Resolution of forces on a crane (Item No.: P1252600)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Mechanik
Subtopic: Kräfte, einfache Maschinen
Experiment: Kräftezerlegung an einem Kran

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

Additional Requirements:

Experiment Variations:

Keywords:

Principle and equipment

Principle

Demonstrate which forces act on a simple crane on which a load is acting and how these forces can be determined.

Equipment

Position No.	Material	Order No.	Quantity
1	Demo Physics board with stand	02150-00	1
2	Torsion dynamometer	03069-03	2
3	Scale for demonstration board	02153-00	1
4	Weight holder for slotted weights	02204-00	1
5	Slotted weight, black, 50 g	02206-01	2
6	Slotted weight, silver bronze, 50 g	02206-02	2
7	Optical disk, magnet held	08270-09	1
8	Fish line, l. 100m	02090-00	1
9	Marker, black	46402-01	1

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Set-up and procedure

Set-up

For the formulation of the problem as well as in preparation for the evaluation of the experiments, make a drawing of a simple crane on the demonstration board; also discuss and draw in the forces occurring under load (cf. Fig. 1).

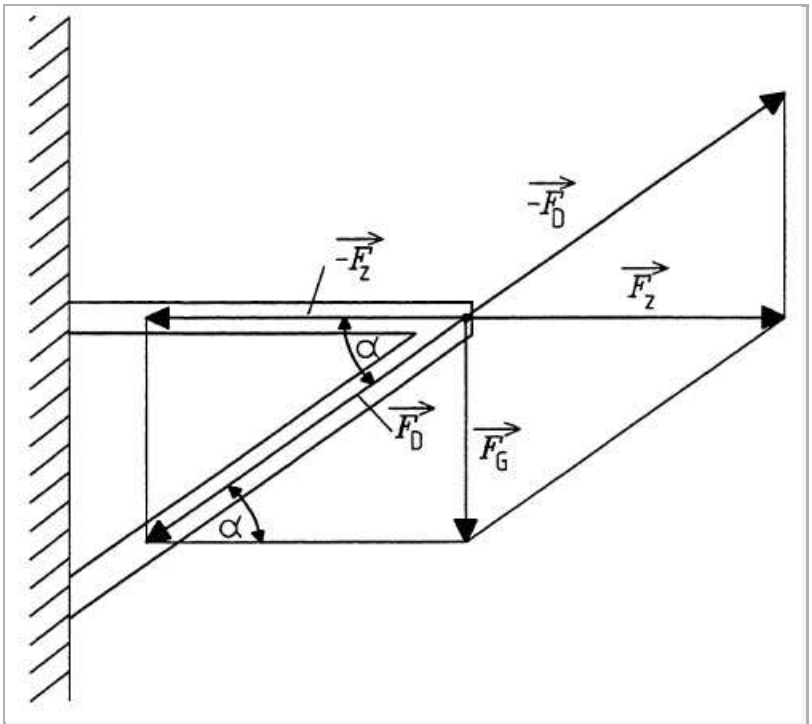

Fig. 1

- Load the weight holder with 4 slotted weights.
- Attach a small loop made of fish line to the weight holder's hook.
- Use both dynamometers in their 4 N measuring ranges.
- Place one dynamometer onto the demonstration board. Measure the weight F_G of the loaded weight holder, and record F_G.
- Place the other dynamometer to the right above the crane.
- Hook the traction cords of the two dynamometers together. Hang the weight holder's loop onto the joined hooks.

Procedure

- Shift the dynamometers until their traction cords lie along the lines of action of $\overrightarrow{F_Z}$ and $\overrightarrow{F_D}$ and the commot]_point of application of the forces $\overrightarrow{F_G}$, $\overrightarrow{F_D}$ and $\overrightarrow{F_Z}$ coincide with the point of application marked on the demonstration board (cf. Fig. 2).
- Measure and record F_Z und F_D.

  Change angle α; whereby the point of application remains unchanged. In each case observe the dynamometer. Record your observations.
- Remove the dynamometers and the weight holder.
- Place the protractor disk onto the demonstration board in such a manner that its centre coincides exactly with the forces' point of application.

  Note: To do this, extend the lines of action of the forces $\overrightarrow{F_G}$ and $\overrightarrow{F_Z}$ sufficiently far that they are not completely covered by the protractor disk.
- Measure the angle α (cf. Fig. 1}, which is enclosed by the lines of action of $\overrightarrow{F_Z}$ and $\overrightarrow{F_D}$.

