32950 SIMPLE MACHINES KIT

Purpose:

The Simple Machines Kit is an assortment of items for teaching the basic principles of the six elementary classical mechanisms: lever, wheel and axle, pulley, inclined plane, screw, and wedge.

Contents:

2	Spring Scales (0-250g)	4	Hooked Weights (100, 200, 500, 1000g)
2	Single Sheave Pulleys	2	Double Sheave Pulleys
1	Wheel and Axle	1	Clamp
1	Hall's Carriage	1	Inclined Plane
2	Wedges	1	Meter Stick
3	Lever Clamps	1	Balance Support
4	Hooked Collars	1	Aluminum Support Rod
3	Wood Cylinders	1	Nylon Cord, spool
1	Support Base & Rod	2	"S" Hooks

To ensure accuracy, calibrate scales prior to use. Instructions are enclosed with spring scales.

THE LEVER

The lever is a bar, or rod, that is free to pivot at a point called the fulcrum. The force exerted on a lever to create pivoting action is called effort. The weight a lever lifts or moves is called resistance. Levers are classified by position of effort, resistance, and fulcrum. In a first class lever, the fulcrum is located between the effort and resistance. In a second class lever, the resistance is located between the fulcrum and effort. In a third class lever, the effort is located between the fulcrum and resistance.

FIRST CLASS LEVER

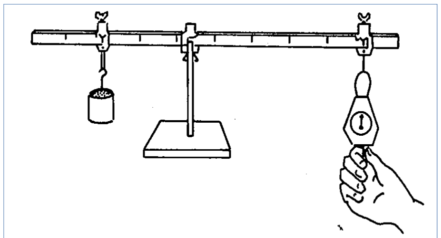


Figure 1

Hold the meter stick horizontally and slide on three lever clamps. Position clamps as shown in Figure 1 and tighten thumb screws. Note: thumb screws on end clamps are facing up and facing down on balance support clamp. Hold the meter stick and suspend a spring scale from one end lever clamp. Retain grasp on meter stick and hook a 500g weight on the other end clamp. Take a scale reading. If the meter stick is considered as the beam of a balance, then the resistance and effort torques must be equal.
The mathematical formula follows:
(Weight) (Weight Arm) = (Force) (Force Arm)

SECOND CLASS LEVER

Lift the meter stick off the balance support and rearrange lever clamps. Position clamps as shown in Figure 2 and tighten thumb screws. Note: thumb screws on balance support clamp and end clamp are facing down. Thumb screw on middle clamp should be facing up. Hold the meter stick with one hand and hook a spring scale on the end clamp. Retain grasp on the meter stick and hook a 100g weight on middle clamp. Take a scale reading. The resistance and effort torques are equal. The same mathematical formula is used with second class levers:

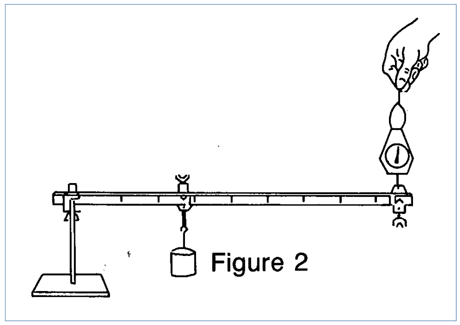


Figure 2

(Weight) (Weight Arm) = (Force) (Force Arm)

THIRD CLASS LEVER

Lift the meter stick off the balance support and rearrange the lever clamps. Position clamps as shown in Figure 3 and tighten thumb screws. Note: thumb screws on balance support clamp and middle clamp should be facing down. The thumb screw on end clamp should be facing up. Hold the meter stick and hook a spring balance on middle clamp. Retain grasp on the meter stick and hook a 100g weight on end clamp. Take a scale reading. The resistance and effort torques are equal. The same mathematical formula is used with all three levers:

