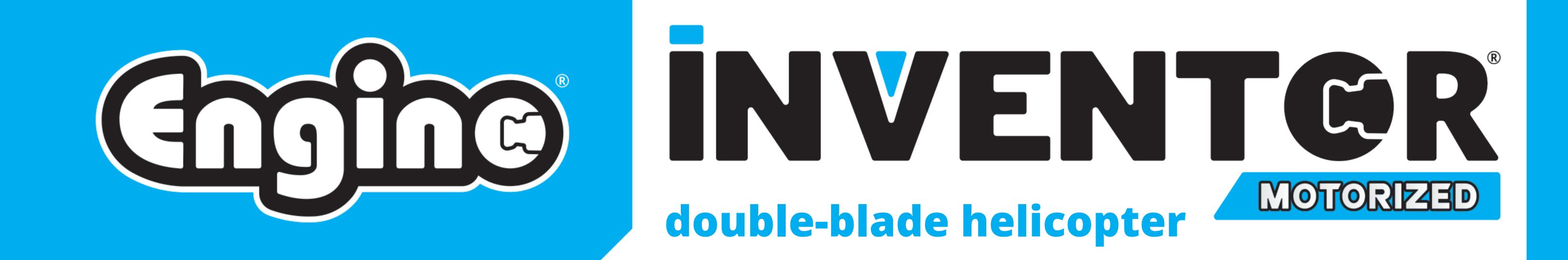
» Multi-model Creation

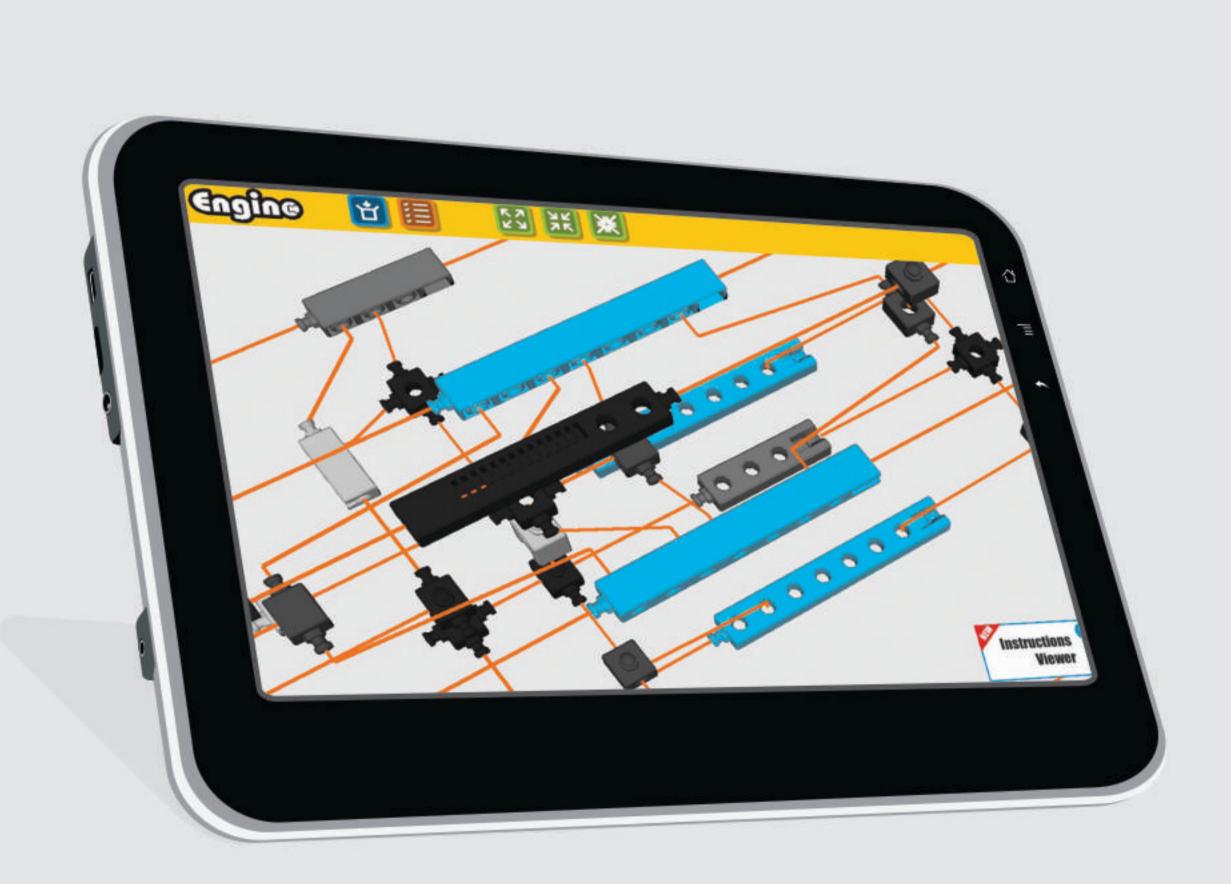










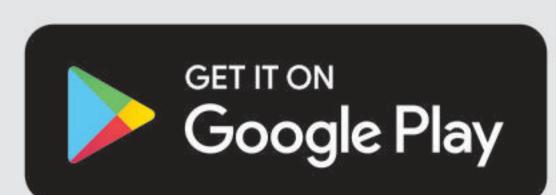


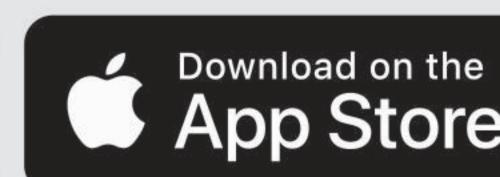
Use your PC or tablet and go to the following link for more models:

www.engino.com/instructions/in70

B Download the app to discover step-by-step instructions in 3D view!

Engino kidCAD (3D Viewer) app:

