Supporting forces (Item No.: P1253400)

Curricular Relevance

Area of Expertise: Physik

Education Level: Klasse 7-10

Topic: Mechanik

Subtopic: Kräfte, einfache Maschinen

Experiment: Auflagerkräfte

Difficulty

Intermediate

Preparation Time

10 Minutes

Execution Time

10 Minutes

Recommended Group Size

1 Student

Additional Requirements:

- Thin wire

Experiment Variations:

Keywords:

Principle and equipment

Principle

Investigate how large the load (supporting force) on two supporting pillars (supports) is, which, e.g., support a bridge on which there are vehicles.

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	2
5	Slotted weight, black, 10 g	02205-01	4
6	Slotted weight, silver bronze, 10 g	02205-02	4
7	Slotted weight, black, 50 g	02206-01	2
8	Slotted weight, silver bronze, 50 g	02206-02	2
9	Lever	03960-00	1
10	Marker, black	46402-01	1
Additional material:			
11	Thin wire		

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Set-up and procedure

Set-up

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Procedure

Procedure 1

- Place a dynamometer onto the demonstration board and measure the weight F_B of the lever (bridge element or beam); record its value.
- Also place the second dynamometer onto the demonstration board and hang the lever with the aid of the wire loops onto the traction cords. Move the dynamometers until the lever hangs horizontally in front of the drawing of the bridge element and the traction cords are perpendicular to it.
- Complete the drawing on the demonstration board by adding power arrows (vector arrows) (Fig. 1).
- Measure the supporting forces $F_{A,1}$, $F_{A,2}$ and record their values.