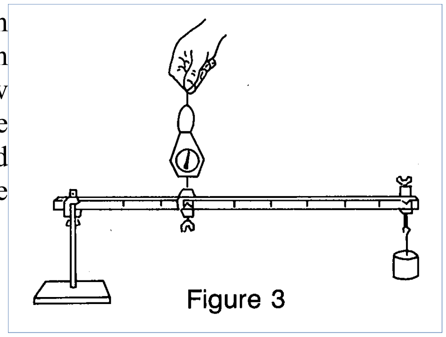


Figure 3

(Weight) (Weight Arm) = (Force) (Force Arm)

THE WHEEL AND AXLE

The wheel and axle is a large wheel fastened rigidly to a smaller wheel, known as the axle, so that turning the wheel also turns the axle. This machine is an adaption of the lever: it has two levers attached to the same axis. A weight is attached to the axle by a chain or rope, and the force which lifts the weight is exerted on another chain or rope fastened to the large wheel. The mechanical advantage is shown by the following equation:

(resistance torque) = (effort torque) or

(weight on axle) (axle diameter) = (force applied on wheel) (wheel diameter).

With a wax pencil, mark the wheel and axle assembly in the following manner : Write A on the largest wheel, B on the next largest wheel, C on the next wheel and D on the smallest wheel (axle). The diameters of these wheels are as follows: A is 10.4cm, B is 6.5cm, C is 5.0cm and D is 3.5cm.

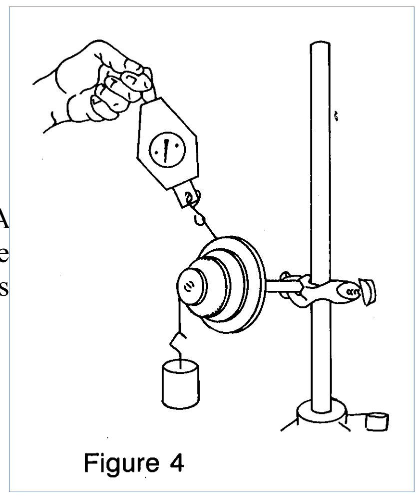


Figure 4

Attach wheel and axle to support rod as shown in Fig.4. Cut two pieces of nylon cord 60cm long. Insert one cord into the hole slightly above the D wheel (axle) and insert the other cord into the hole at the A wheel. Tie a knot at the inserted end of each cord to prevent slippage.

Wrap cord counterclockwise in the groove of the D wheel, or axle, and wrap the A cord clockwise in the groove of the A wheel. Tie a loop at the free end of each cord. Slip the spring balance on the cord loop from the A wheel. Hook a 500g weight on the loop from the D wheel (axle). Allow weight to rest on lab bench. Holding the balance vertically, above the wheel and axle, pull upward and lift the weight off the lab bench. Note the scale reading ; it should be168. This figure was calculated by application of the equation, mentioned previously, resistance torque equals effort torque, or (500) (3.5) = 10.4x. Make at least three measurements of the force required to lift the 500g weight. If desired, other weights can be substituted.

Remove cord from the A wheel and transfer it to the B wheel. Determine the force needed to lift a weight attached to the cord of the D wheel (axle).

In a similar manner, change the cords to different wheels, using A and C, B and D, C and D, and B and C, then repeat experiments.

THE PULLEY

A pulley is a grooved wheel, called a sheave, which is free to rotate on an axle mounted in a frame. The groove retains a cord around the sheave. A pulley fastened to a suitable anchor is called a fixed pulley. A pulley free to move along rope is called a movable pulley. A fixed pulley combined with a movable pulley is called a block and tackle.

