

This is how we measure force with the movable pulley.

### Changing the Magnitude of the Force — the Movable Pulley

Things are different with a **movable pulley**. It can change the required force, reducing it to half the load. But how can a movable pulley cut the required force in half? The movable pulley hangs by two string sections, each of which takes on half of the load. This type of pulley works like a type one lever, as you can see from the picture here. The next experiment will show you that the savings in force must be "paid for" by doubling the length of the string.

#### Experiment 13

#### The String Eater

Hook the end of the string over the force scale as shown below, suspend the pulley with the bottle from the string, and read how much force you saved.

### Fixed Pulley and Movable Pulley Combined — the Combination Pulley

If you want to not only cut the required force in half but also change its direction, then what you need is a simple **combination pulley**. It consists of a fixed and a movable pulley.

#### WORKSHOP XIV

##### Simple Combination Pulley

You will need the fixed pulley again (see page 25 for assembly), as well as the 0 to 2 N force scale (right), and a second pulley with an attachment for the load. Take note of the way you should thread the string through the components (see diagram, lower left).



But you can achieve an even greater savings in force. The more pulleys the combination pulley has — more accurately, the more strings there are running to and fro — the more force you save. The load is simply divided by the number of strings.

As with all machines, when you pull on the string of the combination pulley it swallows up some of the force. The reason for that is provided by another basic principle of mechanics:

**There are no machines without losses.**

Above all, there are losses caused by the friction of the axles and the strings. That is why your force scale shows a slightly higher value when you pull steadily on the string than when in the resting position.

### Forces on a Sloping Path — the Inclined Plane

A wheelchair cannot climb stairs. That is why there is often an extra path designed for wheelchair users, alongside the section with stairs used by other pedestrians. If you were pushing your heavily-loaded bicycle along, would you prefer to push it up the wheelchair ramp or carry it up the steps? Without a doubt, the ramp would be better. You know that the ramp requires less effort. But why is that?

The ramp is an **inclined plane**, a surface that lies at a slant relative to horizontal. In order to observe experimentally how forces are distributed on it, we will first assemble a force scale for 0 to 2 N. In addition, we will build a test vehicle and an inclined plane, which we will attach to the force scale as shown in the picture below, so they can be rotated relative to each other.

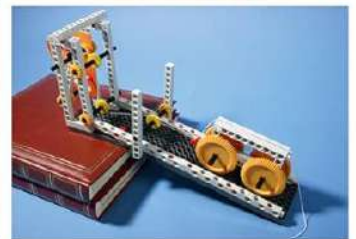
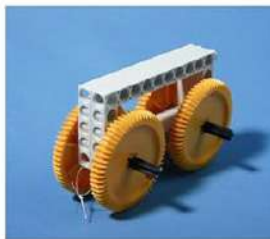


#### WORKSHOP XV

##### Test Vehicle on an Inclined Plane

Assemble your test vehicle as shown in the illustration. Tie a short pull-cord loop to the frame before mounting the front wheels (left). Then slip the loop over the joint pin tied to the end of

the string (top right). That is how the vehicle is connected to the force scale (0 to 2 N) (see page 25 for assembly) over the pulley wheels, shown in the picture on the bottom right.



#### Experiment 14

#### On a Slope Over a Precipice

**Step 1:** Place the force scale at the edge of a table and let the vehicle dangle down by the string. As you take the reading, nudge the pointer bar upward and tip the force scale so that the string unwinds over the pulley wheels. The pointer indicates the weight of the vehicle.

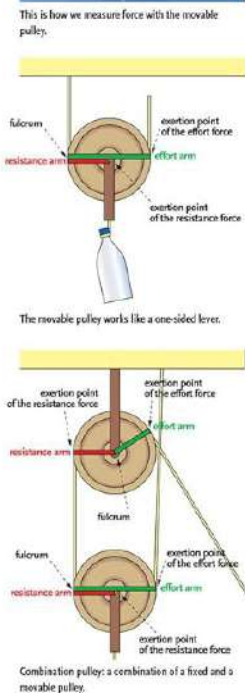
**Step 2:** Next, place the force scale on a stack of two or three thick books and connect it to the inclined plane with the joint pins. Take another reading. Now the force is considerably less. Once again, the question is raised: why is the force reduced on the inclined plane? The answer: because the force of the weight is distributed into two individual forces.