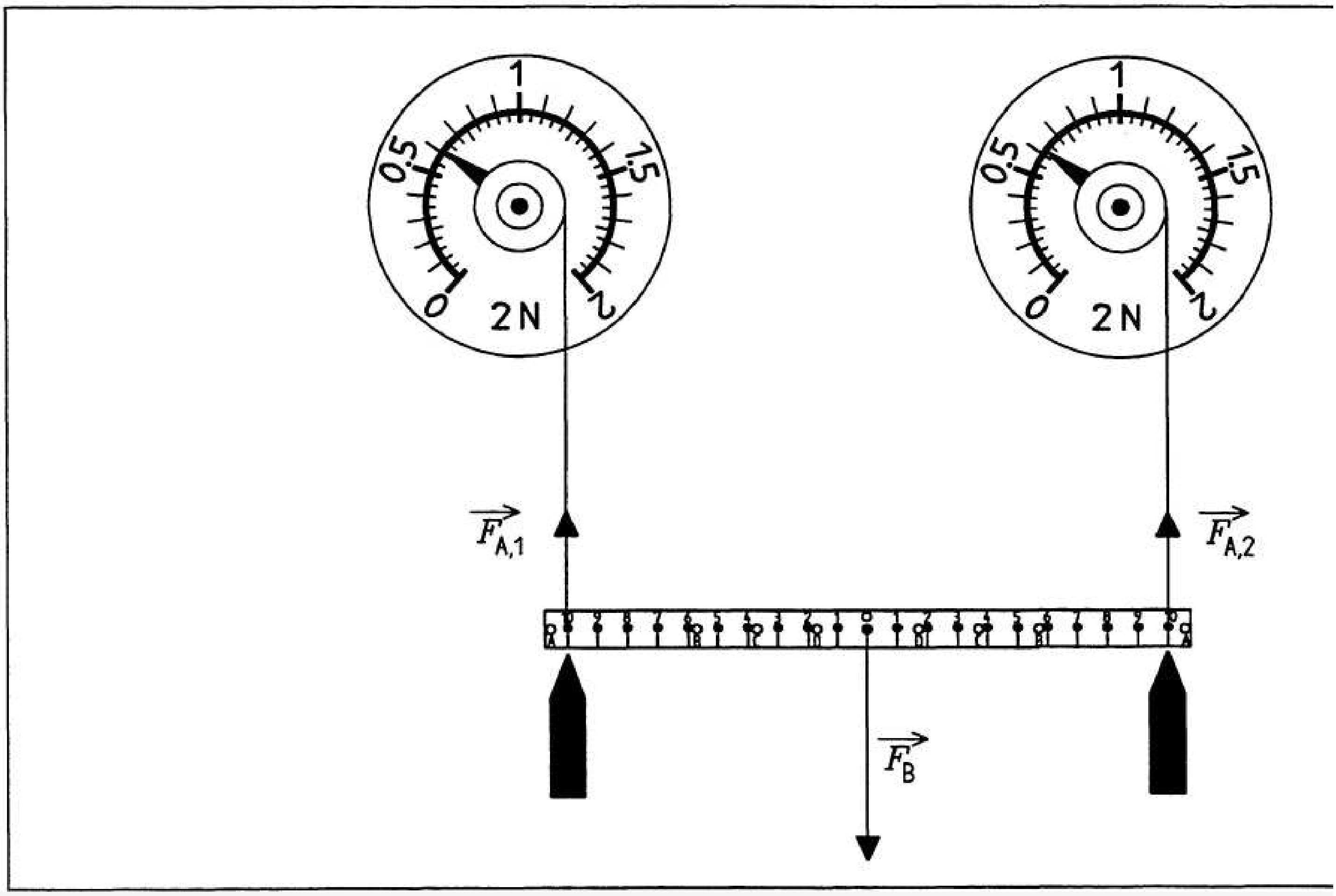

Fig. 1

Procedure 2

- Record F_1 and also F_B from Experiment 1.
- Hang the weight holder successively at different index marks. Shift the dynamometer in each case until the lever is horizontal and the traction cords are perpendicular to it. In each case measure the respective loading forces $F_{A,1}$ und $F_{A,2}$ and record them in Table 1.

Procedure 3

- Record F_2 and also F_B and F_1 from Experiment 2.
- Hang the weight holder from appropriate index marks (if necessary use the dynamometer in the 4-N region). Perform the measurement of the supporting forces $F_{A,1}$ und $F_{A,2}$ as above.
- Record the supporting forces and the numbers of the index marks on which the respective $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ act.

Observation and evaluation

Observation

Evaluation

Evaluation 1

As the students can predict,

$$F_A, 1 + F_A, 2 = F_B \text{ ,}$$

i.e., the sum of the supporting forces is equal to the weight of the bridge which bears no additional load to begin with. Furthermore, the supporting forces are equal.

Evaluation 2

To begin with - in accordance with the results of Experiment 1 - the students realise that $F_A, 1 + F_A, 2 = F_1 + F_B$.

The supporting forces can be calculated using the law of levers: The experimental set-up is considered to be a one-sided lever whose fulcrum coincides with the point of application of the force $F_{A,1}$ bzw. $F_{A,2}$ As a consequence, the following is true (cf. Fig. 2):

$$F_A, 2 * I_A, 2 = F_B * I_B + F_1 * I_{1,1}$$

or

$$F_A, 1 * I_A, 1 = F_B * I_B + F_1 * I_{1,1}$$

whereby $l_{1,2}$ for example, is the power arm of F_1 with respect to the point of application of $F_A, 2 * l_B$ is the power arm of F_B, where F_B acts on the centre of gravity of the lever, therefore l_B = 20 cm.

In practice, the point of interest is the magnitude of the supporting forces under load. If one desires to calculate $F_{A,1}$ e.g., then the following is true:

$$F_A, 1 = \frac{F_B * I_B + F_1 * I_{1,2}}{I_{A1}} \text{ ,}$$

$$F_A, 1 = (1.23N * 20cm + 1.54N * 4cm)/40cm = 30.8N * cm/40cm = 0.77N$$

This agrees with the measured value for $F_{A\ 1}$.