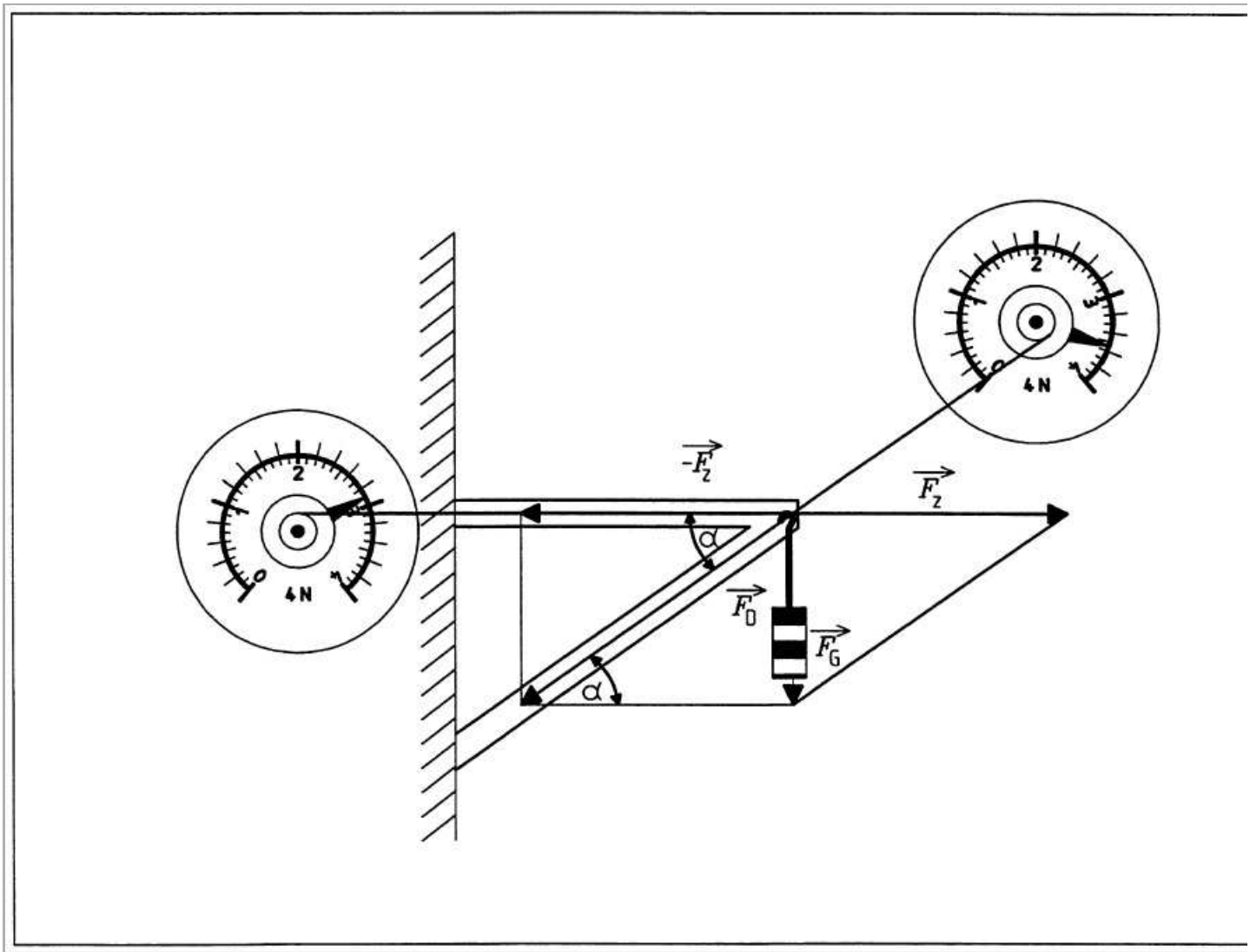

Fig. 2

Observation and evaluation

Observation

$F_G = 2.04N$
$F_Z = 2.90N$
$F_D = 3.55N$
$\alpha = 35^\circ$

Evaluation

The smaller the angle α, the larger the corresponding tractive and compressive forces.

On a loaded crane, the boom is subjected to compression and (for a boom with three degrees of freedom) the load cable to traction. The sum of the magnitudes of the occurring forces is always greater than the magnitude of the force exerting the load:
$F_Z + F_D > F_G$.

How large F_Z and F_D have to be in order for an equilibrium to exist depends on the angle α which the forces $\overrightarrow{F_Z}$ and $\overrightarrow{F_D}$ enclose. The students can predict he observed correlation between α , F_Z and F_D (for constant F_G).

To check the measured values the corresponding force parallelogram is drawn to scale on the demonstration board.

Remarks

If the students have appropriate trigonometric knowledge, the experimental results can not only be graphically but also mathematically evaluated:

$\sin(\alpha) = \frac{F_G}{F_D}$ oder $F_D = \frac{F_G}{(\sin(\alpha))}$;

$\tan(\alpha) = \frac{F_G}{F_Z}$ oder $F_Z = \frac{F_G}{(\tan(\alpha))}$ (vgl. Abb. 1)

With the concrete measured values one obtains the following:

$F_D = 2,04N / \sin(35^\circ) = 3,56N$;

$F_Z = 2,04N / \tan(35^\circ) = 2,91N$.

If the students have the above-mentioned knowledge, the values for F_Z and F_D could also be calculated in advance. Then the experiment would have confirming character.

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