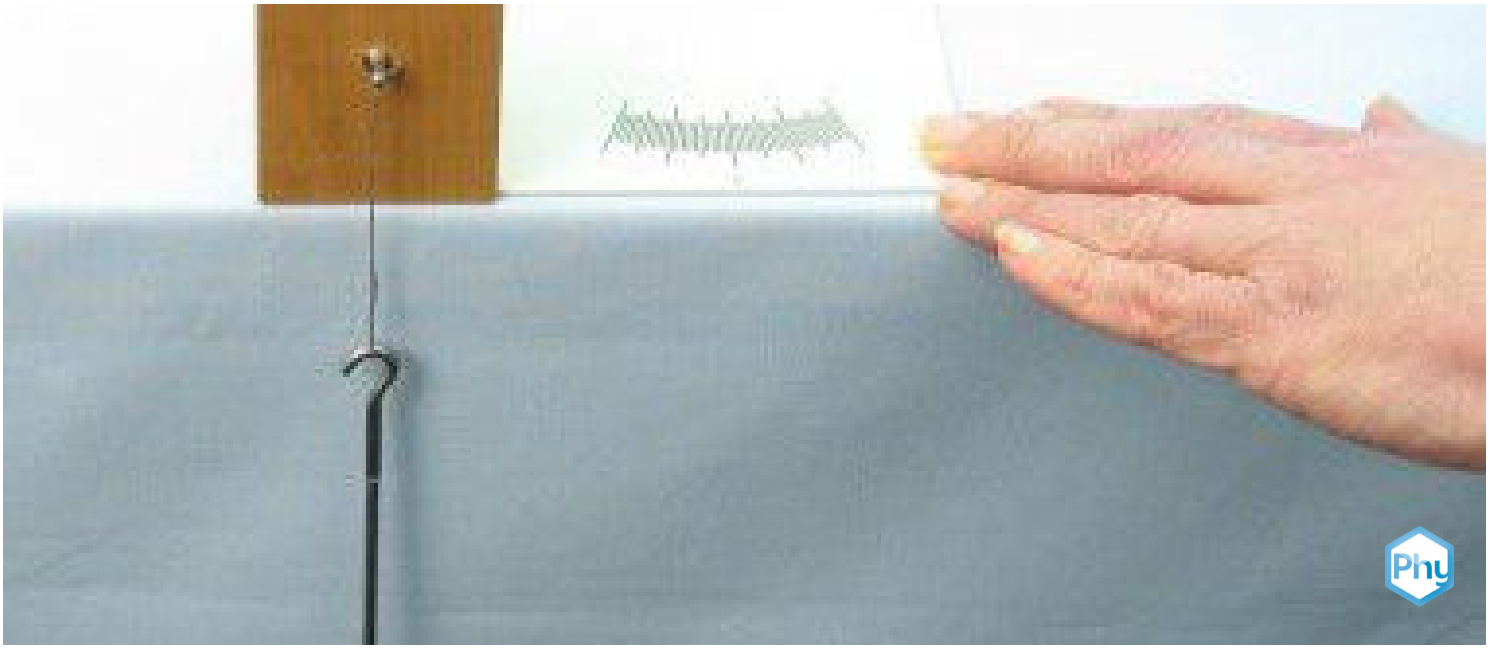
Stability



Physics | Mechanics | Forces, work, power & energy

Difficulty level	Group size	Preparation time	Execution time
easy	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/5f99b2f58f955d0003f13ea7

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Teacher information

Application

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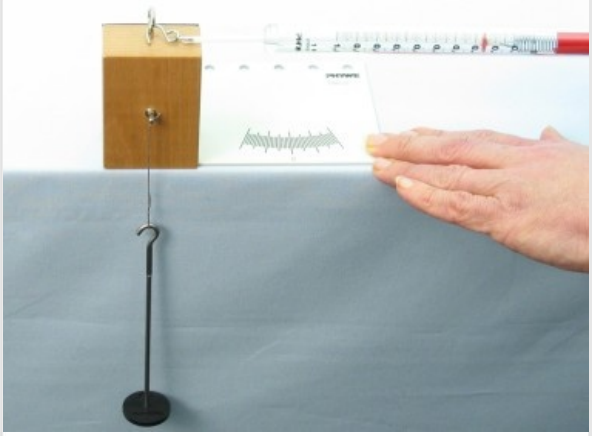

Test set-up for determining the tilting moment of a friction block

If an object is loaded sideways with a certain force and pulled against an obstacle, it will fall over when the plumb bob lies exactly outside its supporting surface due to its centre of gravity.

In this experiment, a wooden friction block is pulled against a plate and thus caused to fall over.

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Other teacher information (1/2)

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Prior knowledge

Before carrying out this experiment, it is advisable that the students have already carried out and understood relevant experiments to determine and understand the effects of forces.

Scientific principle

If a block above its centre of gravity is loaded laterally with a force and pulled against an obstacle, the block will tilt exactly when the plumb line is outside its standing area, due to its centre of gravity.

