FORCES

properties

Inertia:
a body in motion remains in motion
a body at rest remains at rest

Every mass has a certain inertia

Weight x weight-arm = force x force-arm

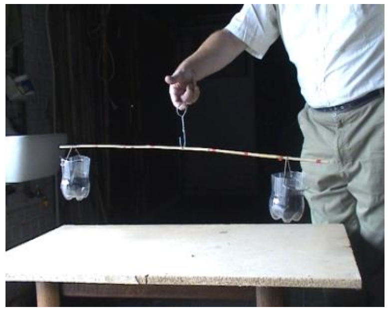
What we win in force, we lose it in distance

A force is capable of changing an object's state of motion

The extension of a spring is proportional to the weight attached to it.
(Robert Hooke)

The total energy of a system is always conserved, but can be transformed

1. A light weight



Material:

A wooden slat with a length of over 1 meter, a thread or hook, two baskets or sacks with handle s, some equal weights (e.g. marbles).

Action:

Mark the exact middle of the slat and attach a thread or hook at that point. Starting from the middle, draw a line on the slat every 10 centimetres.
Fill the baskets or sacks with an equal amount of weights and hang them on the slat at an equal distance from the middle, on both sides (e.g. 30 centimetres from the middle). Pick up the slat using the thread or hook that is attached to the middle.
Now add a weight to the right basket.

What will happen?

In the beginning, the slat has reached a balance.
This balance is lost when the extra weight is added. The slat goes down on the side with more weight.

Why?

When the weight and the distance to the point of support is equal on both sides there is balance.
When weight is added to one side, the balance is lost. There is a way to restore it without putting more weight into the lightest basket or sack.
There will be balance when the product of the weight and the distance to the point of support are equal on both sides.
So, if you move the lightest basket or sack away from the middle (you make the distance to the point of support larger), balance can be restored.

Weight x weight-arm = force x force-arm

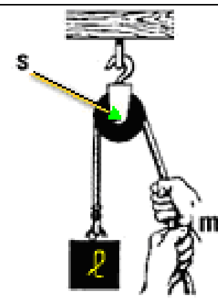
2. The pulley.


<u>Material:</u>

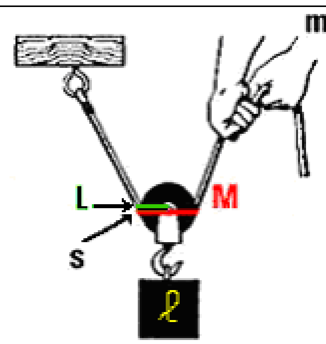
A pulley (made of wheels and a cord), a supporting point to hang the pulley on (a coathook), a burden (a weight).

<u>Action:</u>

1. The fixed pulley.
   Hang the pulley as is shown in the picture and attach the weight to the cord. First let the weight rest on a table. Then pull it up about 30 centimetres.

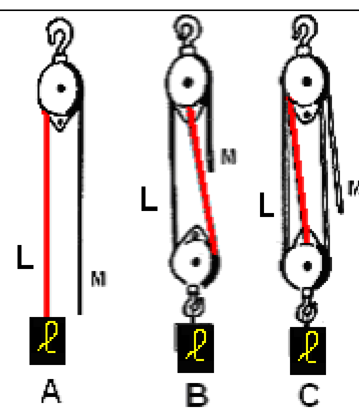


2. The loose pulley.
   Hang the pulley as is shown in the picture and attach the weight to the cord. First let the weight rest on a table. Then pull it up about 30 centimetres.



3. Combination of a fixed and a loose pulley.
   Make the combination you find in picture C. Try to pull the weight up with this pulley.

