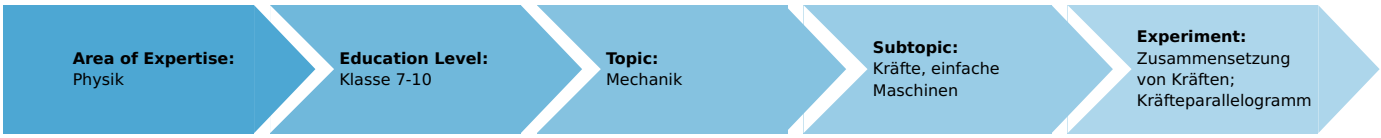
Combination of forces, parallelogram of forces

(Item No.: P0999500)

Curricular Relevance



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

Additional Requirements:

- Scissors
- Protractor sheet, copy

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

Based on their knowledge of Experiment P0999400, the students should determine the direction and magnitude of the resultant force F_r which replaces the two different forces F_1 and F_2. Without knowledge of the trigonometric functions, the evaluation can be performed graphically with the aid of a force parallelogram or it can be calculated as a supplementary problem, if the students are familiar with the trigonometric functions.
The protractor sheet (circle with angular divisions) which is required for the evaluation is provided as a master which can be copied. The xerox copies should be given to the students before they begin the experiment.

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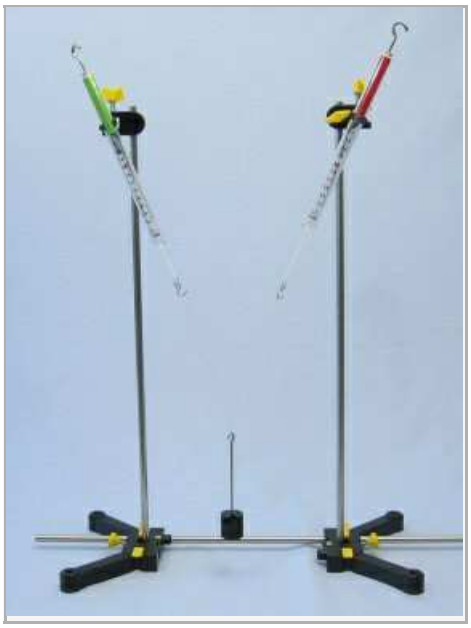
Combination of forces, parallelogram of forces (Item No.: P0999500)

Task and equipment

Task

Can two forces with different directions be replaced by one force?

In this experiment the weight force of a mass is to be measured by two spring balances which are at an angle to each other and the perpendicular. The evaluation is performed graphically.



Equipment

Set-up and procedure

Set-up

Procedure

- Set the bossheads holding the spring balances at the same height.
- Hold the protractor sheet so that the center of the circle is exactly behind the suspension point of the mass and that the direction of the weight (force) coincides with one of the protractor's major axes (Fig. 9).
- Adjust the 1 N spring balance in its holder so that both angles (α_1 und α_2) which the forces F_1 and F_2 form with the perpendicular line are equal (Fig. 10).

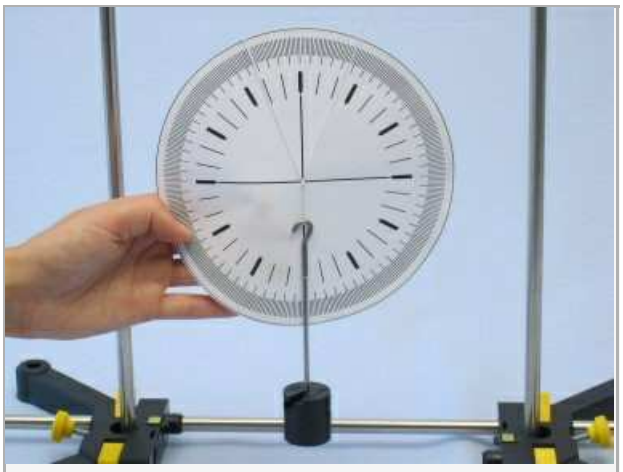


Fig. 9

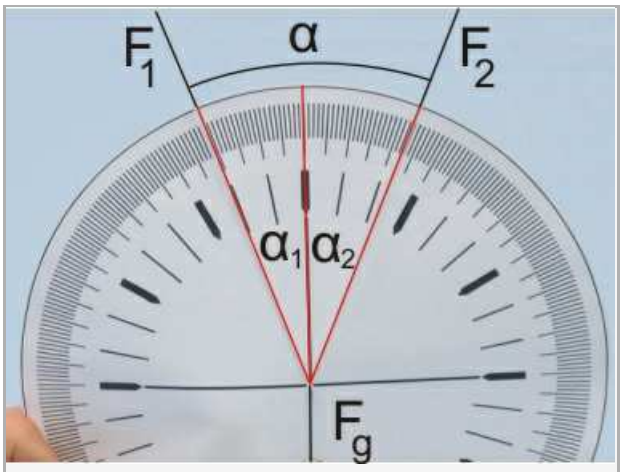


Fig. 10

- Set the angles approximately equal to those given in Table 1 on the Results page by progressively pulling the two halves of the support base apart (Fig. 11). Read the angles α_1 and α_2 and the forces F_1 und F_2 ; note the values in Table 1.

