TEACHER
GUIDE

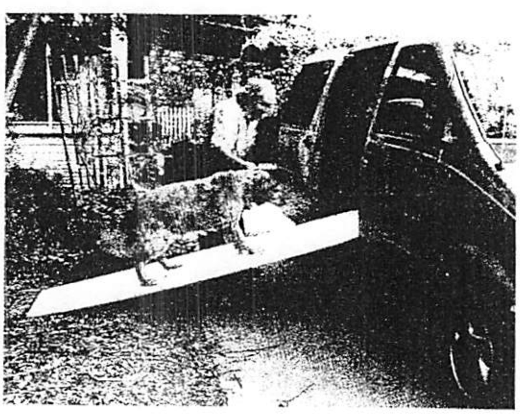
THE INCLINED PLANE

Overview

The Crusader Education Inclined Plane is crafted from durable hardwood to provide a long-lasting piece of laboratory equipment that lets students explore the basic concept of this simple machine. Students can vary the angle and the weight and notice how this affects the force necessary to move an object up the ramp. This Teacher Guide will explain the history and uses of this particular simple machine, plus suggestions for experiments for students to do with the equipment.

The Inclined Plane: A Simple Machine

Most simple machines have one basic goal: to allow you to perform a task using less force than you would otherwise need.



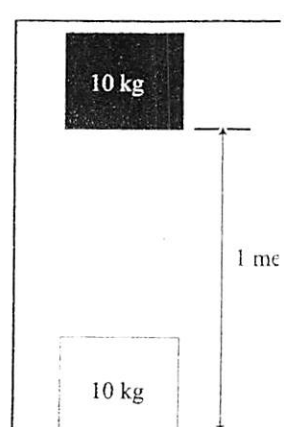
The inclined plane is one of the simplest of the simple machines. It is also one of the most common! You see th usually call them inclined planes; you call them ramps.

Here's a simple example: an older dog has difficulty mak solution? A ramp that lets her work her way up more gra as far, but she does so over a much longer distance. This Moving vans generally have ramps like this as well. And public buildings for wheelchair access. The point is, in e objects to be raised with less force.

Inclined Planes in History

Inclined planes have been in use for thousands of years. something very heavy, it makes sense to use a ramp to he certain that the Egyptians used inclined planes in constru were likely pulled on sledges on a ramp that was built up later, Galileo did experiments on balls rolling down inclined planes that helped him formulate some of the basic ide modern science of physics. In the 1700's and 1800's, steam engines were used to raise large loads. But it still made reduce the force, and so canal barges, freight cars, ore cars in mines and other loads were pulled up inclined planes, many trams and such that go up a slope are known as inclined planes. Even in the 21st century, we haven't outgrow After the Space Shuttle makes its way to the launch pad, it must be raised into place. It does this by rolling up a ver

Physics Principles



There are two basic concepts we need to understand the operation of an inclined plane: work and force. Let's take a look at work first. Whenever you change energy from one form into another, we say you are doing work. When you raise an object up, you increase its potential energy. This means you have done work. Here's a specific example: if you take a box that has a mass of 10 kilograms (about 22 pounds) and raise it by a distance of 1 meter (just over one yard), you do an amount of work that is equal to approximately 100 joules. A joule (the symbol for a joule is J; we write 100 joules as "100 J") is a unit of energy or a unit of work. The equation looks like this:

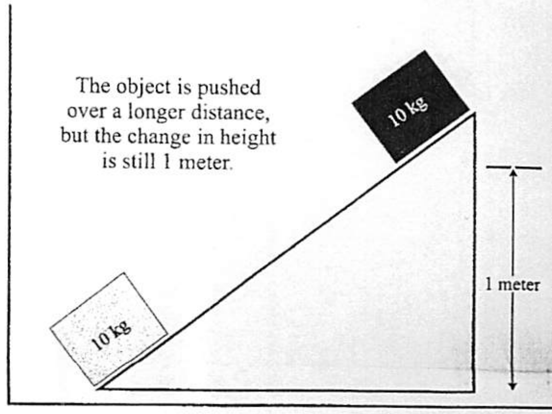
Change in potential energy = Work done = (mass) x (change in height) x (gravity)

By "gravity" we mean a number that represents the strength of gravity. Technically, it is the acceleration of gravity. We use the symbol "g" to represent it, and it has a value of approximately 10 meters per second per second on

a different value. (The 10 meters per second per
bject, after one second, it will be falling at a
r two seconds, it will be falling at 20 meters per
neters per second, per second!) Putting in

done = (10 kg) x (1 m) x (10 m/s2) = 100 joules

gy depends only on the mass, gravity, and the
to push this object up a ramp, as in the diagram
certainly. In the diagram shown, the object is
ige in height is still 1 meter. And since the work
ht, the work done is still 100 J. And this is the
is still the same, but the work was done over a
rk over a longer distance means that you can do



this:

ance over which force is applied

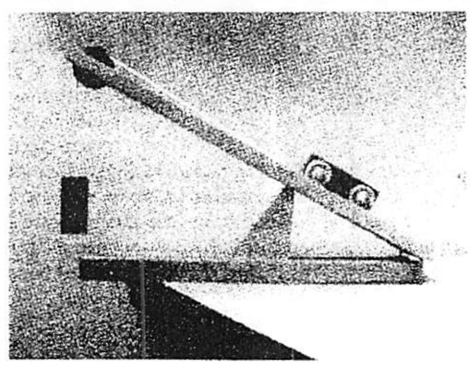
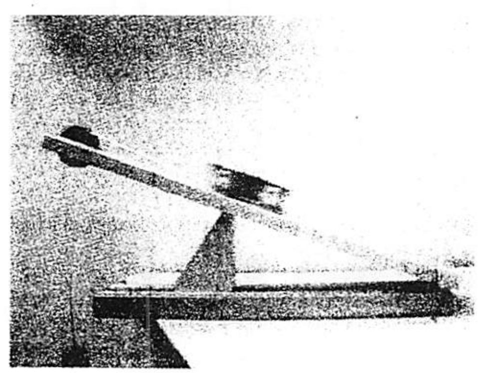
over twice as much distance: 2 meters instead of 1 meter. So we only need about half as much force to push the
.

is done with less force.