A: weight arm = force arm ;
B: weight arm is half of the length of force arm;
C: force arm is three times longer than the weight arm.



s: support point

m: force

ℓ: weight

M : Force arm

L: weight arm

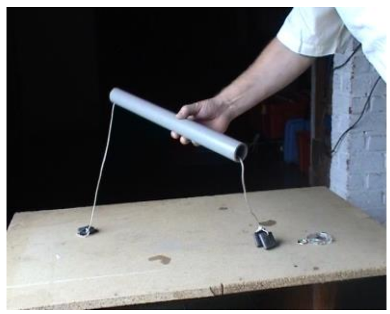
What will happen?

It is easier to lift the weight with the loose pulley than with the fixed pulley. Even more easy is using the combination, but it takes more time.

Why?

1) the weights and the arms are equal
With a fixed pulley you only change the direction of the force
2) With the loose pulley the weight-arm is half the diameter of the wheel and the force-arm the diameter. So the force is the half of the weight.
Remember: what we win at force, we loose it at distance

3. Centrifugal force or force of inertia




Material:

A plastic tube, a rope, two weights (e.g. bags with sand), one weight is twice as heavy as the other one.

Action:

Pull the rope through the tube and attach a weight on each side.
Hold the tube vertically with the heaviest weight at the bottom. Hold the tube in the middle with one hand and turn the upper part around. The upper weight starts to move in circles.

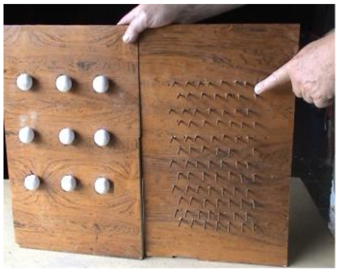
What will happen?

The rope will become longer on the top side. The upper weight starts to make bigger circles. The heavy weight at the bottom is pulled up.

Why?

The upper weight makes circles. Because of the centrifugal force, it wants to describe bigger and bigger circles. It wants to move away from the middle of the circle more and more. This is possible because the weight is not really fixed. The lower weight is pulled up because the upper one asks more and more rope.

4. Playing fakir.



aterial:

Two equally big wooden planks, one with three rows of three polystyrene balls, the other one with twelve rows of seven nails (the pin points outwards)

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Action:

Use each plank as back (of a chair). Describe what you feel; which back feels more comfortable?

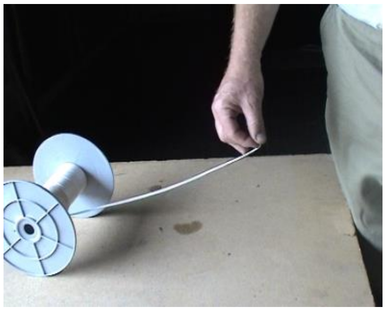
What will happen?

The polystyrene balls feel more uncomfortable than the nails!

Why?

There are only nine polystyrene balls, so nine points of support for your back. Each point has to carry one ninth of the weight of your back. The nails don't push so hard against your back because there are so many. Every nail has to support only one eighty forth of the weight of your back.

5. The rolling reel.



Material:

A reel of cotton.

Action:

First put the reel on the table with the thread on the upside. Pull it.
Then put the reel on the table with the thread on the downside. Pull again.

What will happen?

The reel will come rolling towards you in both cases.

Why?

The point of support for the reel is the spot where it touches the table. This can also be called the turning point. The effect of the force with which you pull, depends on the spot where you pull. In both cases, this point lies above the turning point. So, the force is the same in both cases: same direction (horizontally), same sense (towards you),

6. Superpower.

Material:

A cork, a hammer, a needle, a pair of tongs, a copper or aluminium plate.

Action:

The aim of the experiment is to hammer the needle into the metal plate. We use the cork as support, to hold the needle so it wouldn't break. Put the needle into the cork so the point just doesn't come out on the other side. Remove the top part of the needle that is still sticking out of the cork with a pair of tongs. Place the cork on the metal plate and hit it hard with a hammer.

What will happen?

The needle makes a hole in the plate.

Why?

The surface where the needle touches the plate, is very small. All the force of the hit is concentrated in this point, so it is a very large force. Thus: the magnitude of a force does not only depend on the pressure, but also on the magnitude of the surface on which this force is exercised.

