

# Quick and Easy Simple Machine Experiments to Share with Your Kids

By Aurora Lipper

**Pulleys and levers are simple machines, and they make our lives easier.** They make it easier to lift, move and build things. Chances are that you use simple machines more than you think. If you have ever screwed in a light bulb, put the lid on a jam jar, put keys on a keychain, pierced food with a fork, walked up a ramp, or propped open a door, you've made good use of simple machines.

**Mechanical advantage is like using brains instead of brawn** (using your mind instead of brute muscular strength). With pulleys and levers, you use your 'mechanical advantage' to leverage your strength and lift more than you normally could handle, but it comes at a price. You trade force for distance. When you are using a pulley system, you can thread it up to lift ten people with one hand. Here's the trade-off: You will have to pull ten feet of rope for every one foot they rise up.

**To figure out the mechanical advantage in a pulley system,** count the number of strings in your system. (This will make much more sense after you build the pulley experiments). If there are seven strings, you can pull with seven times your normal strength.

**With levers, it's a little easier to figure out the advantage,** mostly because there are no strings to count or get tangled up. You're just using fulcrums. (Think of the pivot point in a see-saw.) By moving the fulcrum of levers around, you can dramatically change how much you can lift.

Let's get started!

**Second Class Levers** Lay a 2" x 4" x 10' length of wood on the ground. Have a smaller kid sit in the middle of the beam, holding on as you (the larger kid-adult) lift up one end. Leave the other corner resting on the ground – you can even ask a big adult to sit on it so it doesn't slide around. This end is your fulcrum. Have the kid move further back toward the fulcrum, and lift up the beam again. Experiment with both the kid position and effort you exert to lift the beam. Find out where you need to sit to have the kid lift you. They usually can, if you sit in the right position!

**Third Class Levers** Switch places with the smaller kid so that the lightweight child sits on the end of the beam, a big adult on the other end (still your fulcrum), and you lift in the middle. Lift the beam in the middle so that the child's end comes up off the ground. What is the furthest point from the child that you can lift? (If at all?)

**First Class Lever** Use a strong chair, rock, or log as your fulcrum in the middle of the beam. Turn your lever into a see-saw, or teeter-totter. Put a big adult on one end and a lightweight child on the other. Where does the fulcrum need to be in order to balance the two people?

Here's another example of how to use first class levers: Find a strong dowel the same height as a heavy desk or table and stand it up vertically from the floor close to the desk. Find another stick and rest it horizontally atop the first, placing one end under the top ledge of the desk. Push down on the opposite end of the stick, and the desk comes up easily. Notice that you moved your hand further downward than the desk moved upward.

**Block and Tackle** refers to pulleys and rope (in that order). One kid can drag ten adults across the room with this simple setup. (If you can't find pulleys or rings, try the next pulley experiment instead.) Using pliers or vice grips, open the end of a shower curtain pulley and attach to the metal curtain ring. (You can alternatively you can use S-hooks and close them with pliers to prevent the system from separating while you work.)

Attach three pulleys to each ring. Make two or four sets of pulley-ring systems. Take two 18" lengths of dowel and slide one pulley-ring set onto each dowel. Thread a length of rope (about 35') through zigzag fashion first through one pulley on the first dowel, then through a pulley on the second dowel, then an open pulley on the first, then another free pulley on the second, etc... Knot the end to one of the dowels. Attach a kid to the free end of the rope by adding a handle. You can thread a rope through a 6" piece of PVC pipe and tie the rope back on itself. Attach adults to the wood dowels, each adult holding onto the dowel near the ends, straight out in front of their chest. The adults' job is to resist the pull they will feel as the kid walks with his end of the rope.

**Simple Tug-Of-War Pulley System** This is a much simpler setup than the first experiment. Have two people face each other and each hold a smooth pipe or strong dowel (about 18" long) horizontally straight out in front of their chest. (You can also use broomstick handles.) Tie a length of strong nylon rope (slippery rope works best to minimize friction) near the end of one dowel. Drape the rope over the second dowel, loop around the bottom, then back to the top of the first dowel. You're going to zigzag the rope back and forth between the two dowels until you have four strings on each dowel.

Attach a third person to the free end of the rope. The two people hold the dowels will not be able to resist the pull you give when pulling on the end of the rope!

**Return Pulley System** This is a great addition to any tree house or playground structure! Hang a loop of rope from a tree branch. Connect two pulleys to the loop on the tree with S-hooks. Connect one pulley to the basket handle with an S-hook or short piece of rope. Tie a length of rope to the basket handle, then up through one tree pulley, down through the basket pulley, and up through the second tree pulley. Thread a 6" length of PVC pipe onto the end and tie the rope back onto itself to form a handle.