Of course, the basic principle we learned before applies here as well: the savings in terms of force must be compensated for by adding distance. A road sign announces an incline in the road of 15%. That means that a car has to drive about 10 m in order to move just 1.5 m higher (1.5 divided by 10 = 0.15 or 15%).

The driver has to take a longer stretch of road into account in order to get his car over the mountain. If the side of the mountain is too steep for a car to be able to drive up it on a straight road, then switchbacks have to be built — that is, the road has to wind back and forth.

**Real World Physics**  
**Why Is It Called a Pulley?**

You might think a pulley gets its name from the fact that you can use it to pull things up. In fact, the name comes from poles. Creek for "hinge."





# PHYSICS workshop

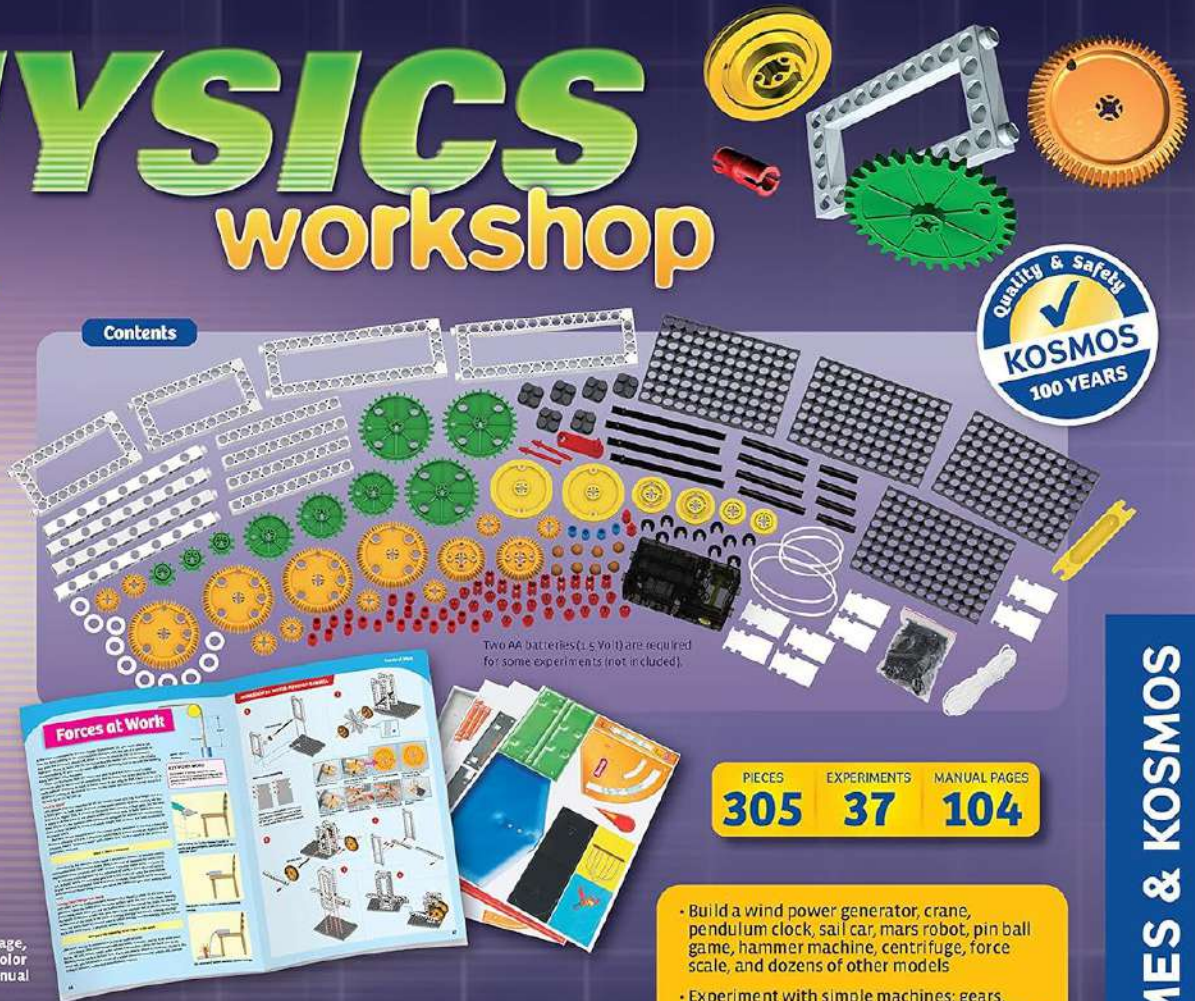
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104-page,  
full-color  
manual



Contents

Two AA batteries (1.5 V) are required for some experiments (not included).