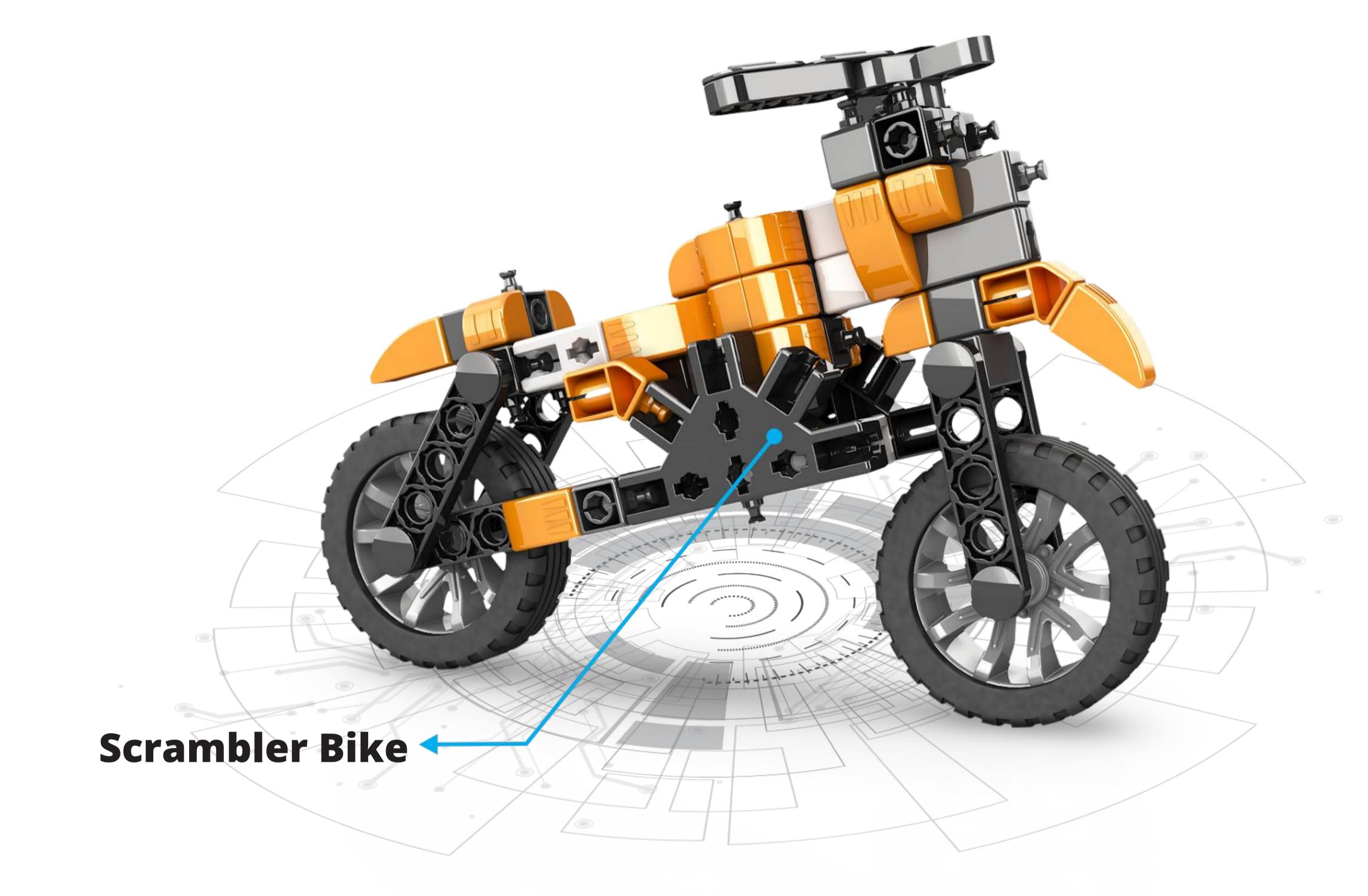




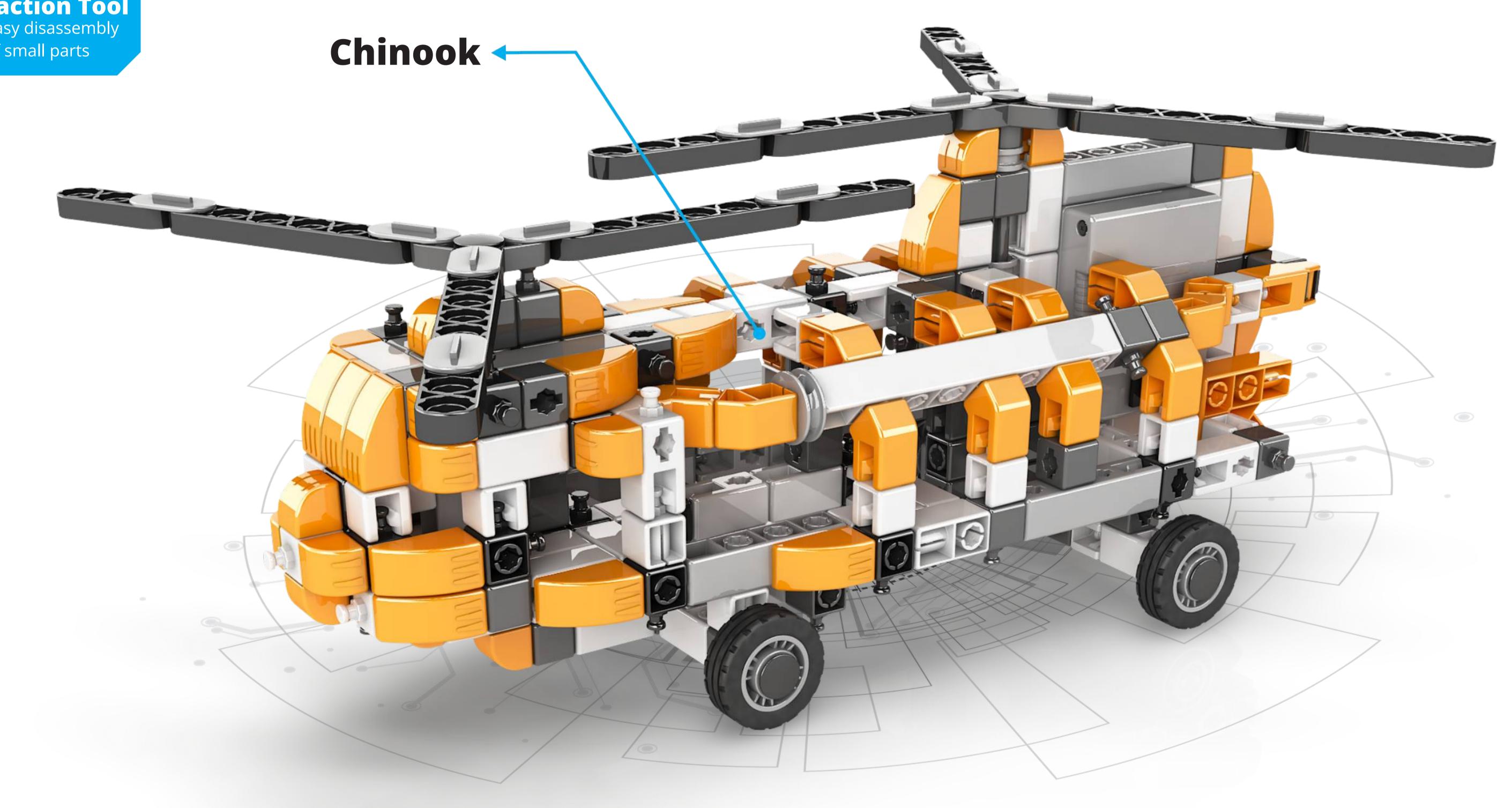


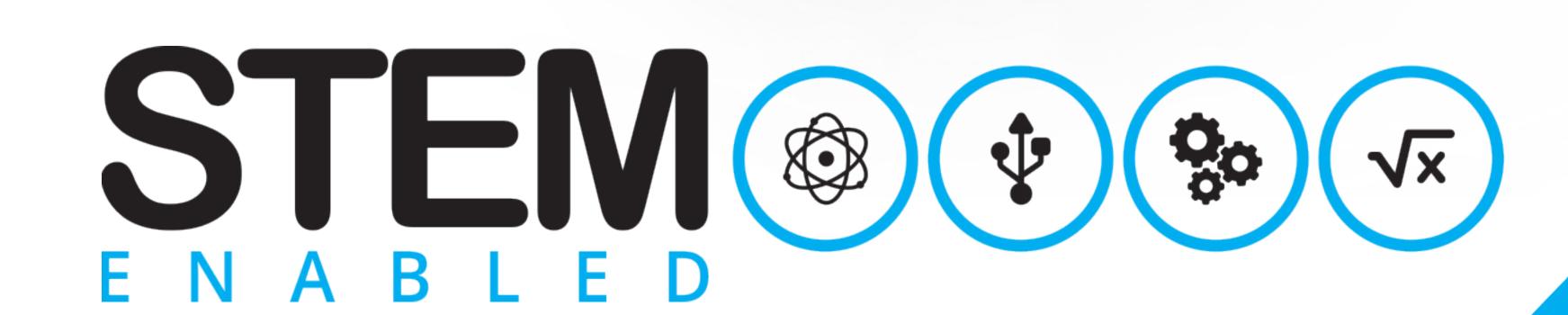






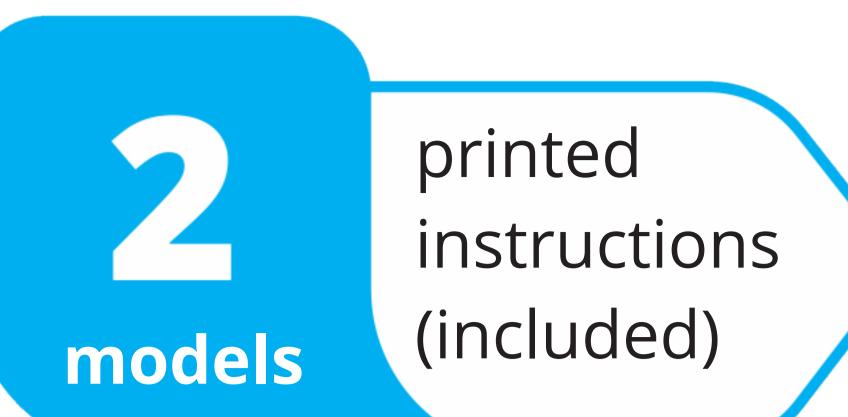






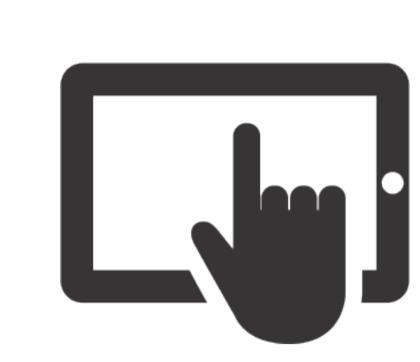


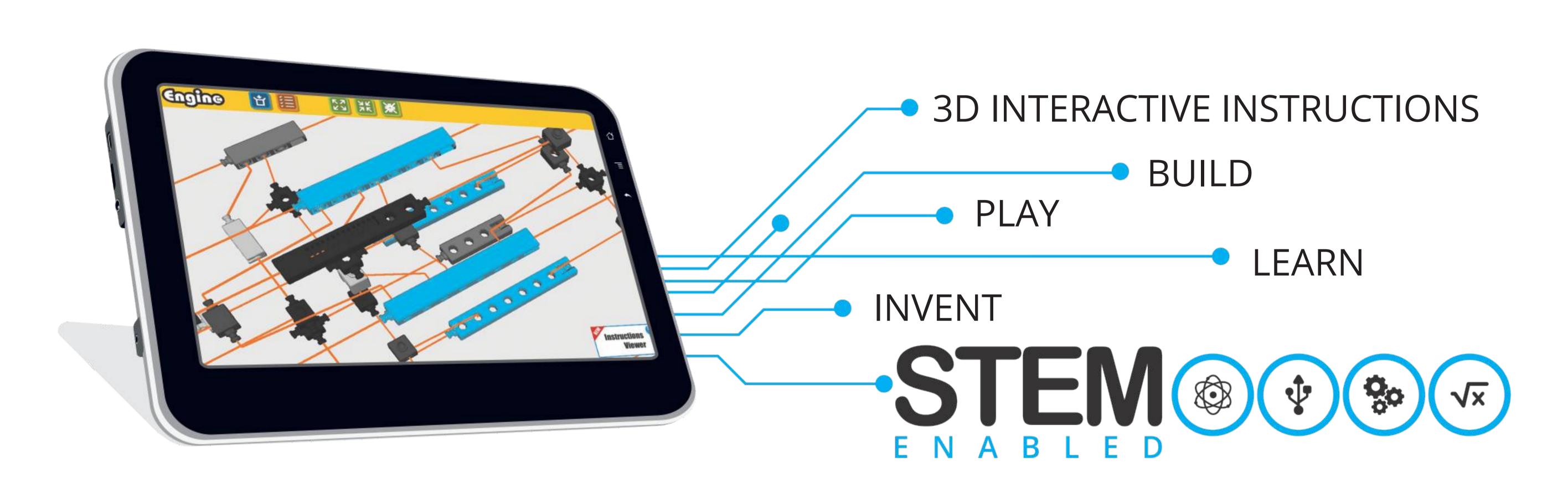


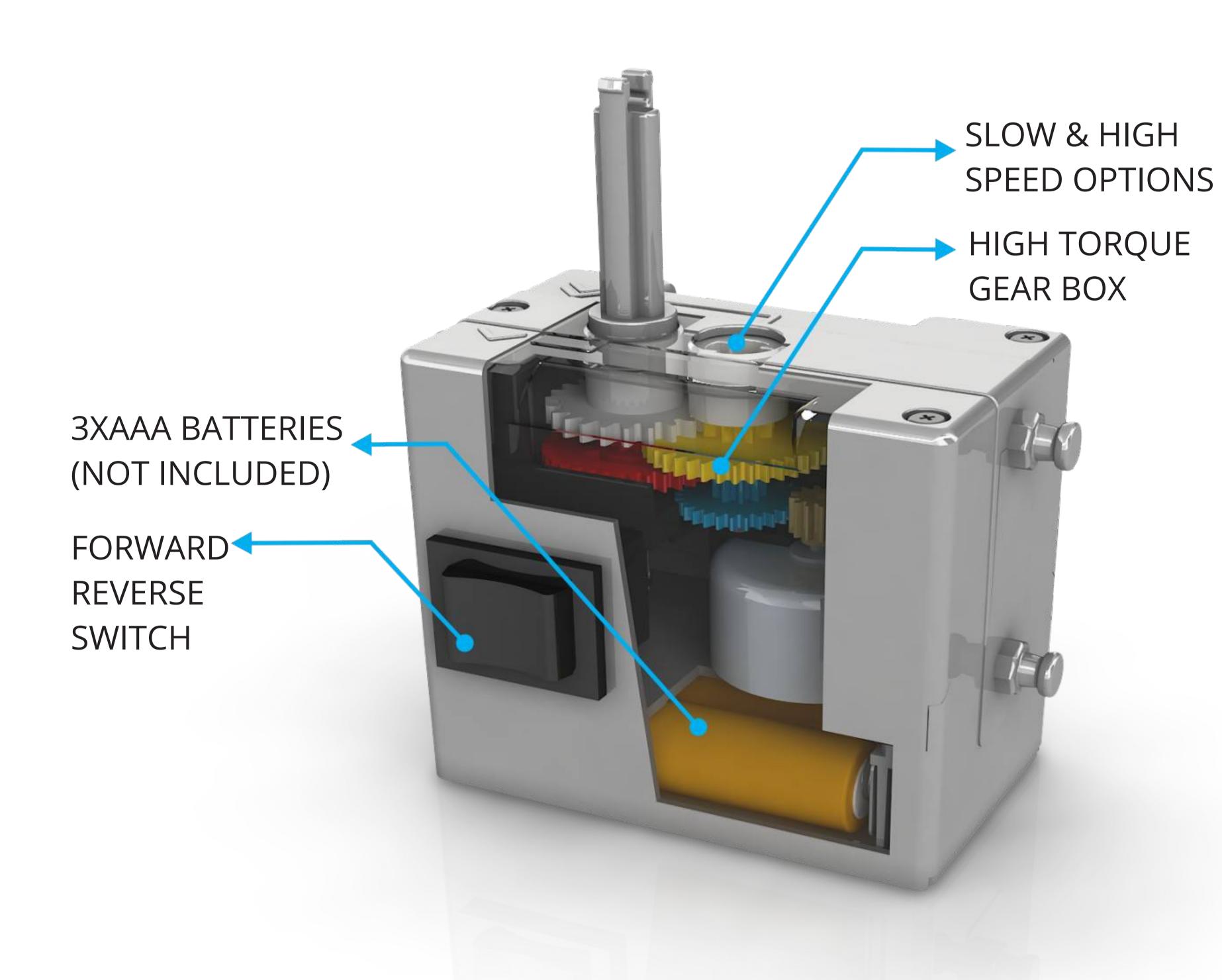


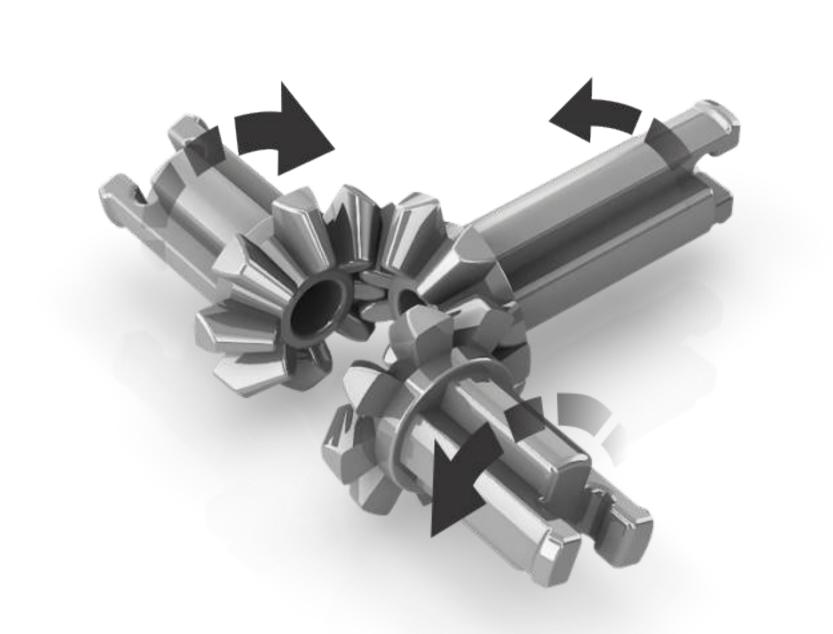


online
3D instructions





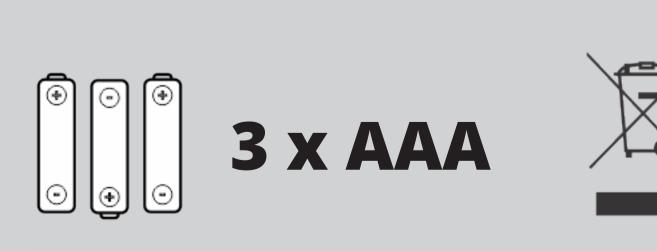




(+) BEVEL GEAR MECHANISM

+ MOTOR POWER

All rights reserved. Photos non-binding. One model can be built at a time. Retain the box for future reference. Colors may vary. WARNING CHOKING HAZARD: Contains small parts. Not suitable for children aged 3 years and under.