7. A simple scale.

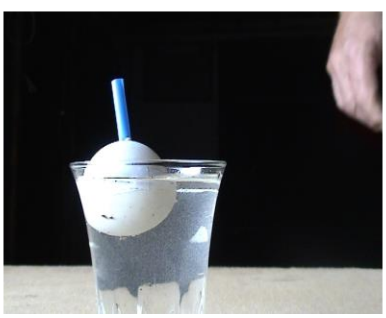
Material:
A hanging scale, a basket, three equal weights (e.g. three equally big apples).

Action:
Hang the basket on the scale. First weigh one object, then two, then three by putting them in the basket. Mind the stretching of the spring.

What will happen?
The spring will stretch more when you add extra weight. You can derive the weight from the length of the spring.

Why?
The spring stretches in proportion to the weight. (E.g.: one apple could make the spring one centimetre longer, two apples would then make it two centimetres longer, three apples would make it three centimetres longer,..)

8. The stubborn ball.



Material:
Two equal glasses, water, two table tennis balls.

Action:
Fill one glass to the edge with water (as full as possible). The other glass should be nearly full. Put a table tennis ball in each glass.

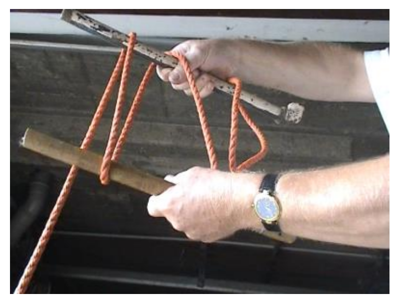
What will happen?

In the fuller glass, the ball floats in the middle. In the other glass, the ball floats against the side.

Why?

The cause of this phenomenon is surface tension. Because the water molecules attract each other strongly (this is called cohesion), a certain tension arises at the surface. The water surface can be considered as a thin film. Because of this tension, the surface in the fuller glass is slightly convex (round). The surface of the second glass is a little concave (hollow). At the surface of the first glass, the molecules are closer together at the sides. The surface tension is bigger on the sides than in the middle. So, there is less resistance in the middle. Thus, the table tennis ball will find its most comfortable space there. At the surface of the second glass, the molecules are closest together in the middle. On the sides, the 'film' is slightly stretched. Since the surface tension is smaller against the sides, the ball will automatically float there. The ball is always pushed towards the weakest spot of the 'film'.

9. Who is the strongest?



Material:

Two solid, wooden sticks, a long rope.

Action:

The rope is attached to one of the sticks. Wind it a few times around the two sticks. Let two (strong) persons hold the sticks at about a metre from each other. They have to try to keep them apart. Now pull the loose end of the rope.

What will happen?

It is a lot easier to pull the sticks together than to keep them apart. One person wins and two lose.

Why?

This experiment works according to the same principle as the pulley. The magnitude of a force doesn't only depend on the pressure. Distance is important too. You have to pull a long distance, but you don't have to pull very hard. If the rope is wound around the sticks three times, this means six metres of rope. You have to move six metres of rope in order to bring the sticks together. The two other persons together move only one metre. If these persons pull as hard as you do, they will lose. They would both have to pull more than three times as hard as you to be able to win.

10. The cork out of the bottle.

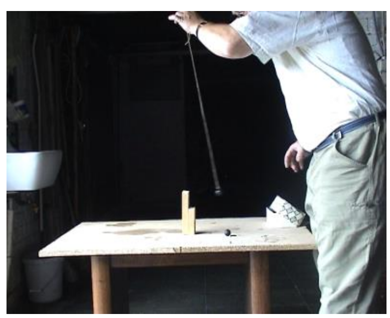
Material:
A bottle with a cork inside, a handkerchief.

Action:
The objective is to pull the cork out of the bottle.
Make a knot in the handkerchief. Put the part of the handkerchief with the knot in the bottle, but make sure there is still a part outside. Turn the bottle around and shake it so the knot is behind the cork. Now pull the handkerchief.