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- Build a wind power generator, crane, pendulum clock, sail car, mars robot, pin ball game, hammer machine, centrifuge, force scale, and dozens of other models
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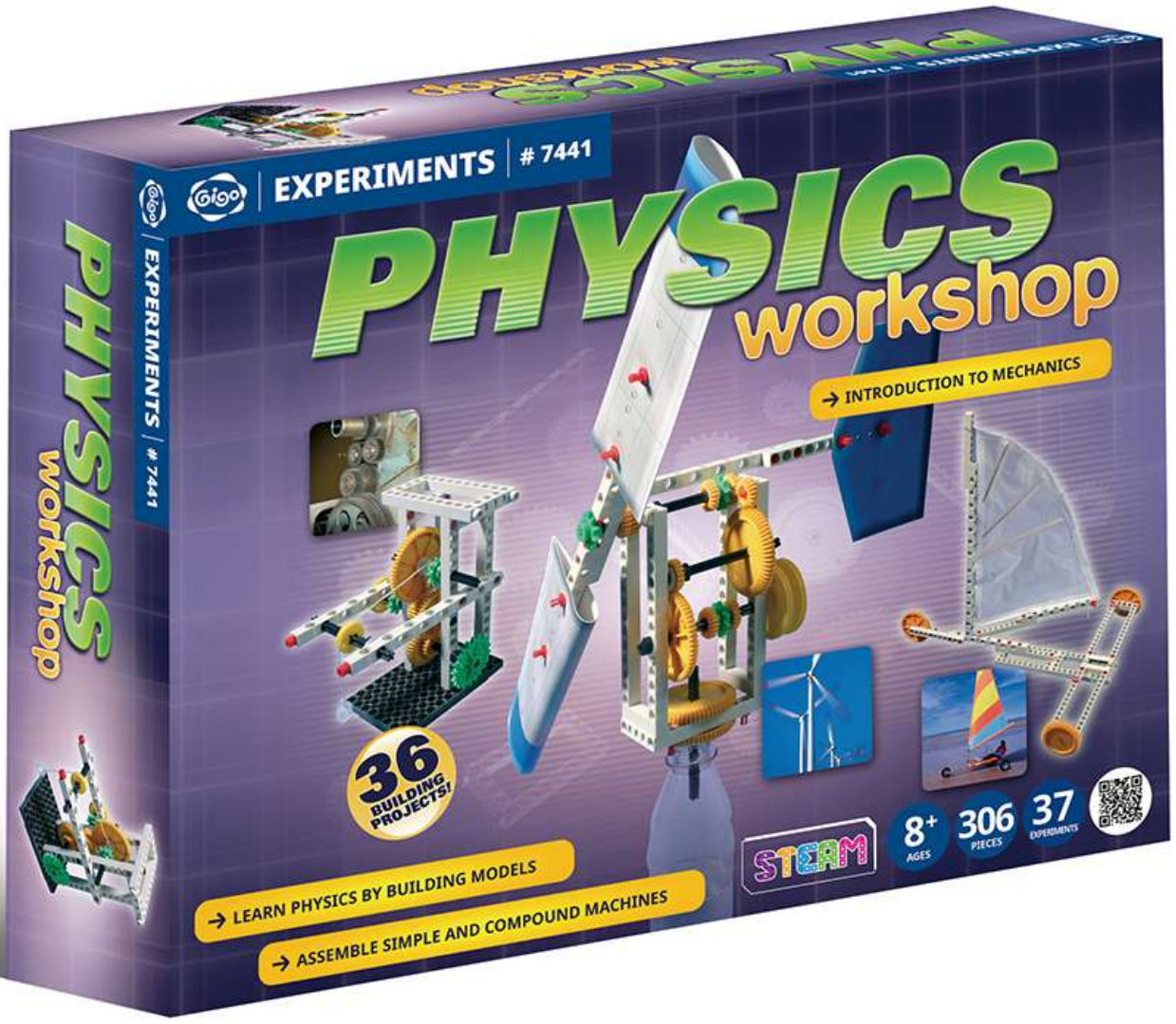
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**WARNING!** Only for use by children aged 8 years and older. Instructions for parents or other supervising adults are included and have to be observed. Keep packaging and instructions as they contain important information.

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