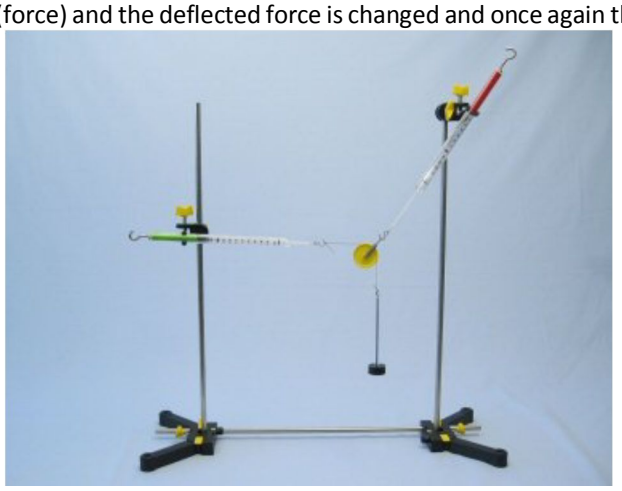
2.10 Forces on a pulley mounting

Task

What forces act on a deflection pulley?

With the aid of a pulley a weight (force) is deflected and the resultant force acting on the mounting of the pulley is measured.
The angle between the weight (force) and the deflected force is changed and once again the resultant force is measured.



Use the space below for your own notes.

Material

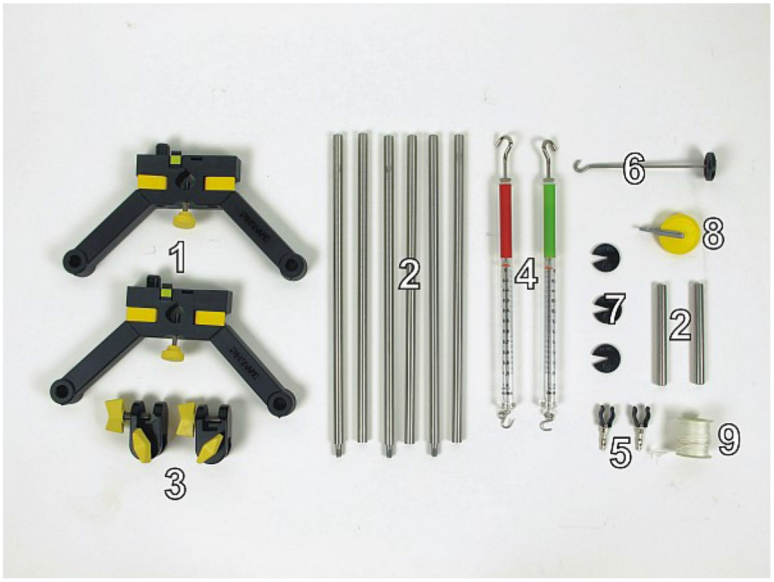
Material from "TESS advanced Physics Set Mechanics 1, ME-1" (Order No. 15271-88)

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	Spring balance, transparent, 1 N	03065-02	1
4	Spring balance, transparent, 2 N	03065-03	1
5	Spring balance holder for transparent Spring balances	03065-20	2
6	Weight holder for slotted weights, 10 g	02204-00	1

7	Slotted weight, black coloured, 10 g	02205-01	3
8	Pulley, movable, *d* = 40 mm, with hook	03970-00	1
9	Fish line, in reel, *d* = 0.7 mm, 20 m	02089-00	30 cm
Additional Material			
	Scissors 1		
	Protractor sheet, copy		1

Print the template of the protractor sheet that you can download by clicking this link and cut it out.

Material required for the experiment



Setup

First screw the splitt support rods together (Fig. 1). Connect the two halves of the support base with the 60 cm support rod and tighten the locking levers (Fig. 2). Set the two 60 cm support rods into the support base halves, tighten them with the locking screws (Fig. 3).

Fig. 1


Fig. 2

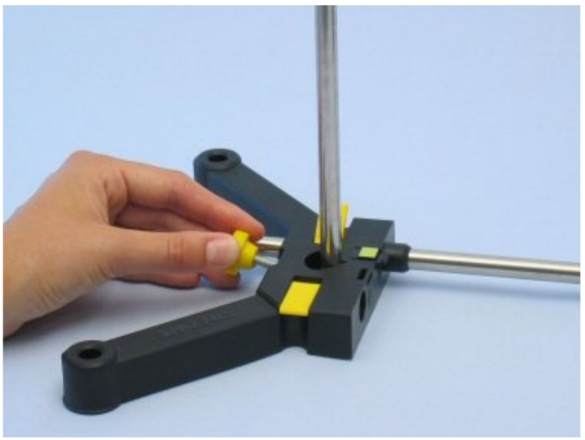


Fig. 3

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).

