Composition of non-parallel forces (Item No.: P1252300)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Mechanik
Subtopic: Kräfte, einfache Maschinen
Experiment: Zusammensetzung nicht paralleler Kräfte

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Principle and equipment

Principle

Investigate how the resultant force of two forces can be determined if their lines of action are not parallel.

Equipment

Position No.	Material	Order No.	Quantity
1	Demo Physics board with stand	02150-00	1
2	Hook on fixing magnet	02151-03	1
3	Torsion dynamometer	03069-03	2
4	Scale for demonstration board	02153-00	1
5	Helical spring, 20 N/m	02222-00	1
6	Optical disk, magnet held	08270-09	1
7	Marker, black	46402-01	1

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Set-up and procedure

Set-up

- Place the hook on fixing magnet near the upper edge of the demonstration board and hang the helical spring on it.
- Place the two dynamometers below the spring in such a manner that their traction cords, whose free ends are hooked to the lower end of the helical spring, sag slightly.
- Adjust both dynamometers and then move them so that the helical spring is stretched, e.g. by approximately 7 cm.
- Place the protractor disk onto the demonstration board in such a manner that its centre is exactly behind the lower end of the helical spring (Fig. 1).

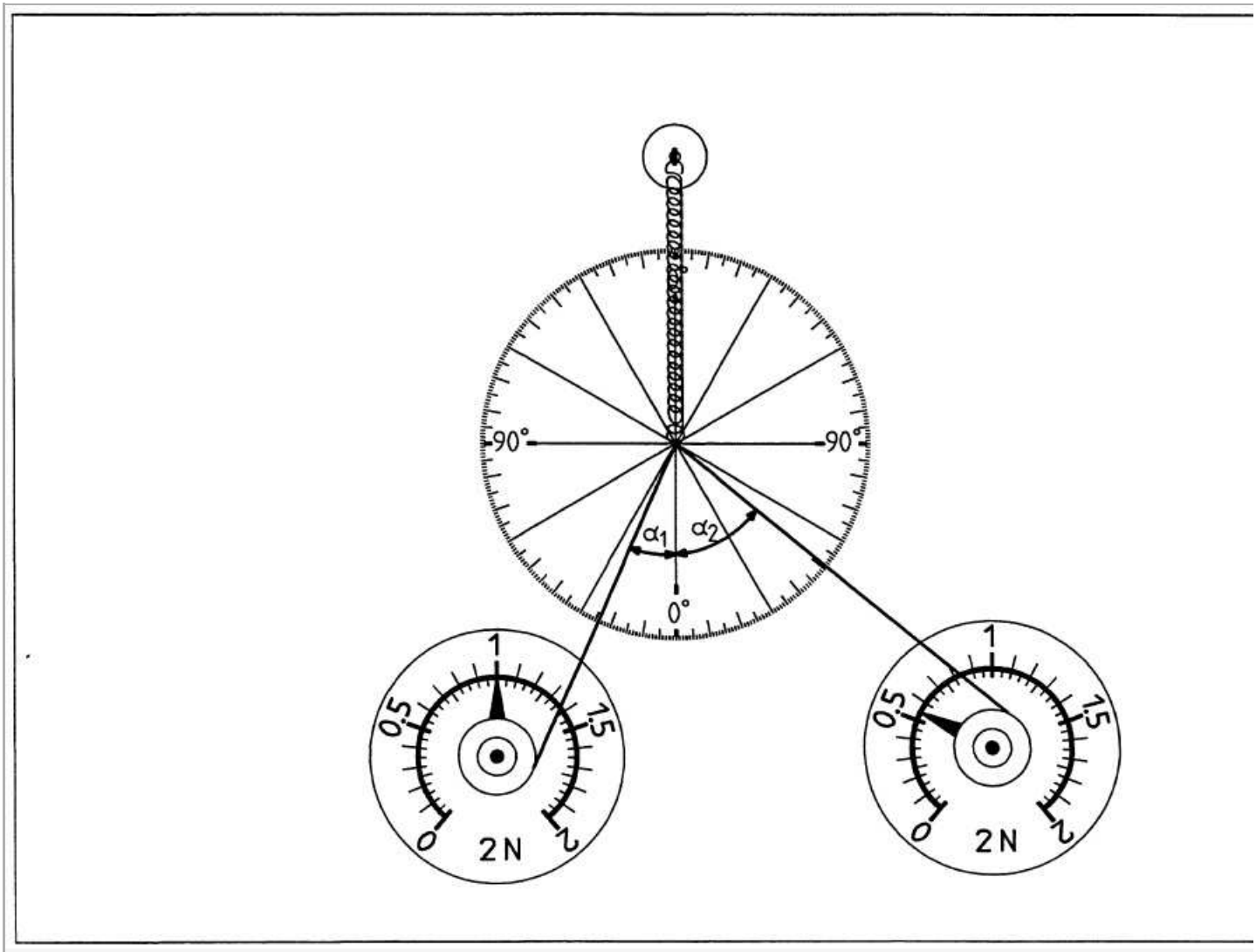

Fig. 1

Procedure

- Read values for the forces F_1 and F_2 indicated by the dynamometers and the angles α_1 and α_2, which are between their lines of action and the perpendicular to the horizontal line of the protractor disk.
- Note the results in Table 1.
- Change the positions of the dynamometers, but not that of the protractor disk. Record the respective magnitudes of $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ as well as the corresponding α_1 and α_2 (including the case where α_1 and $\alpha_2 = 90°$).While doing so, ensure that the lower end of the helical spring (the point of application of the forces) is located above the centre of the protractor disk. Record the measured values in Table 1.
- Subsequent to the last setting, remove one dynamometer and with the other one measure the force F_R which is required to stretch the helical spring to the centre of the protractor disk. Record the value for F_R.
- For a second series of trials preset another extension of the helical spring, e.g., ¥Proximately 10 cm. Select different angles for $\overrightarrow{F_1}$ und $\overrightarrow{F_2}$ and record the values in Table 2. Finally, determine F_R again.