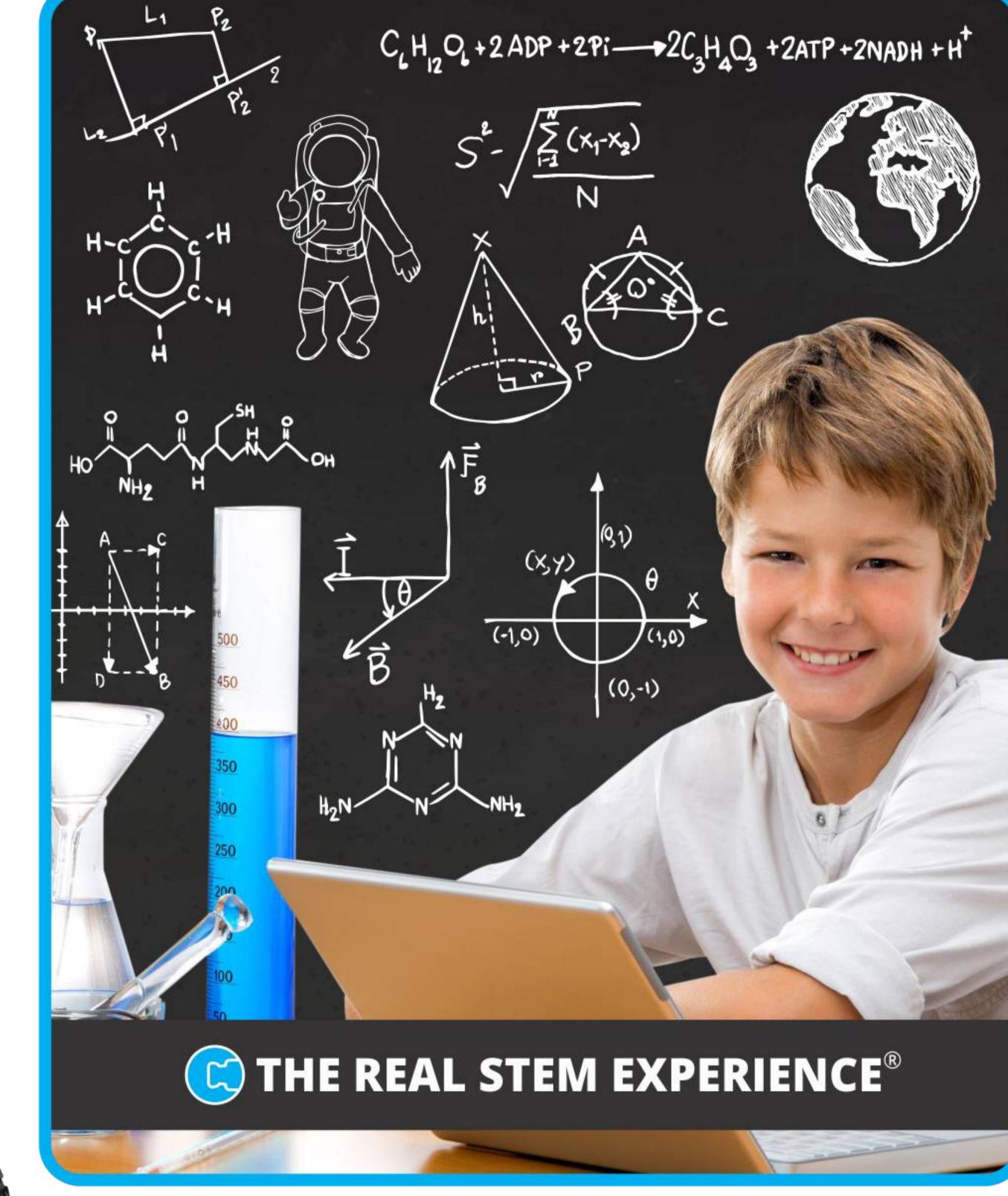
Power motor included.

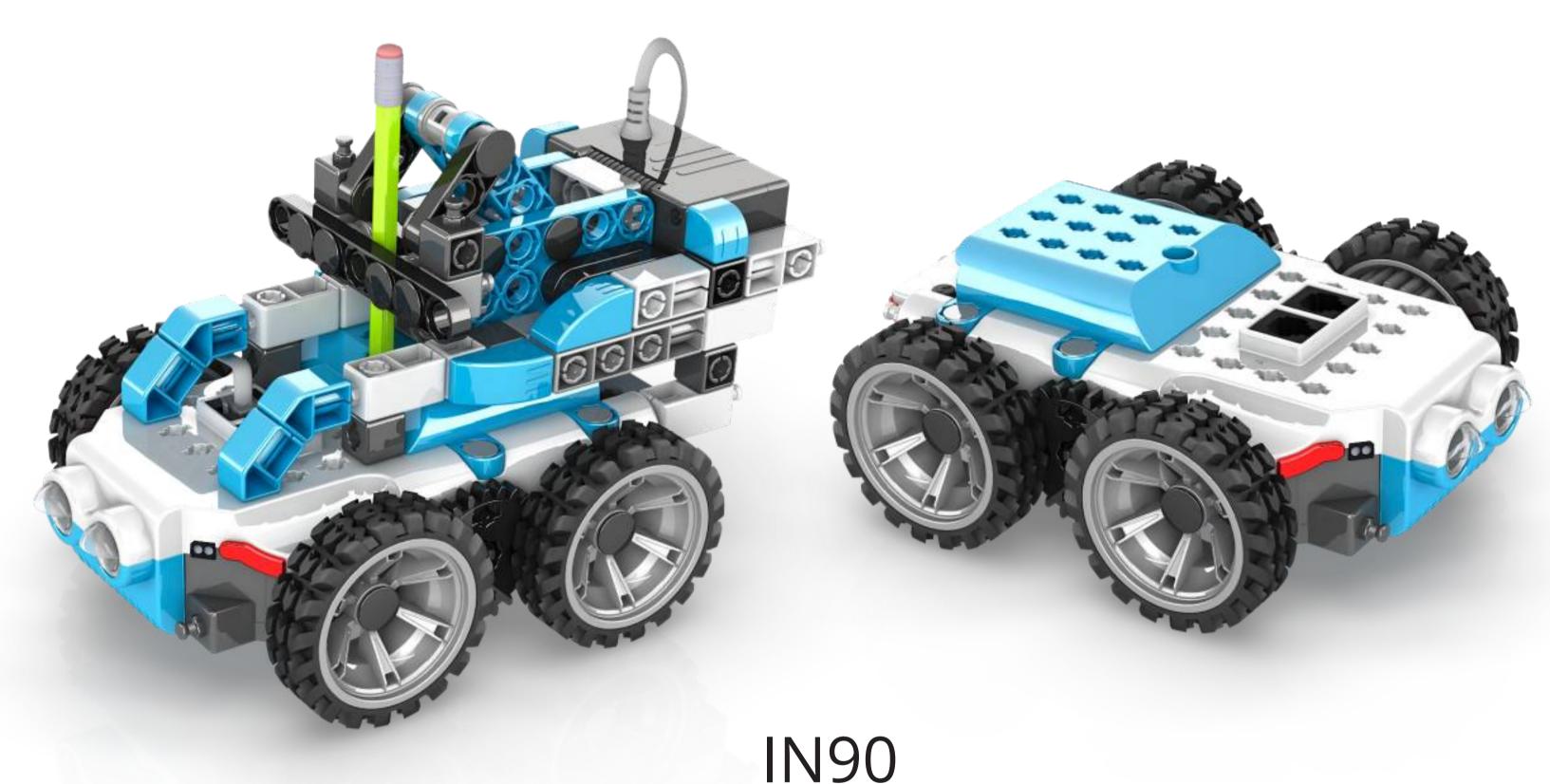
Batteries required but not included.

>> Technology Explained

This new INVENTOR Mechanics range has been developed to inspire children of ages 7-14, to follow STEM careers and develop 21st century skills such as problem solving and critical thinking. The multi-theme approach motivates children to construct a model they can relate to, while the ability to build many different models from the same set enhances creativity and engineering design thinking. INVENTOR Mechanics includes a range of new, highly technical parts that help create fully functional models and learn about various technologies. The top of the range is GINOBOT, a unique robotic vehicle with built-in sensors and Bluetooth which is fully programmable with simple-to-use coding software!