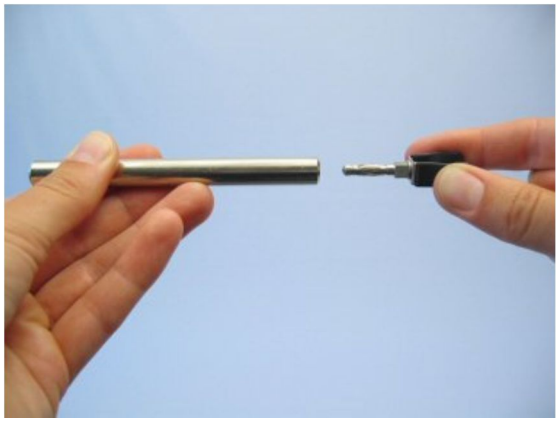


Fig. 4

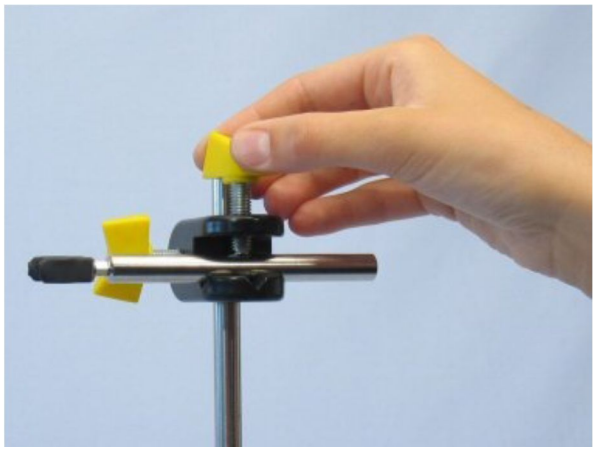


Fig. 5

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

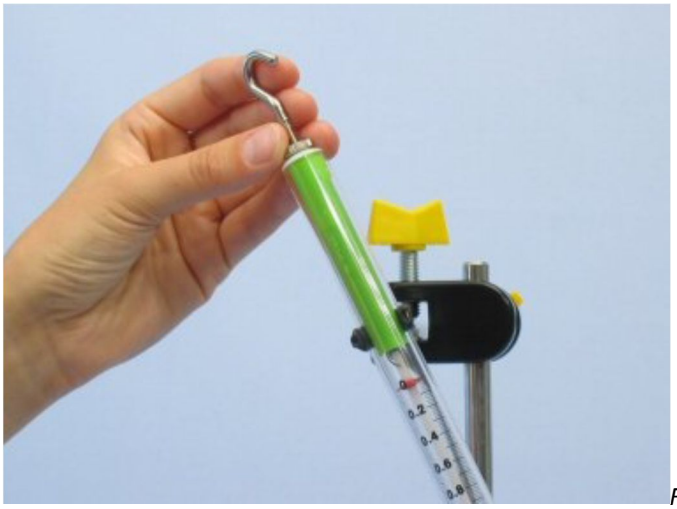


Fig. 6

Hang the pulley on the weighing hook of the 1 N spring balance. Attach the 1 N spring balance to the top of the right support rod with the spring balance holder. Attach the 2 N spring balance horizontally to the right support rod with the spring balance holder. With a piece of fish line hang the weight holder on the pulley; attach the free end of the fish line to the 2 N spring balance (Fig. 7 and Fig. 8).

