2.8 Combination of forces, parallelogram of forces

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.

Use the space below for your own notes.

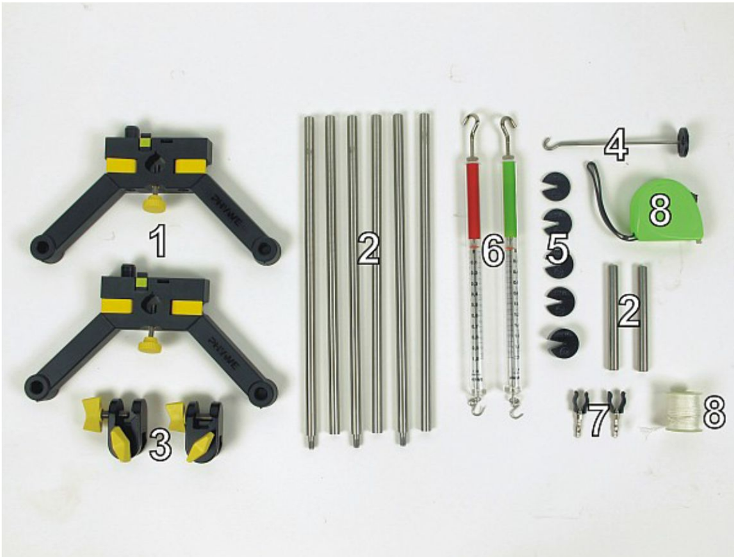
Material

Material from "TESS advanced Physics Set Mechanics 1, ME-1" (Order No.15271-88)

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod with hole, stainless steel, 100 mm	02036-01	2
2	Support rod, split in 2 rods, *l* = 600 mm	02035-00	3
3	Bosshead	02043-00	2
4	Weight holder for slotted weights, 10 g	02204-00	1
5	Slotted weight, black coloured, 10 g	02205-01	4
5	Slotted weight, black coloured, 50 g	02206-01	1

6	Spring balance, transparent, 1 N	03065-02	1
6	Spring balance, transparent, 2 N	03065-03	1
7	Spring balance holder for transparent Spring balances	03065-20	2
8	Measuring tape, *l* = 2 m	09936-00	1
9	Fish line, in reel, *d* = 0.7 mm, 20 m	02089-00	35 cm
Additional Material			
	Scissors 1		
	Protractor sheet, copy		1

Material required for the experiment



Setup

First screw the split support rods together, (Fig. 1). Connect the two halves of the support base with the long support rod and tighten the locking levers (Fig. 1). Set the two 60 cm support rods into the support base halves, tighten them with the locking screw (Fig. 2).

Fig. 1


Fig. 2

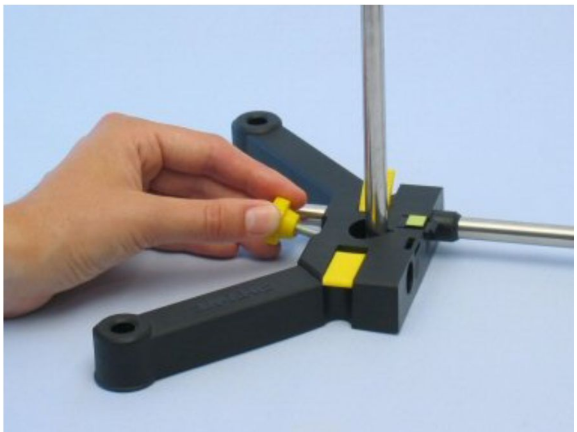


Fig. 3

Insert the spring balance holders into the short rods (Fig. 4). Fix the bosshead at the 60 cm support rod, and clamp the short support rod in the bosshead (Fig. 5).