Some more advanced products of INVENTOR range:



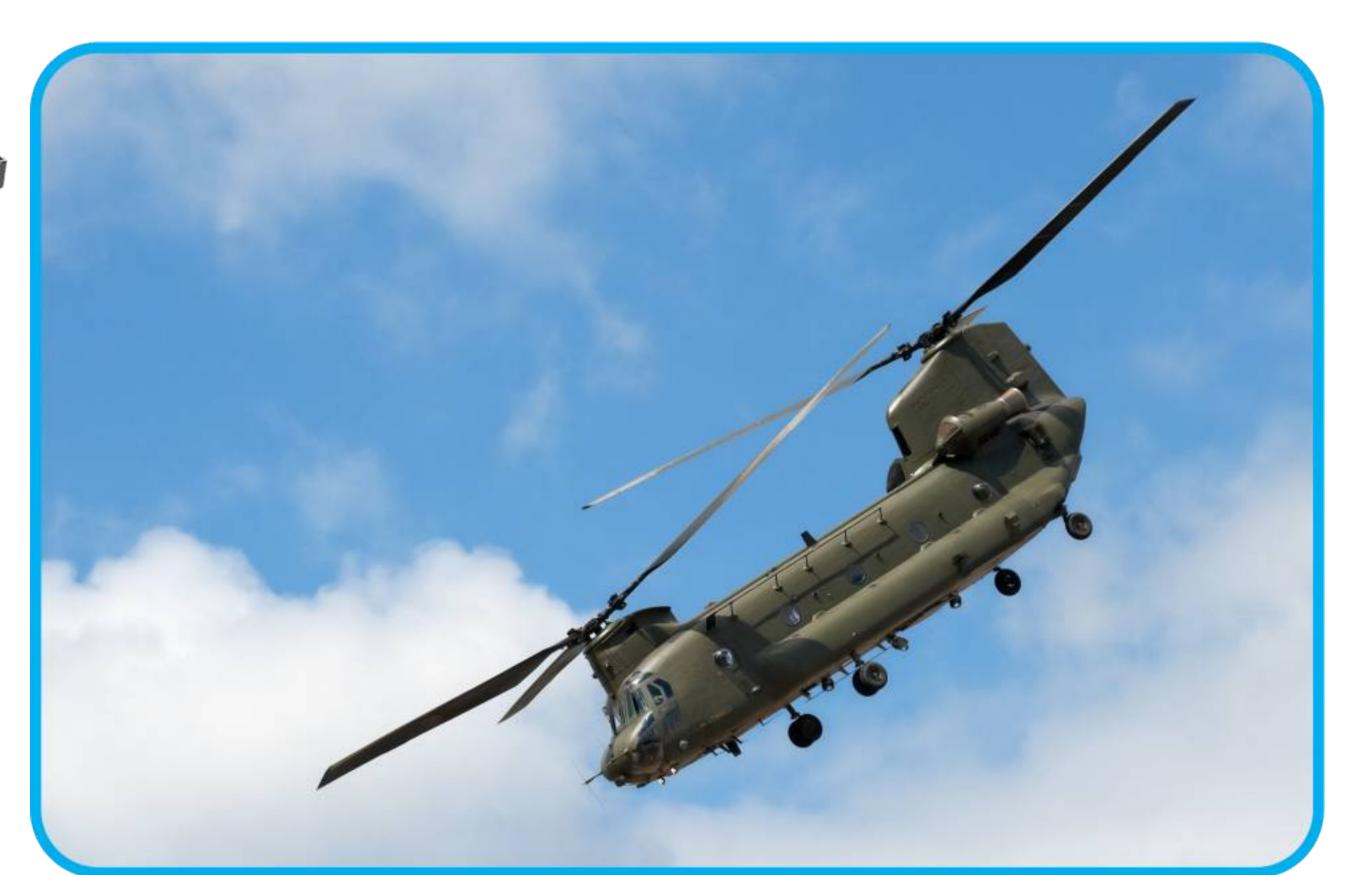


Visit www.engino.com to find out more details!

>> Did you know?

Did you know for example that the Chinook is an iconic helicopter with two rotor blades, each rotating on opposite directions? This innovative design was first demonstrated by its inventor Piasecki in 1945 and became a military machine in 1962. Nowadays, it is also a significant commercial aircraft extensively used in logging, construction and fighting forest fires. This powerful machine can carry numerous passengers and lift outstanding amounts of load. It can carry up to 10 tons of load due to its two powerful engines and can carry up to 55 persons inside its fuselage!



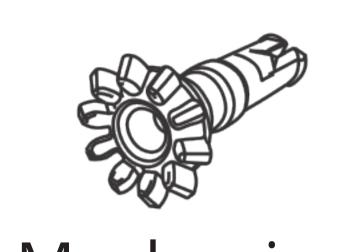


>> STEM Levels

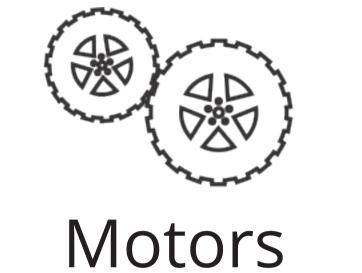
Construction Levels:



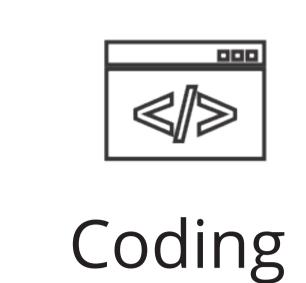
Level 10 20



Mechanics Level 10 20

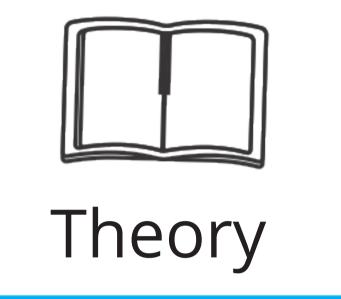


10 20



Level 10 20

Learning Levels:



