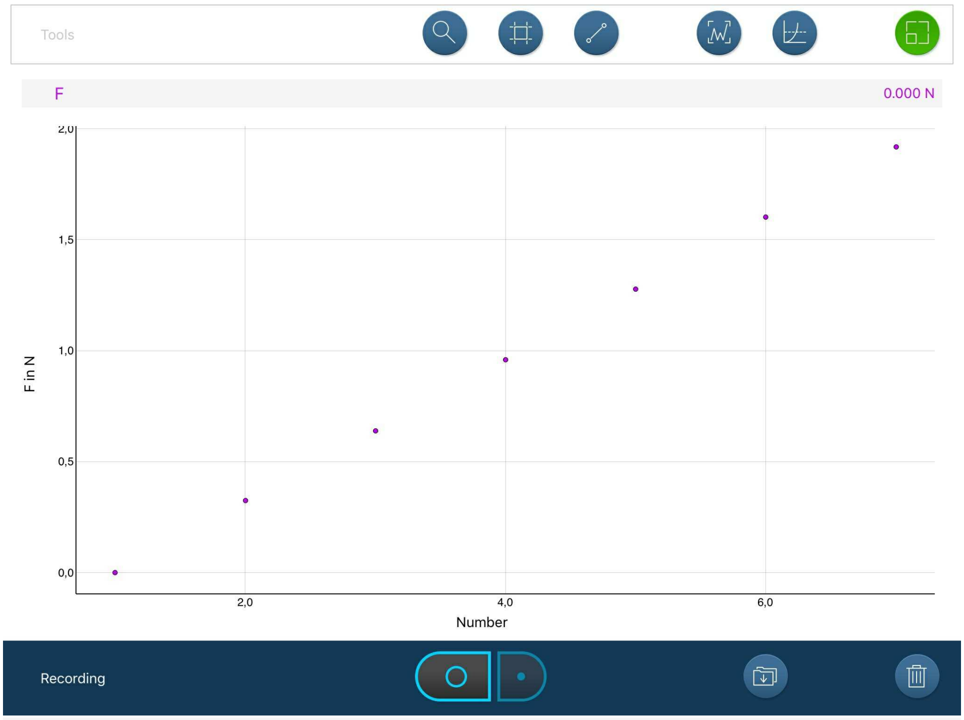


Fig. 2: Examplary measurement.

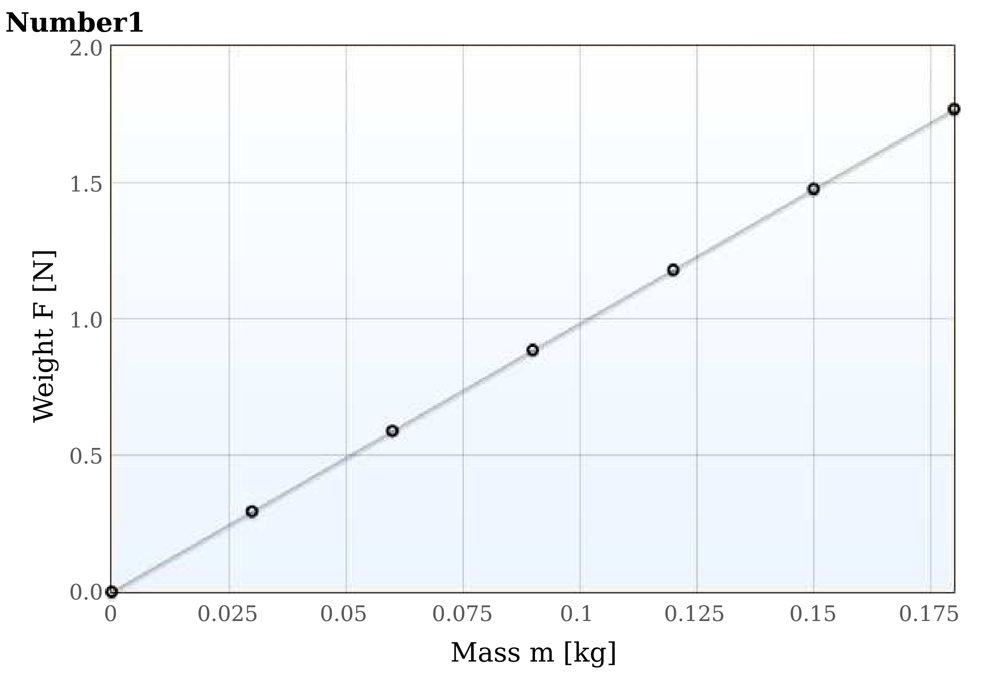
Report: Weight with SMARTsense

Result - Table 1 (10 points)

Enter your measured values in Table 1 and calculate *g* from your data and build the average!

Table 1: Measured values for the weight and evaluation

Measurement Point	Mass m [kg]	Weight F_G [N]	$g = F_G/m$ [N/kg]
1	0.000	0.000	-
2	0.030	0.295 ± 1	9.83
3	0.060	0.590 ± 1	9.83
4	0.090	0.886 ± 1	9.84
5	0.120	1.180 ± 1	9.83
6	0.150	1.476 ± 1	9.84
7	0.180	1.769 ± 1	9.83
		average:	9.83 ± 4



Result - Question 2 **(3 points)**

Which dependency between mass and weight do you assume from the graph that you have created? See Fig. 4.

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Result - Question 3 (2 points)

Calculate the average of the measured values for g, enter it in Table 1. Compare it with the literature value for Central Europe of g = 9.81 N/kg (= 9.81 m/s^2 as 1 N = 1 kg·m/s^2).

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Results - Additional task 1 (2 points)

Remark:
g is called gravity acceleration. Newton's law of inertia states that the force F is equal to the product of mass m and acceleration *a, F = m·a.* Equation (1) can be rearranged to $F_G = m \cdot g$, which corresponds to the law of inertia. This experiment so suggests the equality of inert and heavy mass. The equality of inert and heavy mass cannot be derived from any physical theory, but is required as a basic assumption. For example, general relativity theory assumes that an observer in a closed crate cannot in principle determine, whether the crate is continually accelerated or resides in a gravitational
field.

Which physical quantity does a common balance measure?

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Results - Additional task 2 (6 points)

When a balance display shows a mass, what has the manufacturer assumed from the start and would the balance show the correct value on the moon (acceleration due to gravity on the moon surface g_{Moon} = 1.62 N/kg)?

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Results - Additional task 3 (10 points)

How can this problem be handled with the help of a beam-balance?

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Results - Additional task 4 (4 points)

Which mass m has a weight of 1 N?
On earth: m = ... g, on the moon m = ... g.