What will happen?
You can pull the cork out of the bottle and you hear a sound.

Why?
Because the knot is behind the cork, you can exercise force onto it.

11. Forms of energy.



Material:
A wooden block (e.g. 8 x 3 x 2 centimetres), a rubber elastic ball on a rope, a non elastic ball of the same size and weight on an equally long rope.

Action:
Put the wooden block up and let the elastic ball swing from a certain height. Let it sway against the top of the wooden block. Do the same with the non elastic ball.

What will happen?

The rubber elastic ball knocks the block over. The other ball doesn't.

Why?

Both balls hit the block with the same energy. But this moving energy is transformed differently.
The elastic ball bounces back. So, it develops the same amount of moving energy, although in an other sense..
The energy of the other ball is transformed into heat energy at the moment of the collision. So, the force exercised onto the block is not so big..

The amount of energy always stays the same. But energy can take different forms.

12. Powerful threads.

Material:

Two equally long pieces of strong sewing thread and two people to help you.

Action:

Every person holds a piece of thread with both hands and tightens it. The two threads should be crossed. The person who holds the upper thread now fastly pulls it down. His or her aim is to break the lower thread which is firmly tightened.

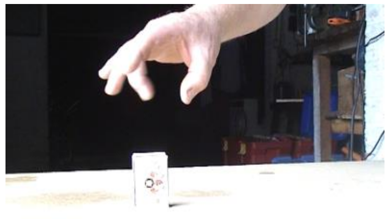
What will happen?

The upper thread breaks.

Why?

Think about the force that is exercised onto the point of contact between the two threads. The thread that has to put up with the largest force will break.
In fact, each thread experiences two forces, because it is pulled or held by two hands. Between these two forces there is an angle. The sum of two forces is larger when this angle is smaller. The thread of the person that pulls, has a smaller angle than the other thread (which has an angle of 180 degrees). This is why it will break.

13. The falling matchbox.



Material:
A matchbox.

Action:
Hold the box up above a table. The distance between the box and the table is about 15 centimetres. Drop the box.

What will happen?
When you close the box before you drop it, the chance is large that the box won't stand straight up on the table. It will fall over.
You have a better chance of succeeding at keeping it straight when you open it (upwards) a little before dropping it.

Why?
When the box lands, a large force is created. It is quite a shock. The box tumbles down. The time of collision is stretched when the box is slightly open. The outside of the box lands first and then the box closes, so the inside lands too.
A long shock is less heavy than a short shock with the same force.

14. The bottlerace.

Material:
5 small plastic bottles (from soda drinks), sand, water, a table.

Action:
Fill one bottle to the neck with water, one with sand. A third bottle should be half filled with sand, a fourth with water. The last bottle stays empty.
Let the table slope. Let the two bottles with sand roll down the table at the same time. Then try the two bottles with water. Also compare the speed with which a bottle with sand and one with water run down the table. Finally, do the races again with the empty bottle.

What will happen?
Some bottles have a slow start and accelerate, other ones start faster but are overtaken later. So, who wins the race will depend on the length of the table.

Why?

All this has to do with inertia'. An object that is at rest, wants to stay at rest. (And an object that is moving wants to keep moving.) A heavier object (e.g. a full bottle) has a larger inertia than a lighter object (e.g. a half filled bottle). This means it has more difficulties coming out of rest and it will start slowlier.

There isn't only a difference between a filled bottle and a half filled bottle. There is also a difference in movement between the bottle that is half filled with water and the bottle that is half filled with sand. The water moves along the sides of the bottle while it is rolling, while most of the sand stays on one side of the bottle. So, the sand is sometimes in the top part of the bottle, sometimes in the lower part. In fact, the sand makes a rolling movement along with the bottle. The water doesn't have to be swirled around, it kind of slides down the table. The movement of the sand means a huge loss of energy which results in losing the bottlerace.