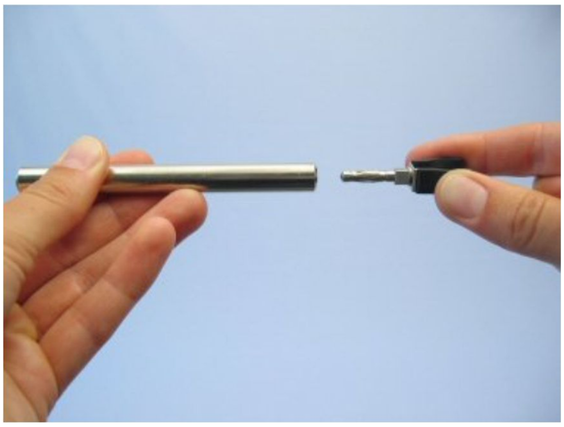


Fig. 4

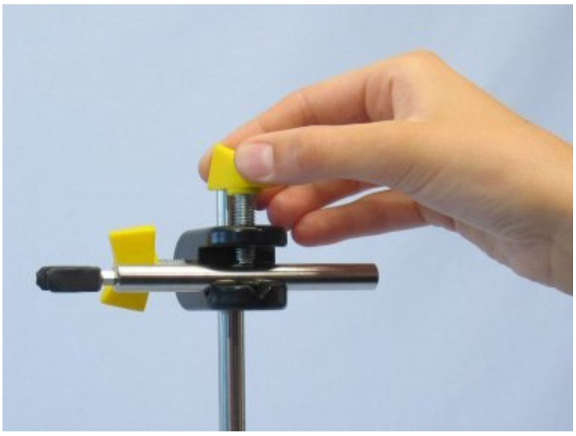


Fig. 5

Clamp the two spring balances into place and adjust them to zero by using the screw (Fig. 6).

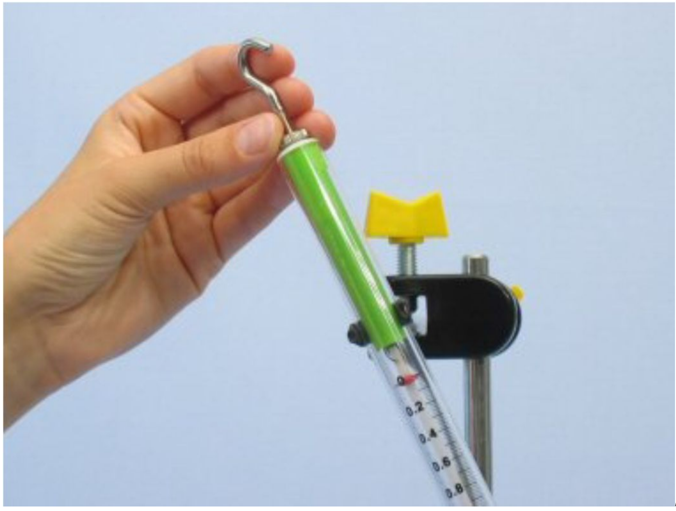


Fig. 6

Tie small loops at each end and in the middle of a short piece of fish line (ca. 35 cm). Hang each end loop on the hook of one of the balances and the weight holder on the middle loop of the fish line and place mass pieces on it until the total mass equals m = 100 g (Fig. 7). For hanging the slotted weight up the weight holder, you should slip the slotted weight over the top of the weight holder (Fig. 8).


Fig. 7

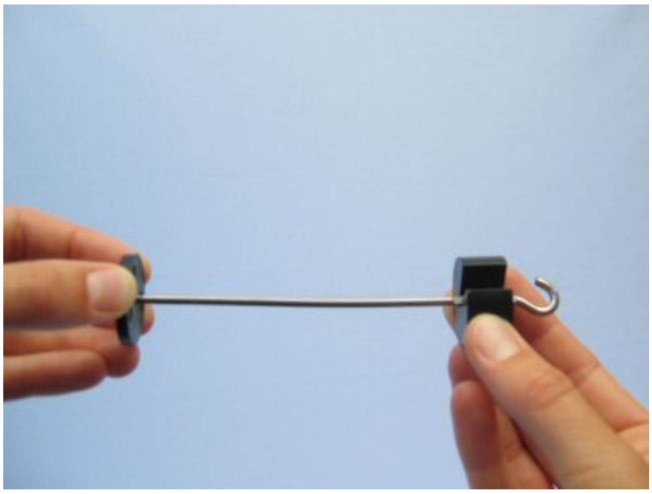


Fig. 8

Print the template of the protractor sheet.

Action

- 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 and α_2) which the forces F_1 and F_2 form with the perpendicular line are equal (Fig. 10).

