3.5 Force and displacement on a free pulley

Task

Which forces and distances occur on a free pulley?

You will see which forces occur on both supporting lines of a movable pulley when you load it with various masses. Furthermore, you will change the point of impact of the load. By doing this, you will derive the equations which are valid for movable pulleys.

Use the space below for your own notes.

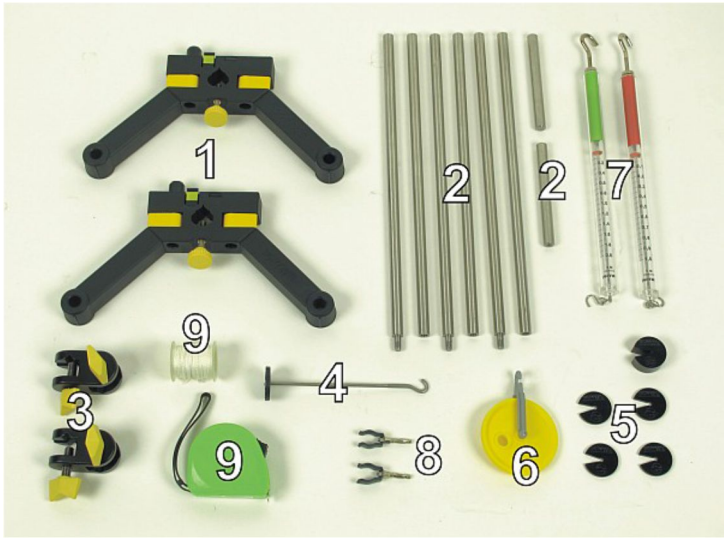
Material

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	Pulley, movable, *d* = 65 mm, with hook	02262-00	1
7	Spring balance, transparent, 1 N	03065-02	1
7	Spring balance, transparent, 2 N	03065-03	1
8	Spring balance holder for transparent Spring balances	03065-20	2
9	Measuring tape, *l* = 2 m	09936-00	1
9	Fish line, in reel, *d* = 0.7 mm, 20 m	02089-00	45 cm
Additional Material			
	Scissors		1

Material required for the experiment



Setup

Part 1

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

Fig. 1

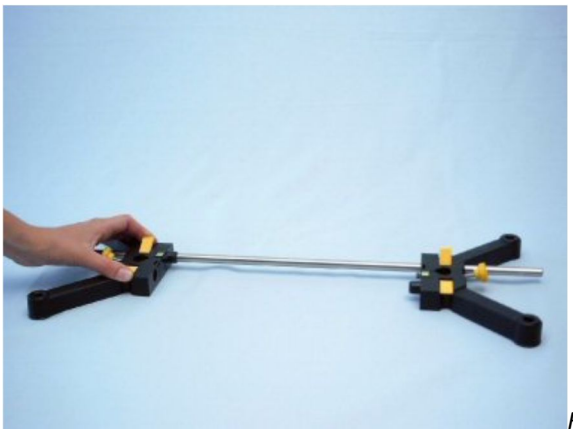


Fig. 2

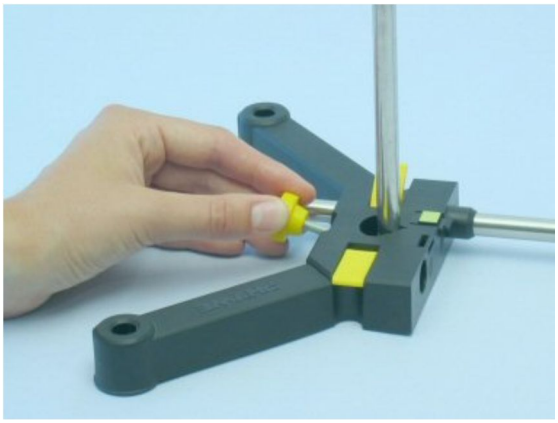


Fig. 3

Insert the spring balance holders into the short rods (Fig. 4). Fix the bossheads at the 60 cm support rods and clamp the short support rods in the bossheads. Clamp the two spring balances into place and adjust them to zero by using the screw (Fig. 5).

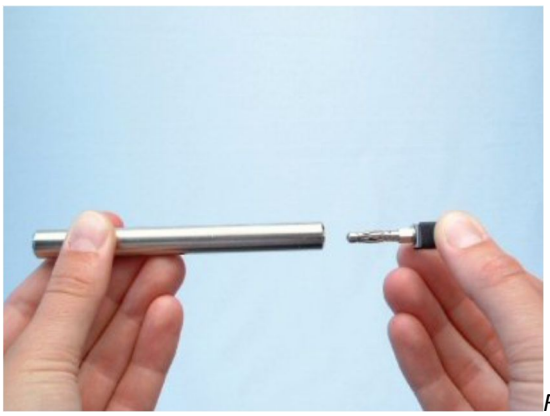


Fig. 4

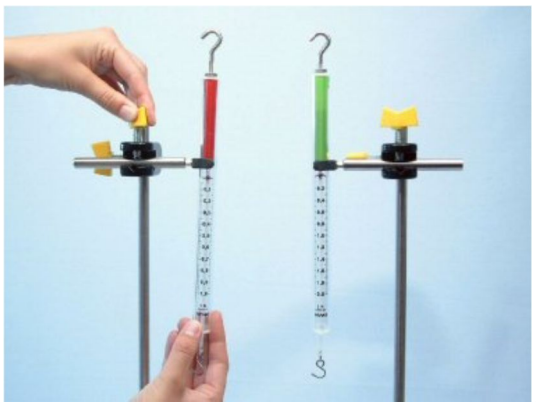


Fig. 5

Connect the two spring balances with a piece of fish line which is about 35 cm long. Hang the movable pulley on the line and attach the weight holder to the pulley's hook (Fig. 6).