Other teacher information (2/2)

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Learning objective

The students are to experimentally determine under which conditions (force, position, etc.) that a standing object tips over.

Tasks

The students measure the force of a wooden block, that is blocked at the bottom edge, required to tip the object over.

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Safety instructions

The general instructions for safe experimentation in science lessons apply to this experiment.

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Student Information

Motivation

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Man on the "tippling" on a chair

As you know, 'Tippling' is a literal balancing act: you balance with the centre of gravity above the back feet of the chair. If you shift the centre of gravity a little too far back, you have to react quickly or you'll fall over backwards. Of course you have a feeling for how far you can lean back without falling over with the chair. This point can be determined very precisely and is also called the 'tipping point'.

In this experiment you learn the relationship between the centre of gravity, tipping point and the falling of an object in relation to a force acting laterally.

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Equipment

Position	Material	Item No.	Quantity
1	Friction block	02240-01	1
2	Weight holder, 10 g	02204-00	1
3	Slotted weight, black, 50 g	02206-01	1
4	Plate with scale	03962-00	1
5	Spring balance,transparent, 1 N	03065-02	1
6	Holding pin	03949-00	1
7	Fishing line, l. 20m	02089-00	1

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7	Fishing line, l. 20m	02089-00	1

Additional equipment

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Position	Equipment	Quantity
1	Scissors	1

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Set-up

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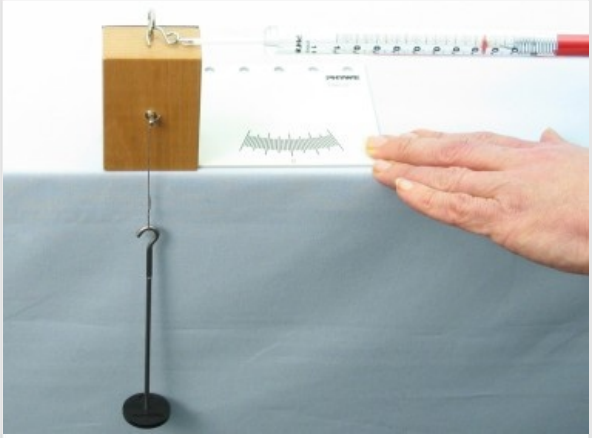

Test setup for determining the tilting moment of a wooden block

Set up the experiment according to the figure.

Place the friction block on the edge of the table so that the weight plate attached to it with a string hangs freely. The weight plate is not weighted down and serves as a plumb line in the experiment.

The friction block should touch the plate laterally and the spring force meter is hooked into the upper eyelet after it has been adjusted to zero in the start position (horizontal).

Procedure

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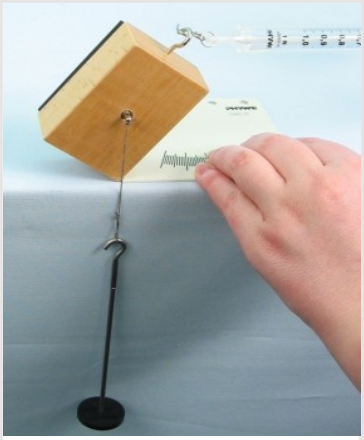
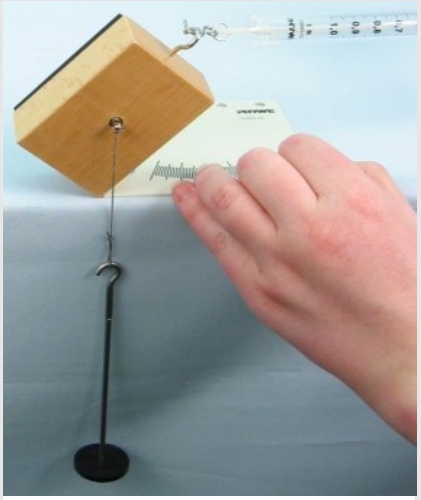


Pull the friction block against the obstacle

- Hold the plate with one hand.
- Now pull the force gauge parallel to the table surface.
- Observe the block and the plumb line in three positions:
  - Block almost begins to tilt
  - Plumb line goes right through the edge
  - Plumb line lies outside the edge and the block starts to tilt.
- Note the tensile forces in the protocol.



Friction block tilts

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Report

Task 1

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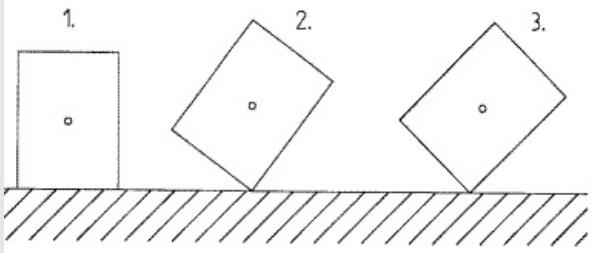
Write down your measured forces for the three positions of the friction block shown.