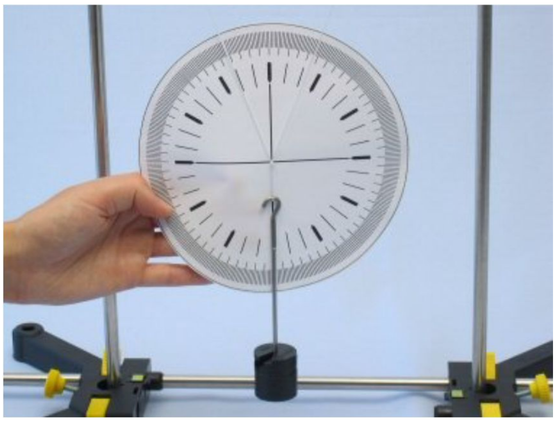


Fig. 9

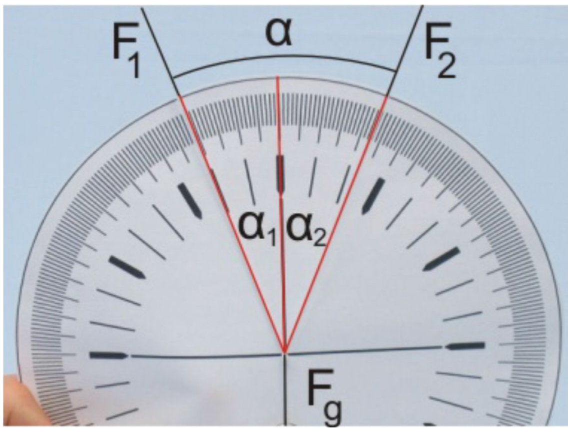


Fig. 10

- 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 and 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 α_1 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.

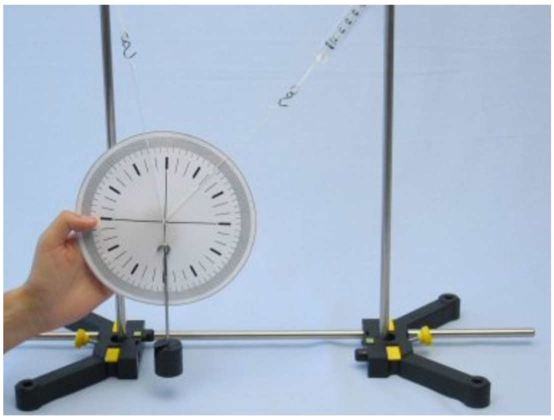


Fig. 12

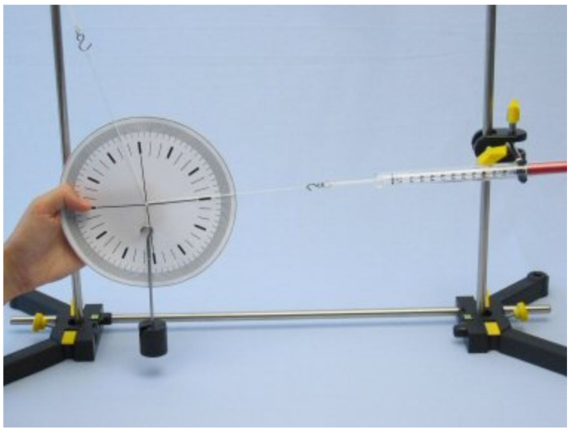


Fig. 13

Results

Table 1

α_1 in °	α_2 in °	α in °	F_1 in N	F_r in N	F_r in N
20	**20**				
30	**30**				
40	**40**				
50	**50**				

Table 2

α_1 in °	α_2 in °	α in °	F_1 in N	F_r in N	F_r in N
40					
55					
70					
90					
115					

Evaluation

Question 1:

Calculate α from α_1 and α_2 and complete the two tables on the Results page.

Question 2:

Using the measured values in Table 1 and Table 2, draw 2 force parallelograms. Use a specific scale for the force, e.g. 1 N corresponds to 10 cm. Draw two sample paralellograms in the Scribble: one for Table 1 (α_1=α_2) and one for Table 2 (different angles).

Question 3:

Determine the resultant force F_r from the diagrams graphically and record the values in the tables on the Results page.

Question 4:

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

Question 5:

Formulate the result of the experiment:

Question 6:

Describe how you determined the resultant F_r:

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: F_{rb} = ______ N