Fig. 11

- Starting in the original position move the 1 N spring balance progressively downwards.
- Set the angle α1 approximately equal to those values given in Table 2 on the Results page as shown in Fig. 12 and Fig. 13.
- Once again read both angles and the forces for each step. Record the values in Table 2.

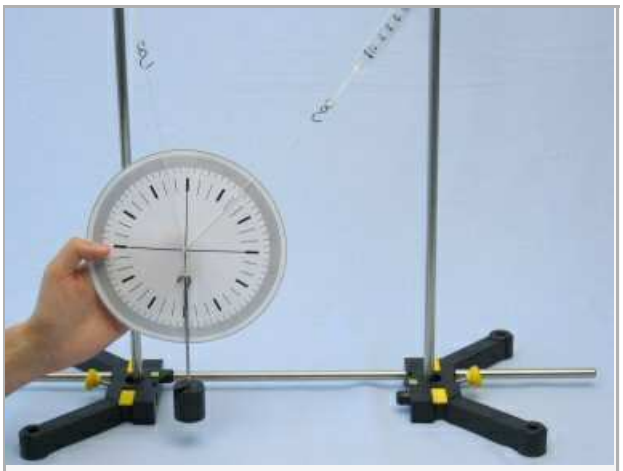


Fig. 12

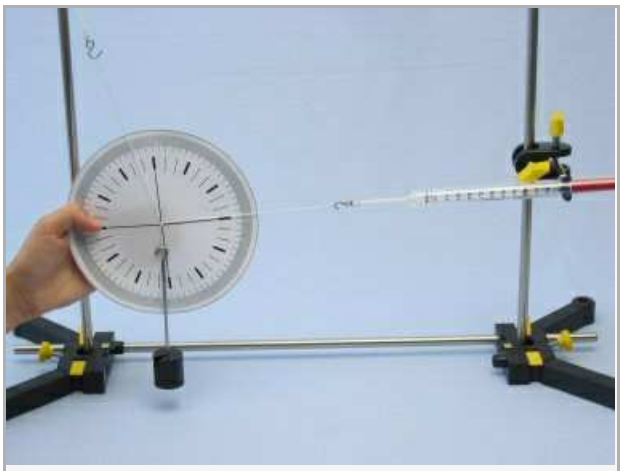


Fig. 13

Report: Combination of forces, parallelogram of forces

Results – Table 1

Record the measured values in Table 1. (m = 100 g; F_g = 1 N.)

Calculate α from α_1 and α_2 and complete the table.

α_1 in °	α_2 in °	α in °	F_1 in N	F_2 in N	F_r in N
20	20	1 ±0	1 ±0	1 ±0	1 ±0
30	30	1 ±0	1 ±0	1 ±0	1 ±0
40	40	1 ±0	1 ±0	1 ±0	1 ±0
50	50	1 ±0	1 ±0	1 ±0	1 ±0

Results – Table 2

Record the measured values in Table 2. Calculate α from α_1 and α_2 and complete the table.

α_1 in °	α_2 in°	α in °	F_1 in N	F_2 in N	F_r in N
40	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
55	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
70	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
90	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
115	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0

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Evaluation – Question 1

Using the measured values in Table 1 ($\alpha_1=\alpha_2$), draw one force parallelogram. Use a specific scale for the force, e.g. 1 N corresponds to 10 cm.

Determine the resultant force F_r from the diagrams graphically and record the value in the table.

Evaluation – Question 2

Using the measured values in Table 2 (different angles), draw one force parallelogram. Use a specific scale for the force, e.g. 1 N corresponds to 10 cm. Determine the resultant force F_r with from the diagrams graphically and record the value in the table.

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Evaluation – Question 3

Compare the graphically determined values for the resultant force F_r with the weight (force) F_g. What do you observe?

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Evaluation – Question 4

Formulate the result of the experiment:

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Evaluation – Question 5

Describe how you determined the resultant F_r:

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Evaluation – Additional Task

Calculate the resultant force F_{rb} for several measurements using: $\sqrt{F_1^2 + F_2^2 + 2 \times F_1 \times F_2 \times \cos(\alpha)}$ and compare the values obtained with the weight (force) F_g and the values F_r for the resultant force which were determined from the diagrams.

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