Fig. 6

Part 2

Clamp the 1 N spring balance so that the mass is just above the table top (Fig. 7).

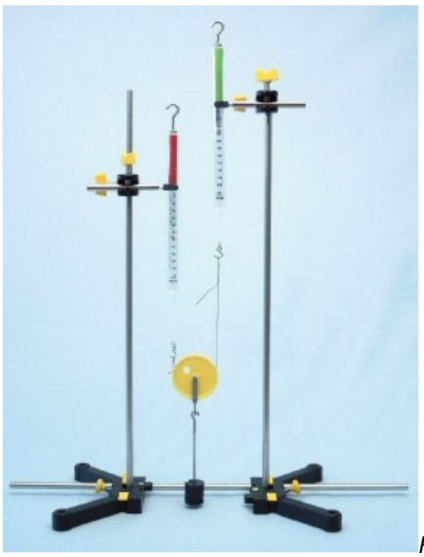


Fig. 7

Action

Part 1

- Determine the weight (force) F_r of the pulley with the 1 N spring balance and record the value in the input box above Table 1 on the Results page (Fig. 8).
- Load the pulley with the masses m given in Table 1 and measure the forces F_1 and F_2 (Fig. 9).

Fig. 8

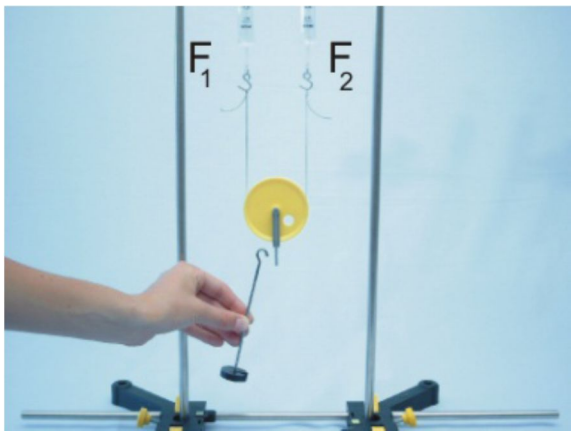


Fig. 9

Part 2

- Load the pulley with a total mass of m = 100 g and read the indicators of both spring balances F_1 and F_2.
- Measure the 1 N spring balance's height h_f above the table top (Fig. 10); the height h_l of the load above the table top is 0.
- Move the 1 N spring balance progressively higher so that the load is about 2 cm higher with each step.
- At each new height of the load read its height h_l above the table top and the height h_f of the 1 N spring balance.
- You can also use the values for F_1 and F_2 from part 1. Record all the measured values in Table 2 on the Results page.

Fig. 10

Results

Part 1

F_r = ☐ N

Table 1

m in g	F_1 in N	F_2 in N	F_g in N	F_1+ F_2 in N
20				
40				
60				
80				
100				

Part 2

m = 100 g
F_1 = ☐
F_g = ☐
F_2 = ☐

Table 2

h_i in cm	h_f in cm	s_i in cm	s_f in cm
0			
2.0			
4.0			
6.0			
8.0			
10.0			

Table 3

h_l in cm	$F_g \times s_l$ in Ncm	$F_f \times s_f$ in Ncm
2.0		
4.0		
6.0		
8.0		
10.0		

Evaluation

Part 1

$F_g = m \times g + F_r$, where g = 9.81 m⁄s$_2$.

Question 1:

Calculate F_g according to the above formula and record the calculated value in Table 1 on the Results page.

Question 2:

Calculate the sum of F_1 and F_2 and add this value to Table 1.

Question 3:

Compare this sum with the weight (force) F_g of the mass and the pulley:
Complete the following statement:
$F_1 + F_2$ is [ ] weight (force) F_g.

Part 2

$F_g = m \times g + F_r$, where g = 9.81 m⁄s$_2$. Use the weight (force) of the pulley F_r from part 1.

Question 1:

Calculate F_g according to the above formula and record the calculated value in Table 2 on the Results page.

Question 2:

From the height difference of load and force calculate the load distance s_l and the force difference s_f. Add these values to Table 2.

Question 3:

Form the product $F_g \times s_l$ and $F_f \times s_f$ where $F_1 = F_2 = F_f$. Record these results in the comparison table (Table 3) on the Results page.

Question 4:

Which relationship do you notice while inspecting the products?

Question 5:

Which relationship exists between load distance s_l and force distance s_f?

Question 6:

Which relationship exists between force F_f and load F_g? Express the observed facts in words and as a formula