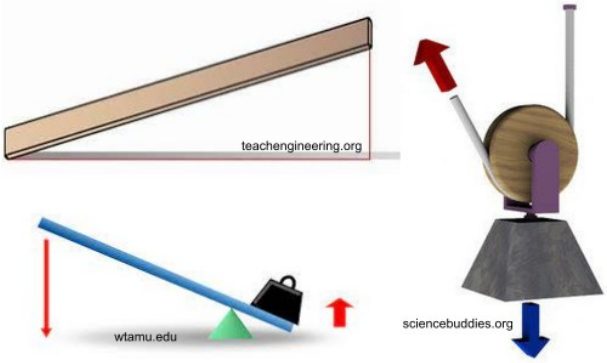
Simple Machines: Same Work with Less Effort

(teacher version)

- Simple machines make it easier to do work like lifting a heavy object. They allow us to lift the same **load** with a smaller **force**.
- A smaller force has to act over a longer distance to do the same work.
- **Work = force x distance** stays the same regardless of what machine you use!



1. Tie a piece of string across the top of the cup to make a handle. Place 1 or more rocks (or a metal weight) in the cup. Put some tape over the top so they don't fall out. This will be your **load.**

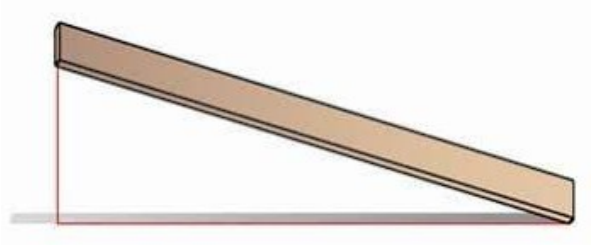
A spring scale is used to measure a pulling force (in "Newtons") based on how much the spring stretches.

Simple Machine 1: Inclined Plane

2. Use the spring scale to slowly lift up the load, from the floor to the height of a chair. Read the force (in N) as you are lifting.

How much force is needed to lift the cup?: _____ N

Over what distance (height) did you lift up the cup?: _____ cm



3. Make a **ramp** by placing 2 meter sticks next to each other, leading from floor to the chair. Using the spring scale, drag the cup slowly up the ramp to the chair. Keep the spring scale parallel to the ramp and read out the force as you drag up the load.

Force to move cup up the ramp: _____ N

Over what distance (measured along the ramp) did you drag the cup?: _____ cm

Using the ramp, the force needed to lift the load was: lower / higher

Using the ramp, the distance over which the force acted was: longer / shorter

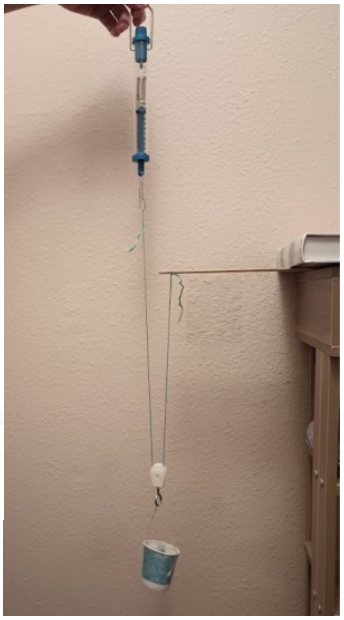
A ramp is an example of a simple machine called an **inclined plane**

Discuss: Where have you seen inclined planes used in everyday life?

Simple Machine 2: Pulley

4. Use heavy books to balance a pencil (or ruler) with the end off the edge of the desk. Cut a piece of string about 100cm in length. Tie one end to the pencil, and thread the other end through a pulley. Make a loop on the free end.

5. Hang your load from the pulley. Attach the loop end to the spring scale, and slowly lift the load to the tabletop.



How much force is needed to lift the load to the top with the pulley ? _____ N

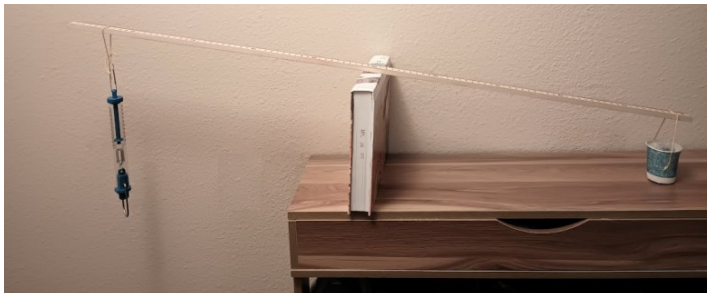
Over what distance does the spring scale move to lift the load to the top? _____ cm

6. Compare to lifting the load directly up with the spring scale (no pulley)

How much force is needed to lift the load directly? _____ N
Over what distance does the spring scale move to lift the load directly? _____ cm

Discuss: How is this simple machine similar to the ramp you used earlier? What does it do to the force needed to lift a load? What does it do to the distance over which the force has to act?

Simple Machine 3: Lever



7. Balance a thick book vertically on the table. Place the meter stick across the book with one end off the table. One student may need to hold the book.
Hang the load off the other end. The meter stick is the **lever** and the book is the **fulcrum**. Start with the fulcrum half-way along the meter-stick.

8. Put a rubber band around the free end of the lever. Attach the spring meter upside down hanging from the rubber band. Slowly, pull down on the spring meter to start lifting the load.

How big a force is needed to lift the load with fulcrum in the middle? _____ N
How does this compare to the force needed without a machine?
Smaller / Larger / about the same

9. Now move the meter stick so that the fulcrum is 10cm closer to the load and farther from the place where you are pulling. Try the experiment again.

How big a force is needed to lift the load with fulcrum closer to load? _____ N
How does this compare to the force needed without a machine?
Smaller / Larger / about the same

When the fulcrum is closer to the load, how does the distance over which you pull compare to the distance the load rises?

Distance for the force to act is: smaller / larger / about the same

What do you think will happen if the fulcrum is closer to the force and further from the load?
The force needed to lift will be: smaller / larger / about the same
(try it if you have time!)

Discuss:

- What general principle do you see connecting the lever, the pulley, and the ramp? What does each of them do to the force needed to lift the load? What happens to the distance over which the force acts?
- Where have you seen levers appear in everyday life?