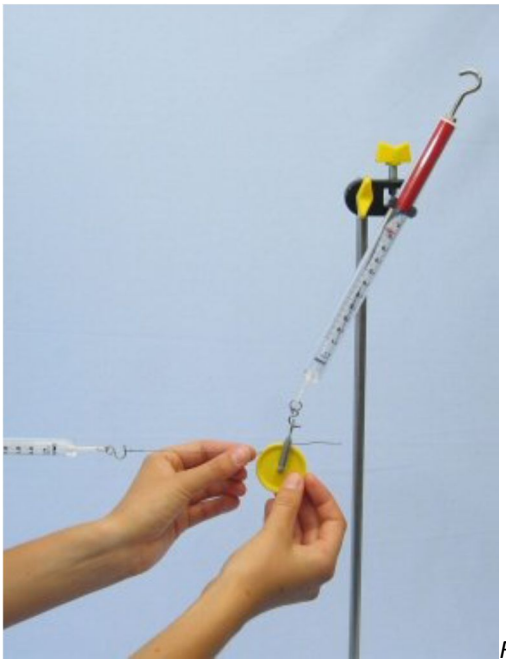


Fig. 7

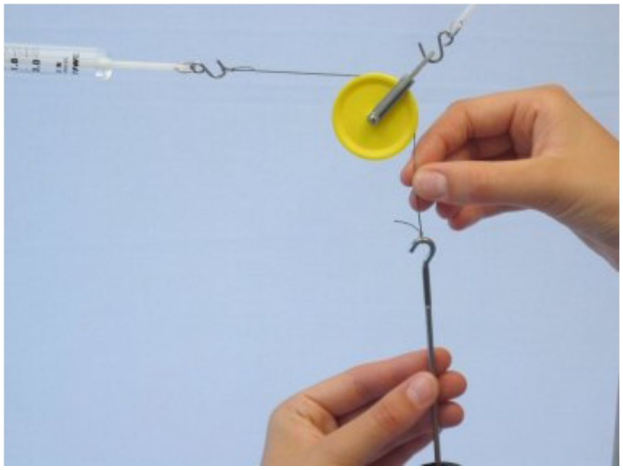


Fig. 8

Print the template of the protractor sheet that you can download by clicking this link and cut it out.

Action

- Load the weight holder with 3 mass pieces ($m_{tot.}$ = 40 g) and align the 2 N spring balance so that it is exactly horizontal (Fig. 9).
- Be sure that the mass is suspended and that the line can move freely.
- For hanging the slotted weight up the weight holder, you should slip the slotted weight over the top of the weight holder (Fig. 10).

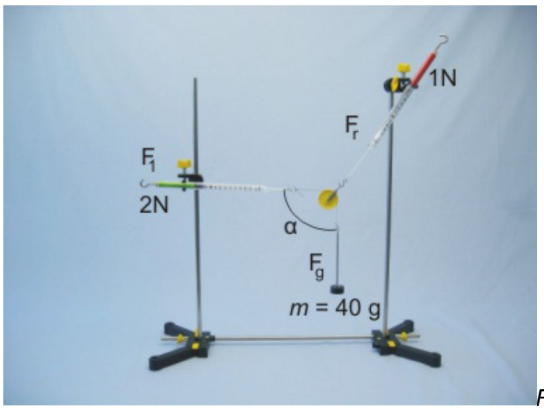


Fig. 9

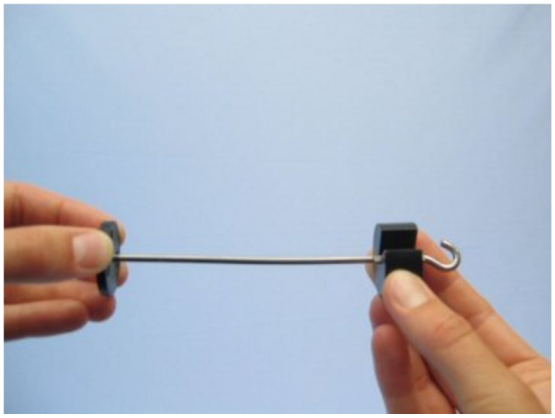


Fig. 10

- Read both spring balances and record the measured values for the deflected force F_1 and the resultant force F_r on the pulley (α = 90°).
- Change the angle α between the weight (force) F_g and F_1 by, first, moving the holder of the 2 N spring balance to the top of and, then, to the bottom of its support rod. Set the angles as nearly as possible to the values in Table 1 on the Results page.
- In each position hold the protractor sheet so that its center is at the intersection of the two force axes.
- For each position, i.e. every angle α, read the forces F_r and F_1 and record the values in Table 1, too.

Fig. 11: Example for measuring α = 90°.

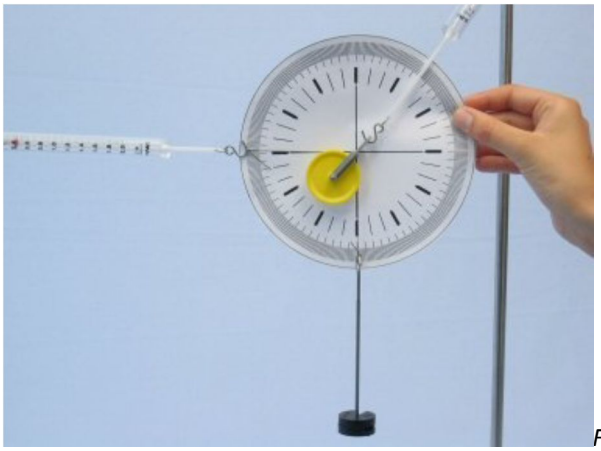


Fig. 11

Fig. 12: Overview of the experimental setup for α = 120°.

