Simple Machines: Lever

The lever is probably the most commonly used simple machine. A lever is a rigid bar or solid object that is used to transfer force.

With a pivot, the lever can be used to change the force that is applied (effort), alter the direction, and change the distance of movement. An effort, a pivot, and a load are three features that are common in every lever.

Depending on the positions of these shared features, you can distinguish between first, second, or third class levers.

**First class levers** have the pivot positioned between the effort and the load. Common examples of first class levers include a seesaw, a crowbar, pliers, and scissors.

**Second class levers** have the pivot and the effort at opposite ends and the load positioned between the two. Common examples of second class levers include nutcrackers, wheelbarrows, and bottle openers.

**Third class levers** have the pivot and the load at opposite ends and the effort positioned between the two. Common examples of third class levers include tweezers and ice tongs.
A1

Build A1 book I, pages 2 to 3
Press down on the lever to lift the load.
Describe how hard or easy it was to lift the load.
Circle and label the pivot, load, and effort.
Which class of lever is this?

A2

Build A2 book I, page 4 to 5
Raise the lever.
Describe how hard or easy it was to lift the load.
Circle and label the pivot, load, and effort.
Which class of lever is this?

A3

Build A3 book I, page 6 to 7
Raise the lever.
Describe how hard or easy it was to lift the load.
Circle and label the pivot, load, and effort.
Which class of lever is this?
Simple Machines: Wheel and Axle

Wheels and axles are usually circular objects, often a big wheel and a smaller axle, rigidly secured to one another.

![Diagram of a wheel and axle]

The wheel and axle will always rotate at the same speed. Due to the bigger circumference of the wheel, the surface of the wheel will turn at a greater speed – and with a greater distance too.

Placing a load on a wheeled vehicle almost always reduces friction compared to dragging it over the ground. Wheels in science and engineering are not always used for transport. Wheels with grooves are called pulleys and wheels with teeth are called gears.

Common examples of wheels and axles are rolling pins, roller skates and pushcarts.

Did you know?
The first constructed wheel found so far was made by the Sumerians some 5,600 years ago.
B1
Build B1 book I, page 8 to 9
Push the model along the table in a straight line.
Describe what happens.
Now try driving it in a zigzag pattern with sharp turns.
Describe what happens.

B2
Build B2 book I, page 10 to 11
Push the model along the table in a straight line.
Describe what happens.
Now try driving it in a zigzag pattern with sharp turns.
Describe what happens and compare with the model above.

B3
Build B3 book I, page 12 to 15
Push the model along the table in a straight line.
Describe what happens.
Now try driving it in a zigzag pattern with sharp turns.
Describe what happens and compare with the models above.
B4
Build B4 book I, page 16 to 17
Describe what happens and the movement of the universal joint when you turn the handle.
Simple Machines: Pulley

Pulleys are wheels that are moved by ropes, chains or belts around their rims.

In a belt driven pulley a continuous belt joins two pulley wheels. The wheel to which an external force is applied (effort) is called the drive wheel, and the other the driven wheel. The drive pulley wheel provides the input force and the driven pulley wheel delivers the output force. When the drive wheel turns the belt moves and causes the driven wheel to turn in the same direction. If the drive wheel is smaller than the driven wheel, the driven wheel will turn more slowly than the drive wheel.

Belt driven pulleys rely on belt friction to transmit motion. If the belt is too tight the belt will create wasteful friction forces on the pulley axle and bearing. If too loose the belt will slip and the effort is not used efficiently. Slip is an overload protection safety feature of belt-operated machinery.

For heavy lifting jobs; multiple pulley wheels can be combined into a lifting system that makes lifting heavy objects easier.

Using a single pulley to lift a load doesn't make it easier, but it changes the direction of motion without any gains in speed or required effort. It only allows you to lift a load up by the pulling of the rope. Pulleys can be either movable or fixed. The difference between fixed and movable pulleys are that fixed pulleys do not move up or down when the load is being moved.

A fixed pulley is often fixed to an overhead beam or rafter and will only be able to rotate around its own axle. The use of multiple pulley wheels on one axle, in a lifting or dragging system, is called a Block and Tackle.

Common examples of pulleys are found in window blinds, curtains and flagpoles.
C1
Build C1 book I, page 18
Turn the handle and describe the speeds of the drive and the driven pulley wheels. Then gently increase your grip on the output pointer and describe what happens.

C2
Build C2 book I, page 19
Turn the handle and describe the speeds of the drive and the driven pulley wheels. Then gently increase your grip on the output pointer and describe what happens.

C3
Build C3 book I, page 20
Turn the handle and describe the speeds of the drive and the driven pulley wheels. Then gently increase your grip on the output pointer and describe what happens.
C4
Build C4 book I, page 21
Turn the handle and describe the speeds of the drive and the driven pulley wheels. Then gently increase your grip on the output pointer and describe what happens.

C5
Build C5 book I, page 22 to 23
Turn the handle and describe the speeds of the drive and driven pulley wheels. Label the drive and driven pulley wheels. Use a circle to show exactly where each one is.