Level 10 20



Quiz & Exercices Level 10 20





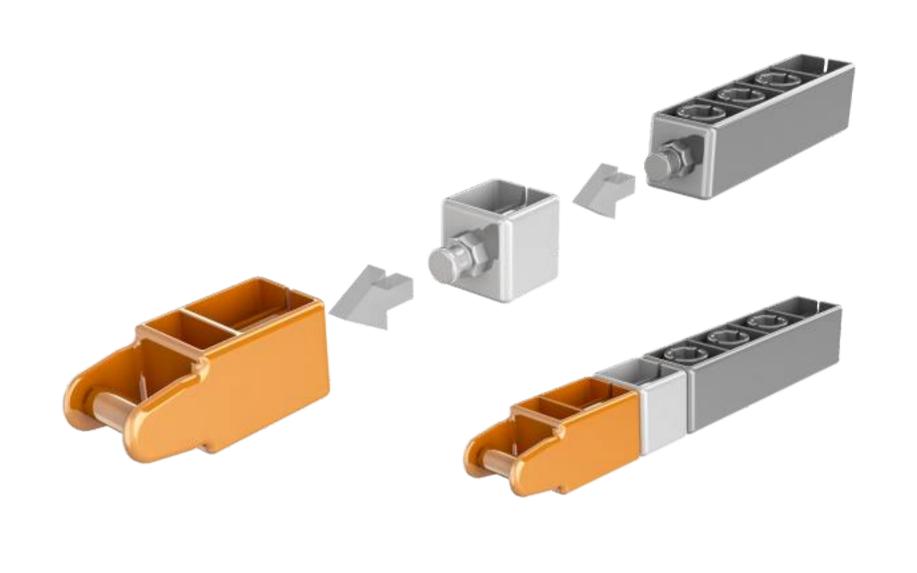
>> Building System

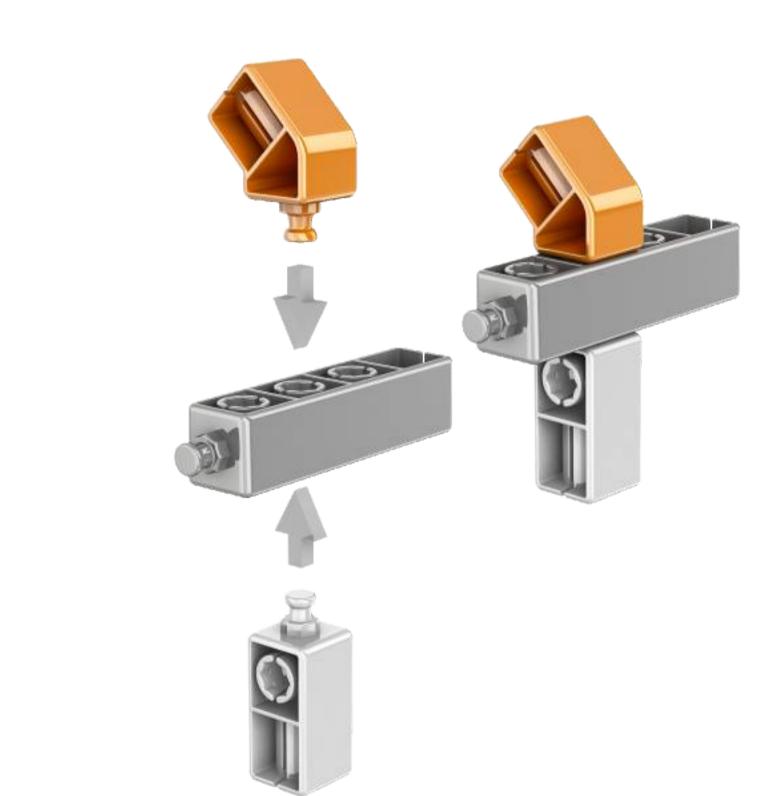


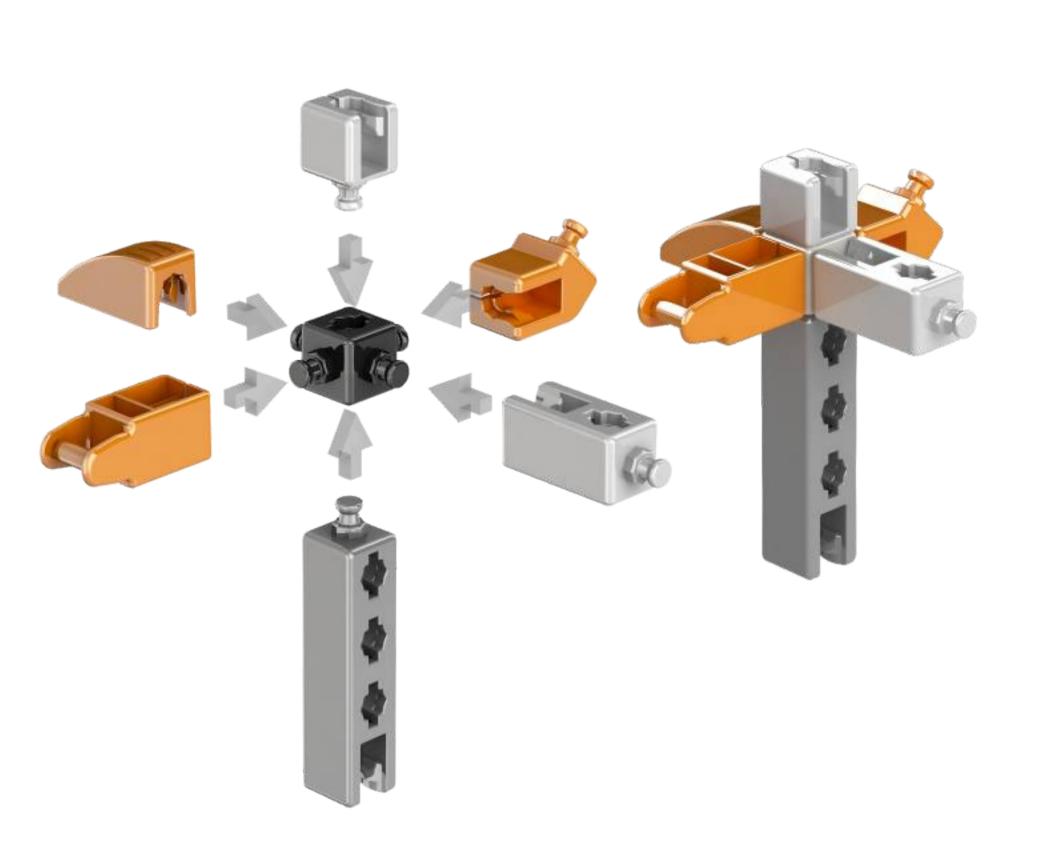