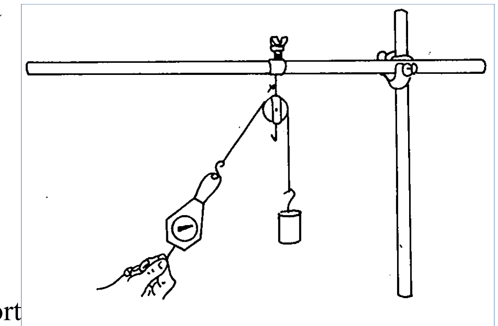


Figure 5

With a fixed pulley, the effort and resistant forces balance each other. With a movable pulley, the effort is one-half the resistance, which means the mechanical advantage is two. With a combination of fixed and movable pulleys (a block and tackle), the mechanical advantage is equal to the number of ropes supporting the resistance or load.

Fasten a right angle clamp to the vertical support rod and attach a horizontal support rod. Slip two hook collars over the horizontal rod, hooks hanging down. Suspend a single-sheave pulley from a hook collar and pass a cord over the pulley. Attach a 100g weight to one end of the cord and a spring scale to the other end, as in Figure 5. Pull down on the scale to lift the weight. Record scale reading; it should indicate 100gm. Replace the 100g weight with a 200g weight and note the force required to lift this weight.

To experiment with a movable pulley, set up apparatus as shown in Fig. 6 (next page). Attach a 500g weight to the pulley and lift it by pulling upward on the spring scale. Record scale reading. Find the scale readings when 300, 200, and 100g weights replace the 500g weight.

To experiment with a combination of fixed and movable pulleys, set up the apparatus as shown in Fig. 7. Attach a 500g weight to the movable pulley and raise it by pulling downward on the spring balance. This pulley arrangement has the same mechanical advantage as a single, movable pulley. To experiment with a more complicated block and tackle, set up apparatus as shown in Fig. 8. Attach a 1000g weight to lower two-sheave pulley and a spring scale to free end of cord. Lift the weight by pulling downward on scale. Note scale reading.

Figure 6

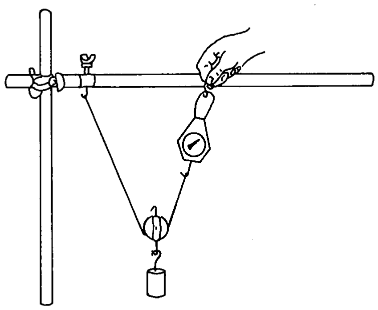
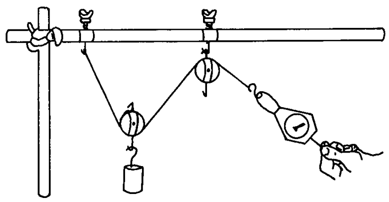


Figure 7



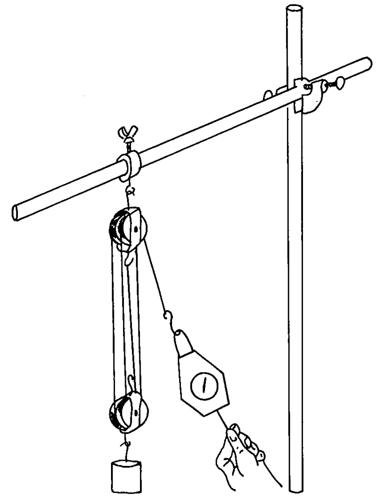


Figure 8

THE INCLINED PLANE

The inclined plane is basically a ramp. Less effort is needed to move an object up an inclined plane than is required to lift an object to the same height. However, the steeper an incline, the greater the force needed to move a load to the top. Calculate mechanical advantage as follows:

Attach inclined plane to the vertical support rod using a right angle clamp. The height of the plane can be adjusted with the angle of slope desired; see tabulation below.

Angle of Slope	5°	10°	20°	30°
Elevation of Upper End of Plane	8.7cm	17.4cm	34.2cm	50cm

Thread a short cord through the hole in the carriage and tie the ends together. Hook the spring balance in the loop and suspend the carriage. Record the weight of the empty carriage (about 190g). Place the carriage on a lab bench and pull carriage using a spring scale. Record scale reading (approximately zero). Repeat with 100, 200, 500,
and 1000g weights.