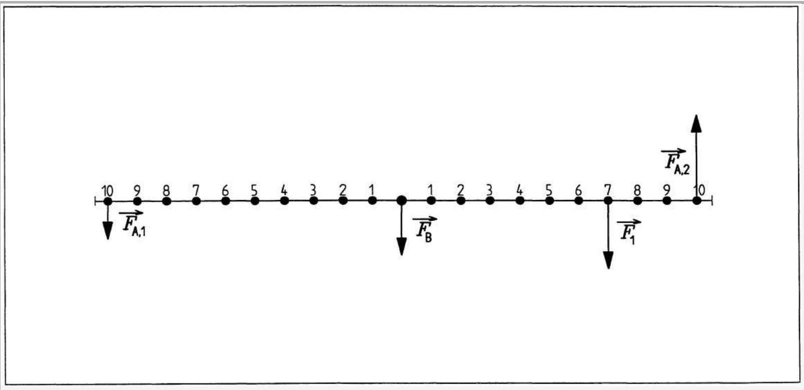

Fig. 2

Evaluation 3

Once again, making allowances for the range of measuring accuracy, the following result is obtained:

$$F_A, 1 + F_A, 2 = F_1 + F_2 + F_B \text{ .}$$

The measured loading forces agree with those resulting from the following approach (cf. Fig. 3):

$$F_A, 1 * I_A, 1 = F_1 * I_{1,2} + F_2 * I_{2,2} + F_B * I_B$$

or

$$F_A, 2 * I_A, 2 = F_1 * I_{1,1} + F_2 * I_{2,1} + F_B * I_B$$

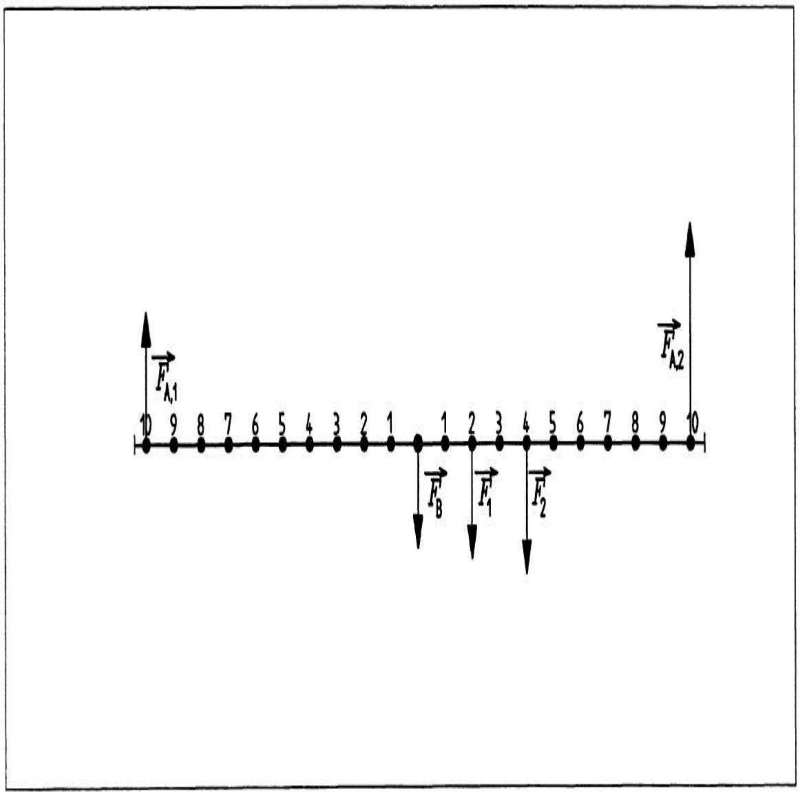

Fig. 3

Remarks

If there is not enough time available, it is also sufficient, e.g. in Experiment 2, to determine only one value each for $F_{A,1}$ und $F_{A,2}$ or only to perform the Experiments 1 and 3 from which the most important aspects of supporting forces can be seen. The considerations for the calculation of the supporting forces are in principle an application of the law of conservation of torque: a one-sided lever is in a state of equilibrium when the sum of the clockwise moments of rotation (the torques) is equal to the sum of the counterclockwise ones. If there is no appropriate wire available to support the lever, it can also be supported with fish line in the "A" holes. In this case, lever arms of other lengths must be considered.