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Machines and Mechanical Systems

Forces in Machines

Mechanical systems and machines

In a way, we have developed super powers that come from our clever invention of machines and mechanical systems

A machine is a device with moving parts that work together to accomplish a task.

A bicycle is a good example of a mechanical system that is made of several machines that work together to transform forces from your muscles to speed and motion.

A machine has an input and an output

The input includes everything you do to make the machine work, like pushing on the pedals.

The output is what the machine does for you, like going fast.

Simple machines

The development of technology begins with simple machines.

A simple machine is a mechanical device that does not have a source of power and accomplishes a task with only one movement

Ex: lever, wheel and axle, block and tackle, gear, ramp

Simple machines work by manipulating forces—an input force and an output force.

The input force of a lever is the force you exert to move it.

The output force is the force the lever applies to the thing you are trying to move.

Most of the machines we use today are made up of combinations of different types of simple machines.

Mechanical advantage

Simple machines work by changing force and motion.

A force is an action that has the ability to change motion, like a push or a pull.

Forces do not always result in a change in motion.

Ex: pushing on a solid wall does not make it move (at least not much)

The action of the force is the same, regardless of its source.

There are two units we use to measure force: the newton and the pound.

There are 4.48 N in a lb.

Mechanical advantage is the ratio of output force to input force.

If the mechanical advantage is bigger than one, the output force is bigger than the input force. A mechanical advantage smaller than one means the output force is smaller than the input force.

Today, we call the people who design machines mechanical engineers.

How ropes and pulleys work

Ropes and strings carry tension forces along their length.

A tension force is a pulling force that always acts along the direction of the rope.

If friction is very small, then the force in a rope is the same everywhere.

The figure below shows three different configurations of a rope and pulleys. Each case uses a different number of pulleys. Each time the rope is threaded around a pulley, another vertical section of the rope is added to help support the load.

As you pull on the rope, your input force is felt at every point along the rope.

A machine made with a rope and pulleys is extremely useful because it multiplies force so effectively.

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Science and Engineering

Most inventions came from practical applications of science principles.
The application of science to solve problems is called engineering or technology.
All technologies arise from someone's perception of a need for things to be done better.
Although technology comes in many forms, there are some general principles that apply to all forms of technological design or innovation.

People who design technology to solve problems are called engineers.

Scientists study the world to learn the basic principles behind how things work, while engineers use scientific knowledge to create or improve inventions that solve problems.
In order to test an idea to see if it works, a prototype is made that closely resembles the final project.

The evaluation of test results is a necessary part of any successful design because it identifies potential problems in the design.

The process of design, prototype, test, and evaluate is the engineering cycle.

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Discipline, patience, and persistence are necessary in engineering design.

The Lever

What is a lever?

Levers still form the operating principle behind many common machines.

Example of levers: pliers, wheelbarrow, human biceps and forearm

A lever includes a stiff structure (the lever) that rotates around a fixed point called the fulcrum.

The side of the lever where the input force is applied is called the input arm.

The output arm is the end of the lever that moves the rock or lifts the heavy weight.

Levers are useful because we can arrange the fulcrum and the lengths of the input and output arms to make almost any mechanical advantage we need.

If the fulcrum is placed in the middle of the lever, the input and output forces are the same.

Mechanical advantage of a lever

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The input and output forces are related by the lengths on either side of the fulcrum.

When the input arm is longer, the output force is larger than the input force.

Ex: If the input arm is 10 times longer than the output arm, then the output force will be 10 times bigger than the input force.

The mechanical advantage of a lever is the ratio of lengths between the input arm and the output arm.

You can also make a lever where the output force is less than the input force where the input arm is shorter than the output arm.

There are three types of levers classified by the location of the input and output forces relative to the fulcrum.