Position 1 (traction force): $F_{Trac} =$ _____ N

Position 2 (holding force): $F_{Hold} =$ _____ N

Position 3 (tilting force): $F_{Tilt} =$ _____ N



Different positions of the friction block during the test

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Task 2

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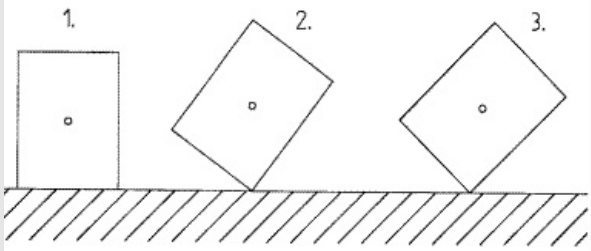
Drag the terms to the correct position.

Position 1: The body _____.
Position 2: The body _____.
Position 3: The body _____.

is raised | tips over | is just standing

Check



Different positions of the friction block during the test

Task 3

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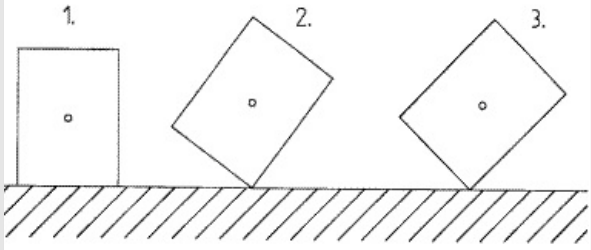
Transfer the displayed image onto a sheet of paper. Then draw in the plumb line for each position of the block. What do you notice in position 3?

- ○ The plumb line is always outside the block.
- ○ The plumb line is partly outside the block.
- ○ The plumb line is always inside the block.

Check



Different positions of the friction block during the test

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Task 4

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Leaning Tower of Pisa

Which condition must be fulfilled for a body (e.g. a tower) not to topple over?

- ○ The perpendicular from its centre of gravity must be parallel to its contact surface.
- ○ The perpendicular from its centre of gravity must pass through its contact surface.

Check

Additional task 1

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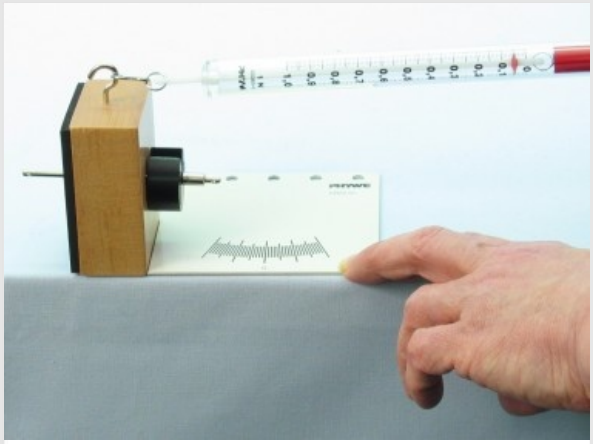
Slide the retaining bolt into a dimensional piece and then insert the free end of the bolt through the hole on the wooden side of the friction block.

- Place the friction block so that the mass piece points in the direction of pull against the plate (see illustration).
- Measure the traction force with the dynamometer and write it down.

Mass in pulling direction: $F_{Pull,1} =$ _____ N



Test with mass piece in tensile direction

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Additional task 2

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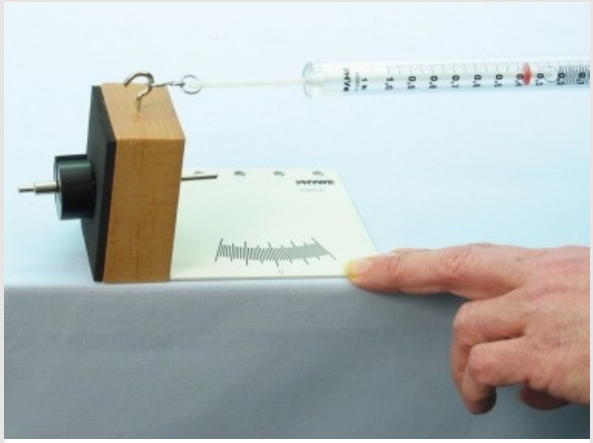
Take the weight from the front side of the block with the retaining bolt and now insert both from the rubber side (the back) into the friction block.

- Place the friction block against the plate in such a way that the mass piece points against the direction of pull (see illustration).
- Measure the traction again and write it down.

Ground against pulling direction: F_{Pull2} = ____ N



Test with mass piece against tensile direction

Additional task 3

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Compare the two measurement results.

What explanation can you give for the situation?

- ○ $F_{Pull,1} < F_{Pull,2}$ as the weight generates a moment in the tilting direction.
- ○ $F_{Pull,1} > F_{Pull,2}$ as the weight generates a moment against the tilting direction.

Check

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