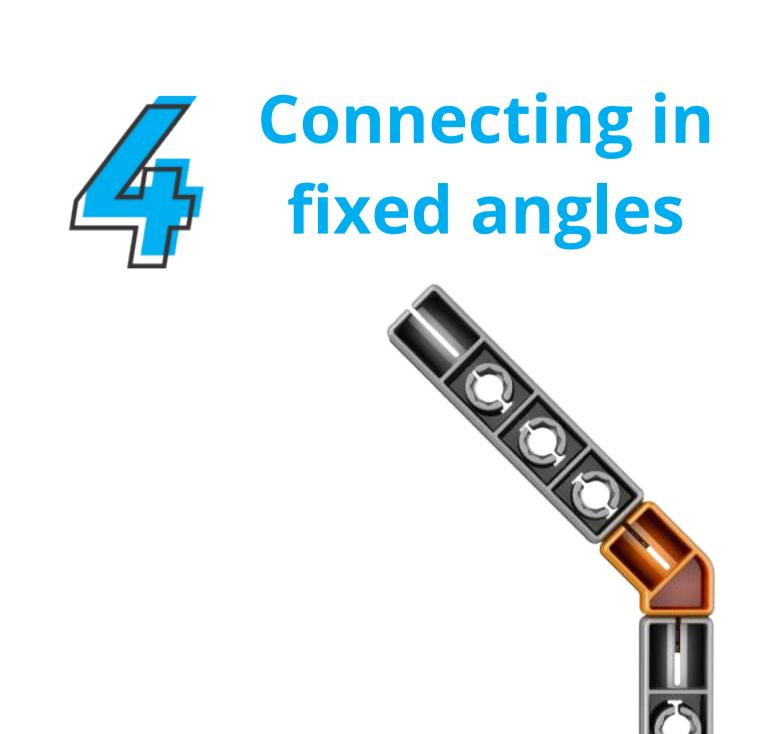


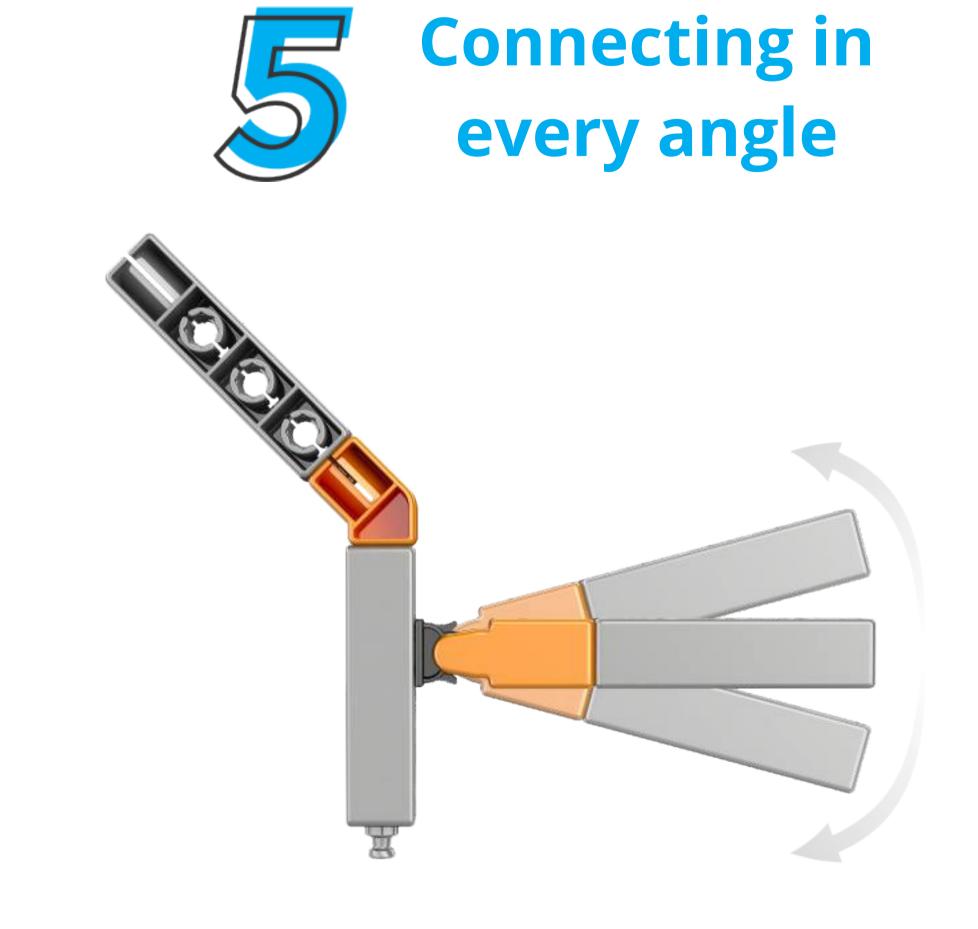


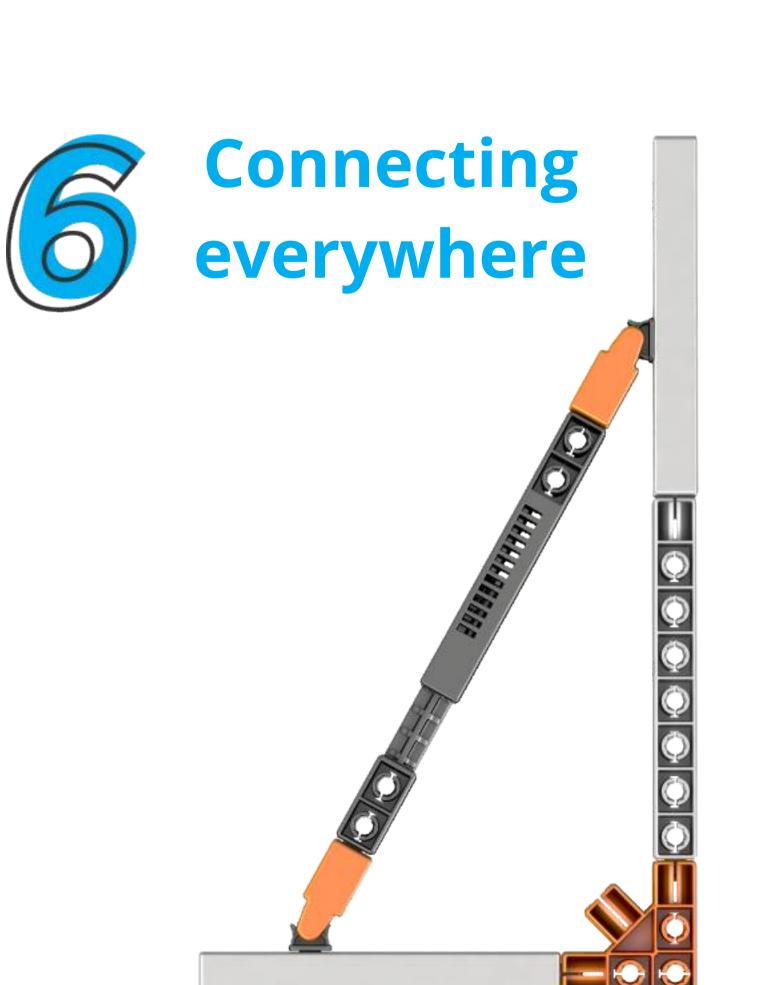




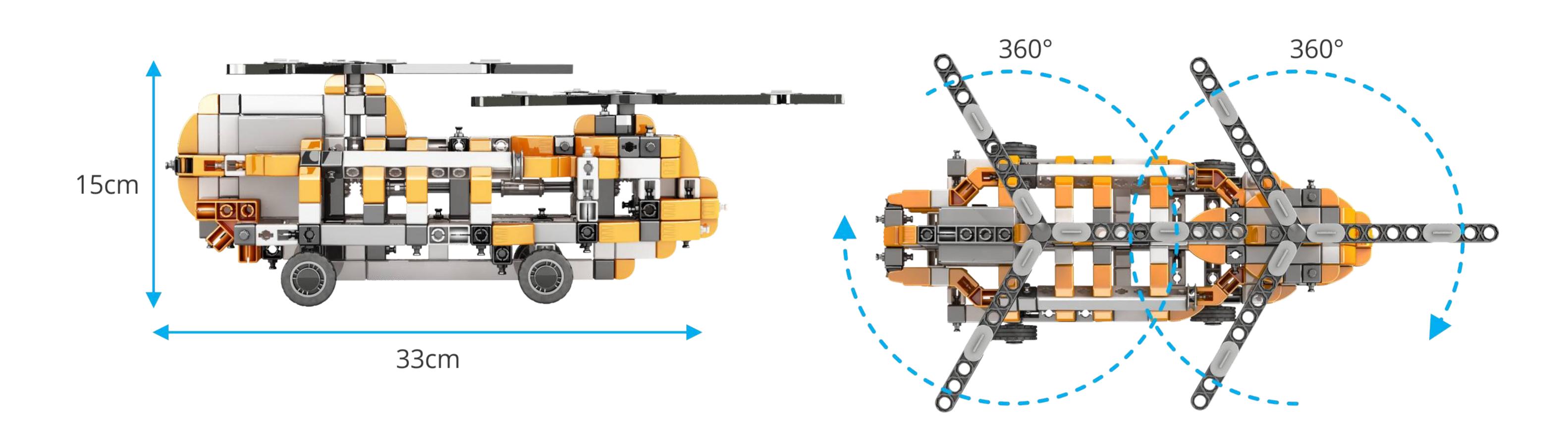




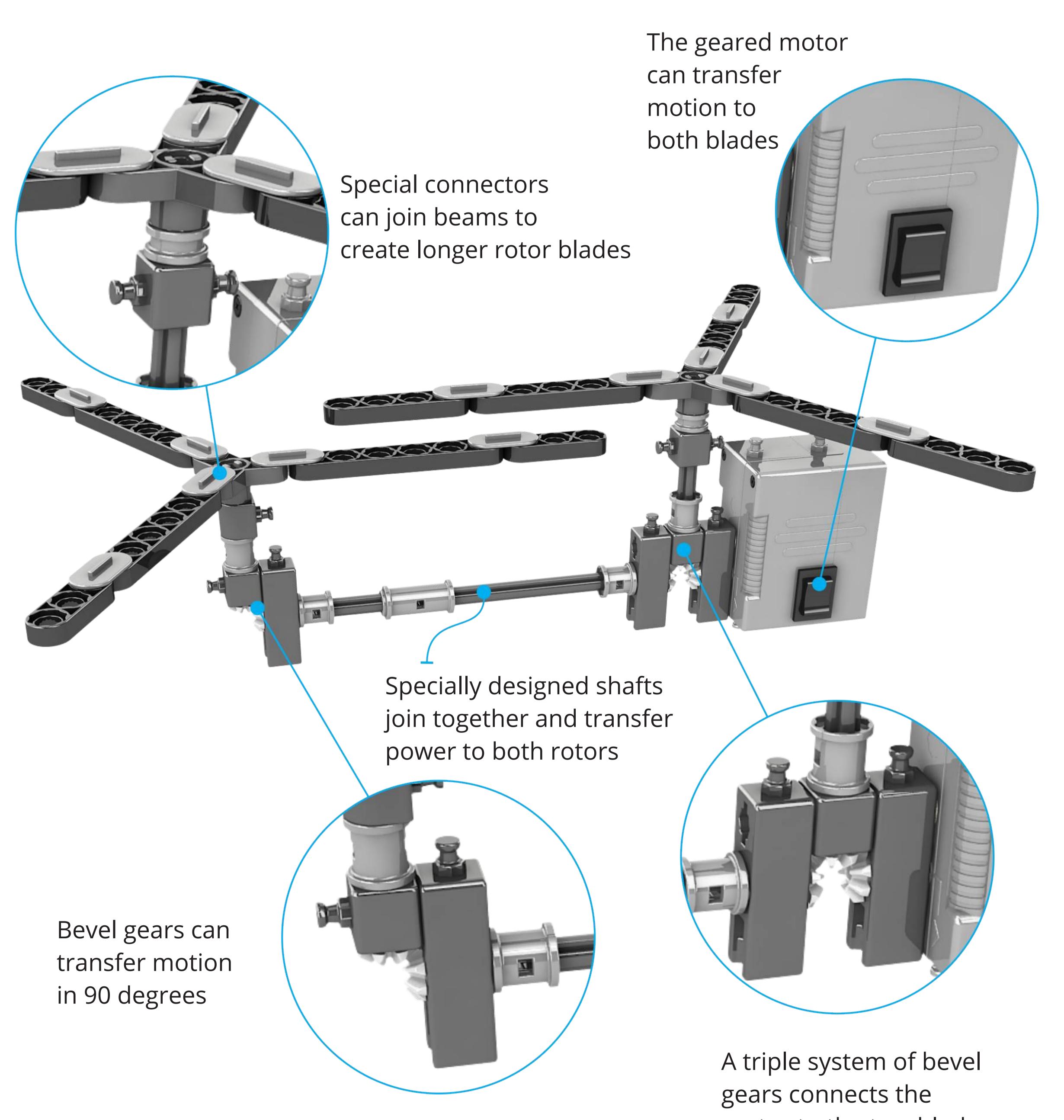