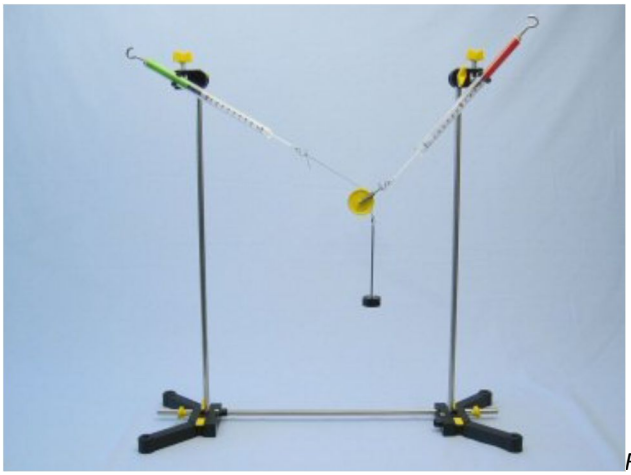


Fig. 12

Example for measuring α = 70° (Fig. 13 and Fig. 14).

Fig. 13

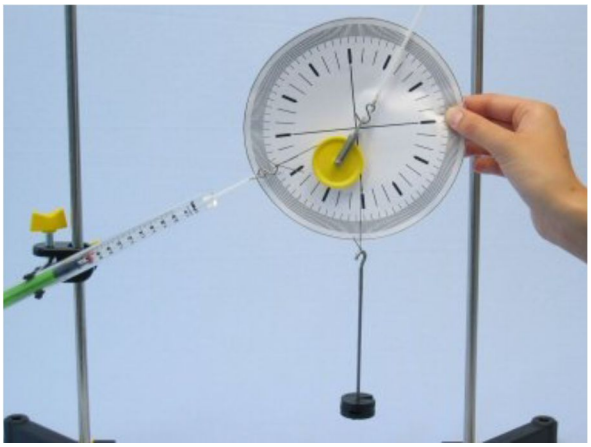


Fig. 14

Remove the 2 N spring balance from its holder and pull it downward, parallel to F_g ($\alpha = 0°$) (Fig. 15). Record these in Table 1.

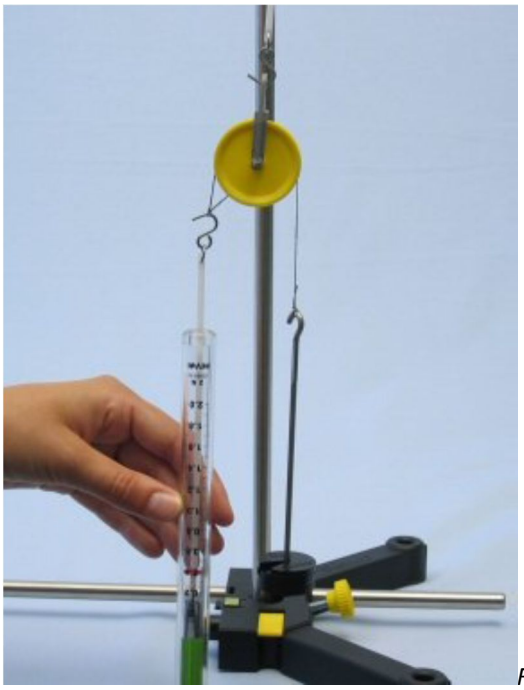


Fig. 15

Results

m = ☐ g

F_g = ☐ N

Table 1

angle α in °	F_1 in N	F_r in N
90		
120		
105		
70		
50		
0		

Evaluation

Question 1:
Calculate the weight (force) F_g from the mass m and record the value in the input box on the Results page.

Question 2:
Compare the measured values for the forces F_r and F_g. Are they equal? Which is larger?

Question 3
Do you have to consider the weight of the pulley?

Question 4:
How large is it? Measure it with a spring balance.

Question 5:
For which of the angles α is the force F_r the largest?

Question 6:
For which angle is it the smallest?

Question 7:

How do you explain this?

Question 8:

Draw the force parallelograms for the angles 70° and 120° on a separate sheet of paper.
Determine the resultant force F_r from them and record it in Table 2. Compare it with the measured results in Table 1 on the Results page. Decide on a suitable scale before you begin drawing, e.g. 1 N corresponds to 10 cm.

Table 2

angle α in °	F_r in N
70	
120	

Supplementary problems

Question 1:

Calculate F_r for 3 angles α with the following formula using the two forces F_1 and F_g:

$$F_r = \sqrt{F_1^2 + F_2^2 + 2 \times F_1 \times F_2 \times \cos \propto}$$

angle α in °	120°	50°	0°
F_r in N			

Question 2:

Compare these results with your measured values! What do you notice?

Question 3:

What does the force parallelogram look like for α = 90° when you consider the weight (force) of the pulley? Sketch this parallelogram on the scribble.