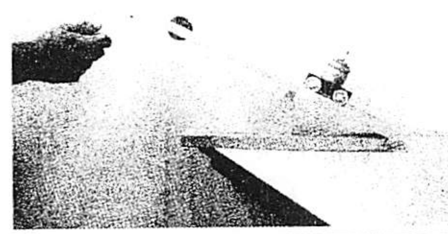
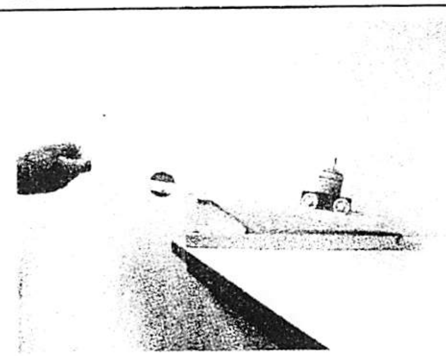
amp. You do the same work, but over a longer distance. And so you need less force!

iging Angle

plane, of course. It is easy to show that the force necessary to pull the car up the ramp changes with angle. There

on of Balance	
igle of the inclined plane so that iging block provides exactly the e to balance the car on the ramp. r which balance is possible, so ne. The force is not sufficient to he ramp. But with just a bit more	
the angle so that it is much less w let the car go, and watch what i see, the car accelerates rapidly, ip the ramp.	

Here are some questions to ask your students about this exercise:	1. In Step 2, the small block falls and the cart goes up the ramp. Which experiences a bigger change in height: the block, or the car? Explain why this is true. (When the car moves up the ramp, its energy increases. This energy must come from the energy lost by the block! But since the block has a lower mass, it much fall farther.) 2. If you put the ramp at an even lower angle, would it make the car go faster? (Yes! Since the car will raise by less, it will pick up less potential energy. This energy must go somewhere: into kinetic energy!)

Method #2: Direct Sensing	
Step 1: Place the ramp at a steep angle, and use the cord to directly pull the car up the ramp. Note how much force is required to do this. (Note: it is easier to sense the force if you add a mass to the well of the car as shown.)	
Step 2: Next, adjust the angle so that it is much less than in step one. Again, pull on the cord to see how much force is required to pull the car up the ramp. You will find that it is much less!	
Here are some questions to ask your students about this exercise:	1. In Step 2, there was less force required to pull the car up the ramp. Explain why. (Since the angle is less, the work is done over a longer distance - meaning less force is required.) 2. Less force is used in Step 2, but something was given up as well! What can you say about the amount that the car was raised up the ramp in the two cases? (The car is raised up less in the second case: less total work is done.)

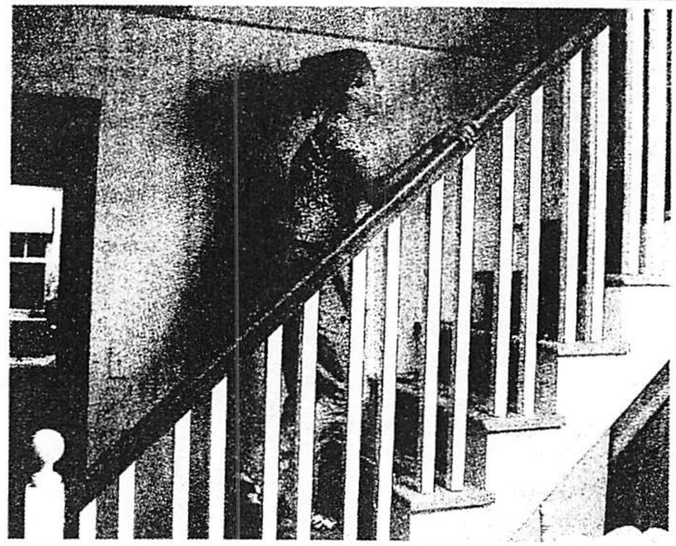
Extensions

Once your students have fully explored the inclined plane system, there are some nice extensions you might have them think about.

A Set of Stairs is An Inclined Plane

When you walk up a set of stairs, you are essentially moving up an inclined plane! When you walk up a ladder, you must raise yourself directly up. But on a set of stairs, you can move at an angle: you move vertically but also horizontally. This means that you don't have to use as much force!

Of course, wheelchairs can't use stairs, so most public buildings also have ramps, inclined planes!



Inclined Planes in Everyday Life: Stairs

Why is it easier to walk up a set of stairs than to go up a ladder? The angle! These are both examples of inclined planes, and, as we have seen, reducing the angle means you can use less force.

Inclined Planes at the Playground: The Slide

A playground slide is of course, an inclined plane. But in this case you go down the ramp, not up it. The basic point is the same: there is less force. But in this case, it means there is less force accelerating you down the ramp. If you fall, you feel the full force and acceleration of gravity. When you go down a slide, you don't; you only feel some fraction. So you still accelerate, but at a rate that is more enjoyable!

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