**Exponential Friction** Find a smooth, cylindrical support column, such as those used to support open-air roofs for breezeways and outdoor hallways (check your school). Wind a length of rope one time around the column, and pull on one end while three friends pull on the other in a tug-of-war fashion. Experiment with the number of friends and the number of winds around the column.

**Simple Balance** Suspend a flat ruler from its center-point with a 12" piece of rope from a low tree branch (or stack a big pile of books on a table, and place a ruler between books near the top so part of the ruler sticks out, and you can suspend the balance from it). When the ruler is in balance, add to identical baskets to each end and place objects in the baskets (or directly on the ruler). Make one basket slightly heavier than the other, and slide it toward the fulcrum until the ruler is in balance again.

**Slingshot Block** Nail three nails in a triangular pattern into a scrap piece of wood. Stretch a rubber band around two of the nails. Loop a small piece of string around the middle of the rubber band and knot to the third nail. (See image above.) Place the entire block on a bed of naked straws. Place a projectile (such as a good size rock) in the slingshot and cut the string. The projectile goes one way and the nail-block another.

**Inclined Plane** Cut a right triangle out of paper, about 11" on its base, the short side 5 1/2". Find a short dowel (or use a cardboard tube from a coat-hanger. Roll the triangular paper around the tube beginning at the short side and roll toward the triangle point, keeping the base even as it rolls. Notice that the inclined plane (hypotenuse) spirals up as a tread as you roll. Remind you of screw threads? Those are inclined planes. So are jar lids, spiral staircases, light bulbs, and key rings. These are all inclined planes that wind around themselves. Some inclined planes are used to lower and raise things (like a jack or ramp), but they can also used to hold objects together (like jar lids or light bulb threads).

**Wedge** Make a simple wedge from a block of wood and drive it under a heavy block (like a tree stump or large book) with a kid on top. A wedge is a double inclined plane (top and bottom surfaces are inclined planes). You have lots of wedges at home: forks, knives, and nails just name a few. When you stick a fork in food, it splits the food apart.

**Simple Catapult** Use a spoon and a quarter (placed at the end of the handle). Show yourself that the longer end of a lever (spoon handle) travels faster and further than the shorter end. Think about the position of the fulcrum – what happens when the fulcrum is not at the center?

**Fast Catapult** Stack five large popsicle sticks (the tongue-depressor size from the doctor's office) together and wrap the ends tightly with rubber bands. Stack two large popsicle sticks and wrap one end tightly with a rubber band. Open the ends apart to form a V and insert the five-stack, pushing it right up to the rubber band end, maximizing the V-angle. Wrap a rubber band around the intersection to secure. Hot glue a milk jug cap open-end up an open end of the V. This holds your ping pong ball (or other projectile).

**Simple Gears** Punch holes in the centers of bottle caps. Flatten out the cap edges as well as you can (you can place it between two boards and hammer) while keeping the circular shape intact. Nail the caps to a small wood board so the teeth-edges mesh and the gears turn freely.

**Belts and Pulleys** Take a rubber band and a roller skate (not in-line skates, but the old-fashioned kind with a wheel at each corner.) Lock the wheels on one side together by wrapping the rubber band around one wheel then the other. Turn one wheel and watch the other spin. Now crisscross the rubber band belt by removing one side of the rubber band from a wheel, giving it a half twist, and replacing it back on the wheel. Now when you turn one wheel, the other should spin the opposite direction.

**Wheels and Bearings** Stand on a cookie sheet or cutting board which is placed on the floor (find a smooth floor with no carpet). Ask someone to gently push you across the floor. Notice how much friction they feel as they try to push you. Now place three or four dowels parallel about six inches apart between the board and the floor. Smooth wooden pencils can work in a pinch, as can the hard cardboard tubes from coat-hangers. Ask someone to push you. Is there a direction you still can't travel easily? Replace the dowels with marbles. What happens? Why do the marbles make you do in all directions? What direction(s) did the dowels roll you in?

**Ball Bearings** Get two cans (with a deep groove in the rim, such as paint cans) and stack them. Turn one (still on top of the other) and notice the

resistance (friction) you feel. Now sandwich marbles all along the rim between the cans. Place a heavy book on top and note how easily it turns around. Oil the marbles (you can spray with cooking spray, but it is a bit messy) and it turns more easily yet.

**Simple Homemade Pulleys** Cut a wire coat-hanger at the lower points (at the base of the triangular shape) and use the hook section to make your pulley. Thread both straight ends through a thread spool, crossing in the middle, and bend wire downwards to secure spool in place. Be sure the spool turns freely. Use hook for easy attachment.