- For the graphical evaluation remove both dynamometers and construct the force parallelogram with the white board pen for one on the demonstration board of the investigated cases using the protractor disk and the scale (Fig. 2).

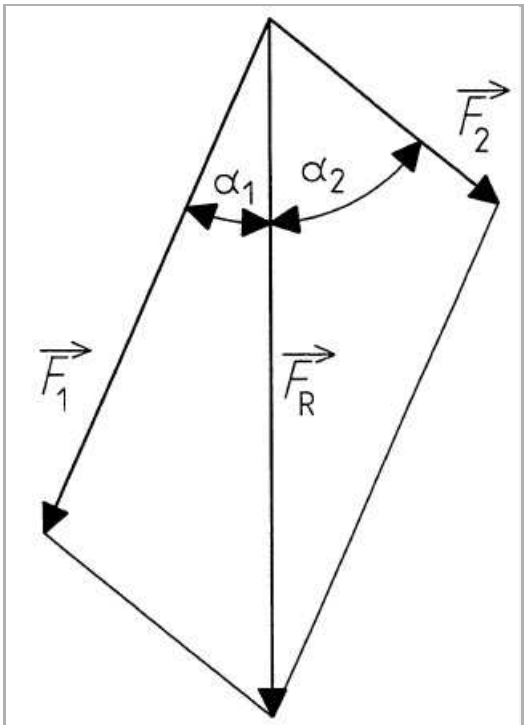

Fig. 2

Observation and evaluation

Observation

Table 1 (Sample measurement)

F_1 / N	F_2 / N	$\alpha_1 / 1^\circ$	$\alpha_2 / 1^\circ$	F_R / N	$\frac{F_1 + F_2}{N}$	$\frac{\alpha_1 + \alpha$
1.10	1.33	67	50	1.27	2.43	117
1.10	0.64	30	60	1.27	1.74	90
1.02	0.54	24	51	1.27	1.56	75
0.92	0.52	20	39	1.27	1.44	59

Table 2

F_1 / N	F_2 / N	$\alpha_1 / 1^\circ$	$\alpha_2 / 1^\circ$	F_R / N	$\frac{F_1 + F_2}{N}$	$\frac{\alpha_1 + \alpha$
1.46	0.77	24	51	1.81	2.23	75
1.57	0.91	30	60	1.81	2.48	90

Evaluation

It can be seen from Tables 1 and 2 that the sum of the magnitudes of $\overrightarrow{F_1}$ und $\overrightarrow{F_2}$ are always larger than $\overrightarrow{F_R}$ and that the larger the angle enclosed by the angles α_1 and α_2, the larger their sum is.

In any case, $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ result in the same action as the force $\vec{F}$; $\vec{F}$ for this reason $\overrightarrow{F_R}$ is termed the resultant force, $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ are termed its components.

$\overrightarrow{F_R}$ can be determined as the diagonal of a force parallelogram whose sides are formed by the components drawn to the same scale.

Two forces, whose lines of action intersect, i.e. which have a common point of application can be replaced by a single force. This can be determined by construction or calculation.

Remarks

It is advisable to have the students simultaneously construct the same force parallelogram in their notebooks while the teacher is drawing it on the demonstration board.

The special case in which $\alpha_1 + \alpha_2 = 90°$ was selected in order that the students could check their results with a sample calculation even without knowledge of trigonometry.

An additional task could be a graphical check of the remaining measurements.

Recording an exact series of measurements is not absolutely necessary. One can also restrict the experiment to a single measurement of F_1, F_2, α_1 and α_2 and determine the force parallelogram by quadrupling the values. In this case, one should however demonstrate qualitatively that the components enclose arbitrary angles and as a result can have differing values.

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