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Friction
(rolling friction)

Workshop 3.
Why does the spinner spin for so long?
(rolling friction)

Picture 6: Spinner

Can you do tricks like in the picture 6. with the spinner?
But do you know why these tricks can be performed at all?
Why the spinner doesn't stop after only a few revolutions?
Regardless of your knowledge of performing tricks with a spinner, try your hand at performing a physics experiment to confirm the answer to the question from the title of this exercise.

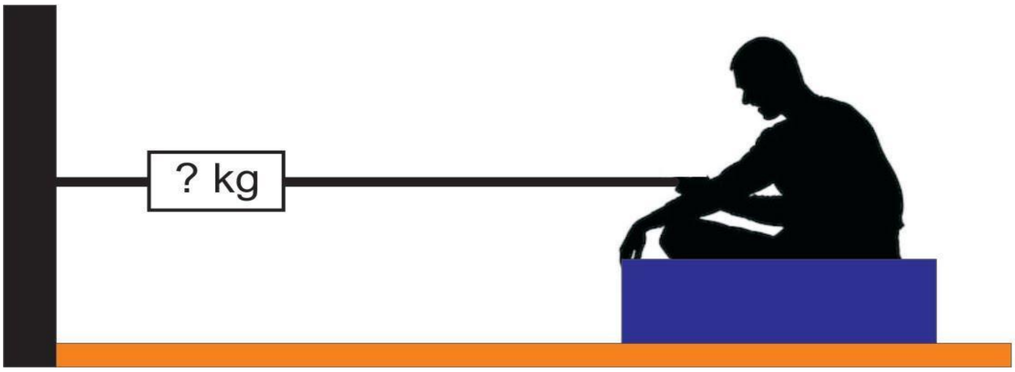
Tasks:

1. Calculate the force (by measuring the mass) required to pull the student (in a sitting position) on the box across the floor.
2. Calculate the force, similar to the first task, needed to pull the student across the floor when there are balls or rollers between the wooden box and the floor.
3. Compile a table for all participants of this workshop according to the template in the text.
4. Answer the questions at the end of the text.
5. Prepare a presentation and briefly present the workshop and the main conclusions of the experiment to the participants of other workshops, the presentation time should be within 5 minutes.

List of accessories:
hand scale (0-50 kg), rope thicker than 3 m, belt of 1 m, wooden box (100 cm x 50 cm), 50 tennis balls or larger balls (can also be 10 round sticks), paper, pencil, calculator.

Experiment 1.
You need to assemble the measuring apparatus according to Picture 7. As the hand scale actually measures the force, and then automatically recalculates the mass and displays the result on the scale's display, we can also use it in such a way as to indirectly measure the force, i.e. to calculate the force from the relation $F= m \cdot g$. For this case of our body dragging on the floor, we know from that the amount of frictional force is equal to the minimum pulling force. Therefore, by measuring the mass using a hand scale, we can calculate the amount of the frictional force according to the expression $F_{T1}= m_1 \cdot g$, where g is the quotient of weight and mass and is $g = 9.81$ N/kg
(g is called the acceleration of free fall and has unit m/s^2).

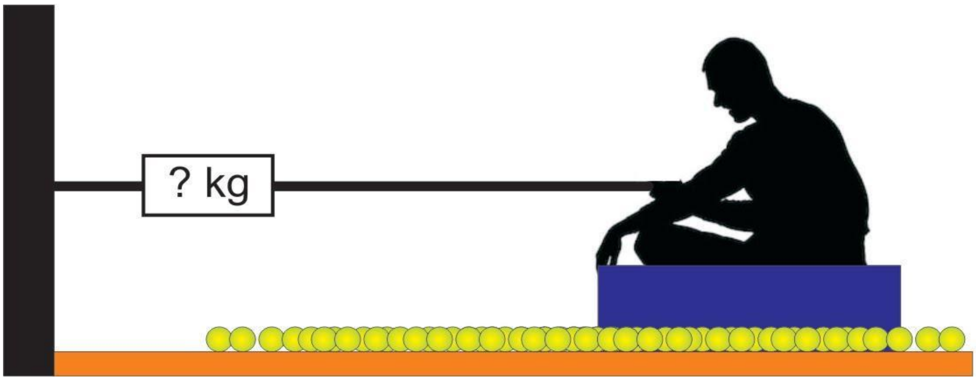
When you measure the weight shown by the hand scale when pulling, the numbers on the digital display will change rapidly, so measure that value at the very beginning when starting, i.e. the pull should not be done suddenly and with full muscle power, but the rope should be pulled gradually while do not start.



Picture 7: Rope pull with hand scale

Enter the measurement results for each participant of this workshop in the table below.

Experiment 2.
Now you need to place balls or metal rollers under the box with the student.



Picture 8. Pulling a rope with a hand scale with balls

Repeat the measurement with a hand scale, similar to experiment 1, calculate the friction force and enter the results in the table.

Enter the results of measurements and calculations in table 4.

Table 4. Results of sliding and rolling friction measurements

Measurement	Name	m_1	F_{T1}	m_2	F_{T2}
unit		kg	N	kg	N
1.					
2.					
3.					
4.					

Questions:

1. Compare the friction forces for experiment 1 (sliding friction force F_{T1}) and for experiment 2 (rolling friction force F_{T2}). In which experiment is the amount of frictional force smaller?

2. Calculate the ratio of friction forces and express how much one type of friction is greater than the other type?

3. What can you conclude about the sum of the sliding friction force and the rolling friction force (which force is smaller)?

4. Can you conclude from the experiment what is the cause of the stopping of a body?

5. Can you answer the introductory question; *Why doesn't the spinner just stop after a few spins?*