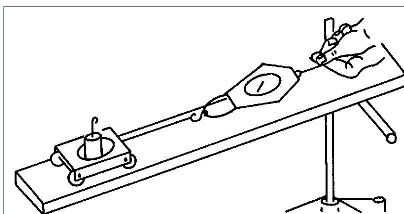


Figure 9

Adjust elevation of the inclined plane to 17.4cm, and pull the carriage up the incline using the spring scale. See Figure 9. Record scale reading. Repeat with 100, 200, 500, and 1000g weights.

Continue experiments with the inclined plane at various slopes. Tabulate the data obtained.

Results should show that the effort required to move the carriage increases as the angle of the plane increases. The force reaches maximum value when the carriage is suspended vertically.

Although less force is required to move an object up an inclined plane than to raise the object vertically, the object must be moved through a longer distance. Also, more time is required to move an object up an inclined plane than to raise an object vertically to a higher level.

THE SCREW

The screw is an inclined plane wound around an axis. This can be easily demonstrated by the following procedure. Cut a wedge from a sheet of paper. Hold a point of the wedge against the bottom of a pencil and rotate the pencil and paper; note the edge of paper as it is wrapped around the pencil. Observe Fig. 10. An edge of paper represents threads of a screw.

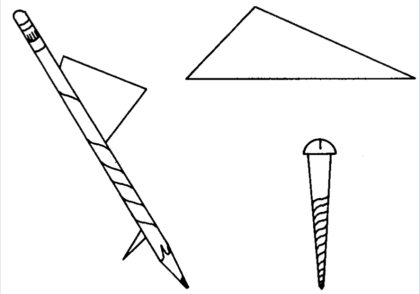


Figure 10

In a common form jack screw, the movable, upright screw is threaded into stationary base, and it supports a load at the top. The screw is turned by a horizontal bar. The distance between the consecutive turns of thread, measured parallel to the axis of the screw, is called pitch. If the screw has ten threads per centimeter, the pitch is 0.1cm. One turn of the screw will raise or lower the top by one millimeter.

Examples of the screw are: light bulb base, nuts, bolts, “C” clamp, micrometer caliper, house jack, rotating piano stool, and vise.

THE WEDGE

The wedge is a modification of the inclined plane. An inclined plane is not movable, a wedge is movable. The smaller the angle of a wedge, the easier it is to push the wedge into a resistance. For example, an ax with its sharp edge can be forced into a wood block with less effort than a steel bar with a blunt edge. The friction encountered by the wedge (ax) entering the wood block (resistance) is so great that it is difficult to show any mechanical advantage.

Place two wedges back to back to form a double inclined plane. Place the narrow end of a wedge under a table or chair leg. Tap the thick end of the wedge with a hammer to drive the wedge completely under the leg. Notice the table or chair is tilted quite easily.

FRICTION

Friction is a force which opposes motion. When two surfaces rub against each other, there is friction between both surfaces. Friction produces heat. In winter, you rub your hands together to make them warmer.

Many factors affect the amount of friction produced between materials. Soft, rough surfaces produce more friction than firm, smooth surfaces. It is easier to roll an object than to slide it, and it is easier to keep sliding it than to start sliding it. Therefore, rolling friction is less than sliding friction, and sliding friction is less than starting friction. Friction is reduced by making surfaces smoother and harder ; by using lubricants ; by using rollers, wheels, and ball bearings.

Dismantle the inclined plane setup and place the plane on a lab bench. Attach a short length of cord to the plane. Tie a loop at the free end and attach a spring scale. While holding the scale horizontally, pull the plane across the lab bench and note the scale reading. Repeat experiment with a 500g weight on the plane.

Position the plane on three equally spaced wooden dowels. Put all the weights, a total of 1800g, on the plane and pull the assembly across the bench. Note the scale reading.

Time Allocation:

To prepare this product for an experimental trial should take less than ten minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.

Feedback:

If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.