C6
Build C6 book I, page 24 to 25
Turn the handle and describe the speeds of the drive and driven pulley wheels. Label the drive and driven pulley wheels. Use a circle to show exactly where each one is.
C7
Build C7 book I, page 26 to 27
Turn the handle and describe the speeds of the drive and driven pulley wheels.
Label the drive and driven pulley wheels. Use a circle to show exactly where each one is.

C8
Build C8 book I, page 28 to 31
Lift the string to lift the load. Describe what happens.

C9
Build C9 book I, page 32 to 35
Pull the string to lift the load. Describe what happens.
C10
Build C10 book I, page 36
Pull the string to lift the load. Describe what happens.
Simple Machines: Inclined Plane

An inclined plane is a slanted surface used to raise objects. One example is a ramp.

![Diagram of an inclined plane with labels for distance and height.]

Using an inclined plane to raise an object to a given height, the object must be moved a longer distance, but with less effort needed than if the object was to be raise straight up. It is a trade-off either to use a lot of effort to raise a given load a short distance straight upwards or to apply much less force to raise it gradually over the longer distance of an inclined plane. That means the same amount of work is done.

Common examples of inclined planes are ramps, ladders, and stairs.

Did you know?
The advantage of using an inclined plane has been known and used for thousands of years. The ancient Egyptians used inclined planes made of earth to ease the transport of their giant stone blocks to the top of the pyramids.
D1
Build D1 book II, page 2 to 12
Release the load. Describe what happens.

D2
Build D2 book II, page 13 to 15
Release the load. Describe what happens.
Simple Machines: Wedge

A wedge is a modification of the inclined plane. Unlike an inclined plane a wedge can move.

A wedge can have a single or two sloping surfaces. The effort you need depends on the relationship between the length and width of the wedge and consequently the sloping surface.

Common examples of wedges include axes, knives and doorstops.

Did you know?

- Wedges are used to split granite!
- A simple device called a wedge and feather can split huge granite blocks.
E1
Build E1 book II, page 16 to 25
Push the wedge under the load. Describe what happens.

E2
Turn the wedge around and then push the wedge under the load again. Describe what happens and compare with the model above.
Simple Machines: Screw

A screw is a modification of an inclined plane. The threads of a screw are like an inclined plane wrapped around a cylinder. The width of the treads are like the angle of an inclined plane.

![Thread image]

The finer the pitch of the screw, the more turns are required, but the less effort is needed to drive the screw in. The load is the friction and other forces exerted by the wood on the screw.

When a screw is screwed into a piece of wood, it is like rotating the long inclined plane through the load. The effort of a turning screwdriver is converted into a vertical effort that screws the screw into an object. How far the screw is able to move in one complete revolution is determined by the pitch of the screw.

The pitch is the number of threads per cm of screw. If a screw has 8 threads in a cm the screw has a pitch of 1/8. A screw with a pitch of 1/8 will in one complete revolution move a distance of 1/8 of a cm into an object.

Common examples of screws are screws, cork screws and drills.

Did you know?
Archimedes, the Greek scientist, mathematician and inventor, used a screw as the basis for his screw-pump design to move water for irrigation in the 3rd century BC.

F1

Build F1 book II, page 26 to 32
Turn the handle and describe what happens to the speed and the direction.
Mechanisms: Gear

Gears are wheels with teeth that mesh with each other. Because the teeth lock together, they can efficiently transfer force and motion.

The drive gear is the gear that is turned by an outside effort, for instance your hand or an engine. Any gear that is turned by another gear is called a driven gear or follower. The drive gear provides the input force and the driven gear delivers the output force. Using a gear system can create change in speed, direction, and force. But there are always advantages and disadvantages. For example, you cannot have both more output force and an increase in speed at the same time.

To predict the ratio of which two meshed gears will move relative to each other, divide the number of teeth on the driven gear by the number of teeth on the drive gear. This is called the gear ratio. If a driven gear with 24 teeth is meshed with a drive gear with 48 teeth, there is a 1:2 gear ratio. That means the driven gear will turn twice as fast as the drive gear.

Gears are found in many machines where there is the need to control the speed of rotary movement and turning force. Common examples include power tools, cars, and egg beaters!
G1
Build G1 book III, page 2
Turn the handle and describe the speeds of the drive and the driven gears. Circle and label the drive and driven gears.

G2
Build G2 book III, page 3
Turn the handle and describe the speeds of the drive and driven gears. Circle and label the drive and driven gears.

G3
Build G3 book III, page 4
Turn the handle and describe the speeds of the drive and driven gears. Circle and label the drive and driven gears.
G4
Build G4 book III, page 5 to 6
Turn the handle and describe the speed and direction of the drive and driven gears. Circle and label the drive and driven gears.

G5
Build G5 book III, page 7 to 8
Turn the handle and describe the speed and direction of the drive and driven gears. Circle and label the drive and driven gears.

G6
Build G6 book III, page 9 to 10
Turn the handle and describe the movement of the driven gear.
G7
Build G7 book III, page 11 to 14
Turn the handle and describe what happens.


G8
Build G8 book III, page 15 to 18
Turn the handle and describe what happens.
What happens if you stop one of the output pointers?
What happens if you stop both output pointers?


G9
Build G9 book III, page 19 to 22
Turn the handle and describe what happens.
What happens if you try turning the output pointer?
G10
Build G10 book II, page 23 to 25
Turn the handle and describe what happens.