>> Size & Functions

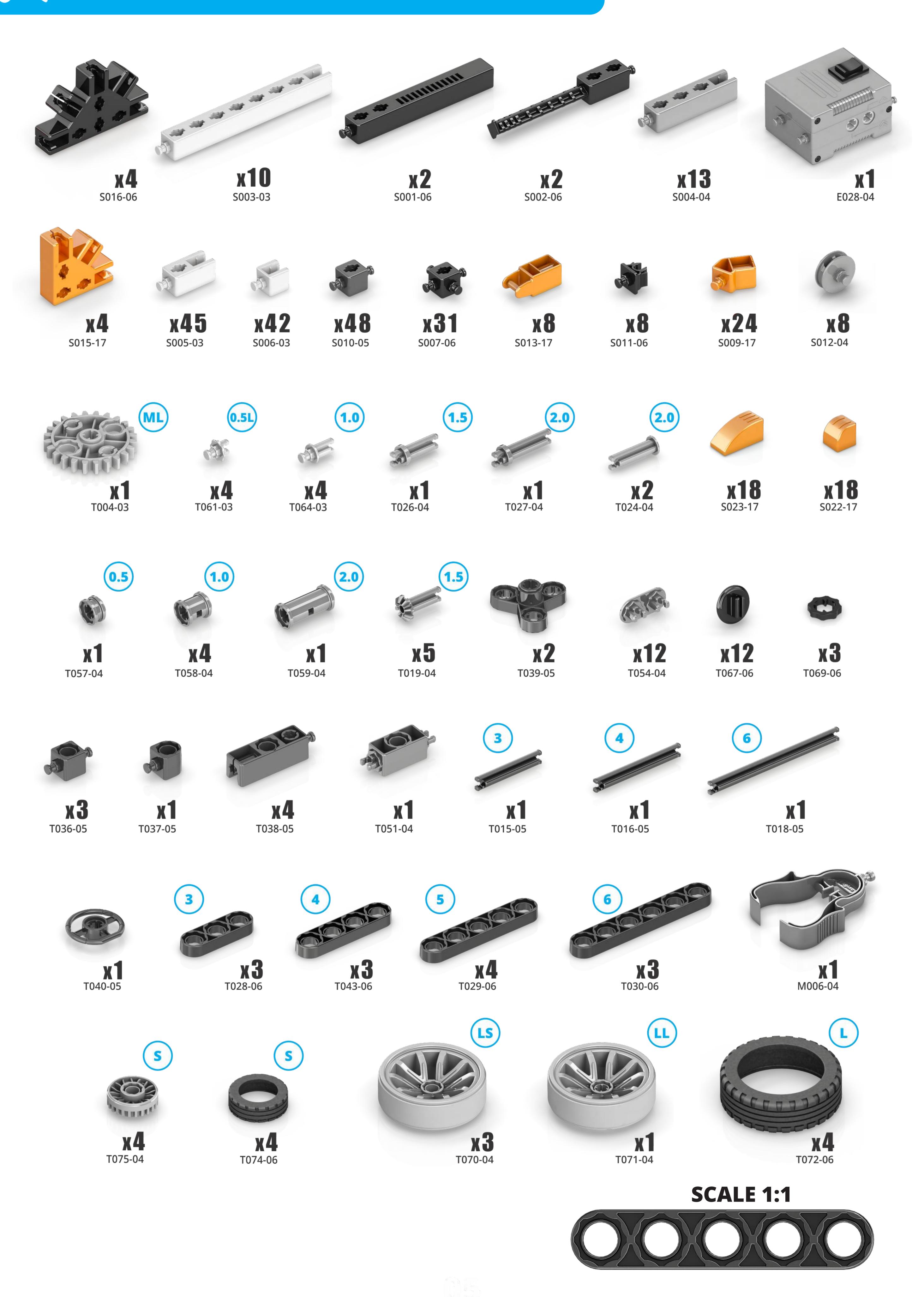


>> Featured Mechanisms



motor to the two blades

X List of Materials



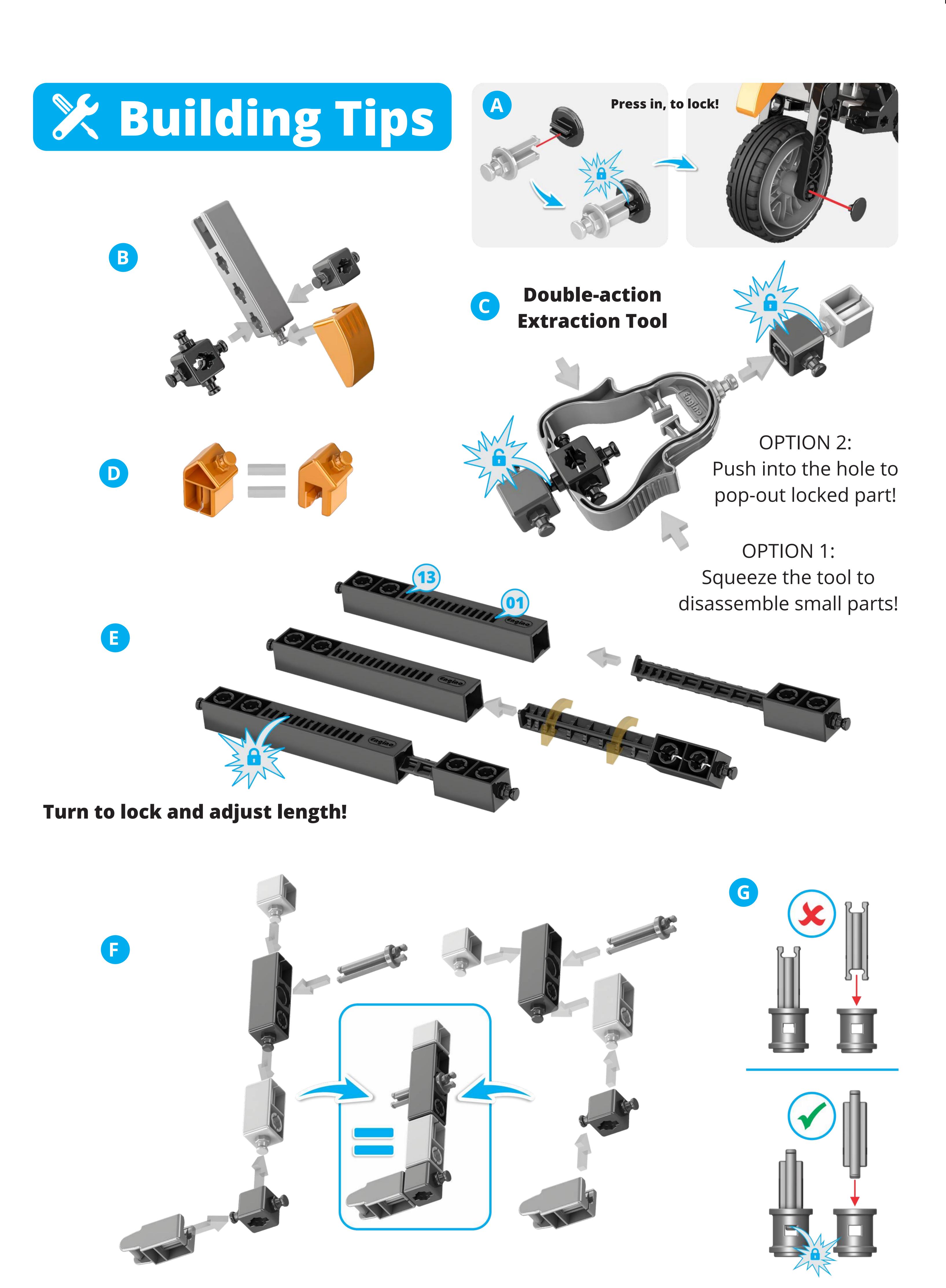


Figure 19 Theory

What we will learn

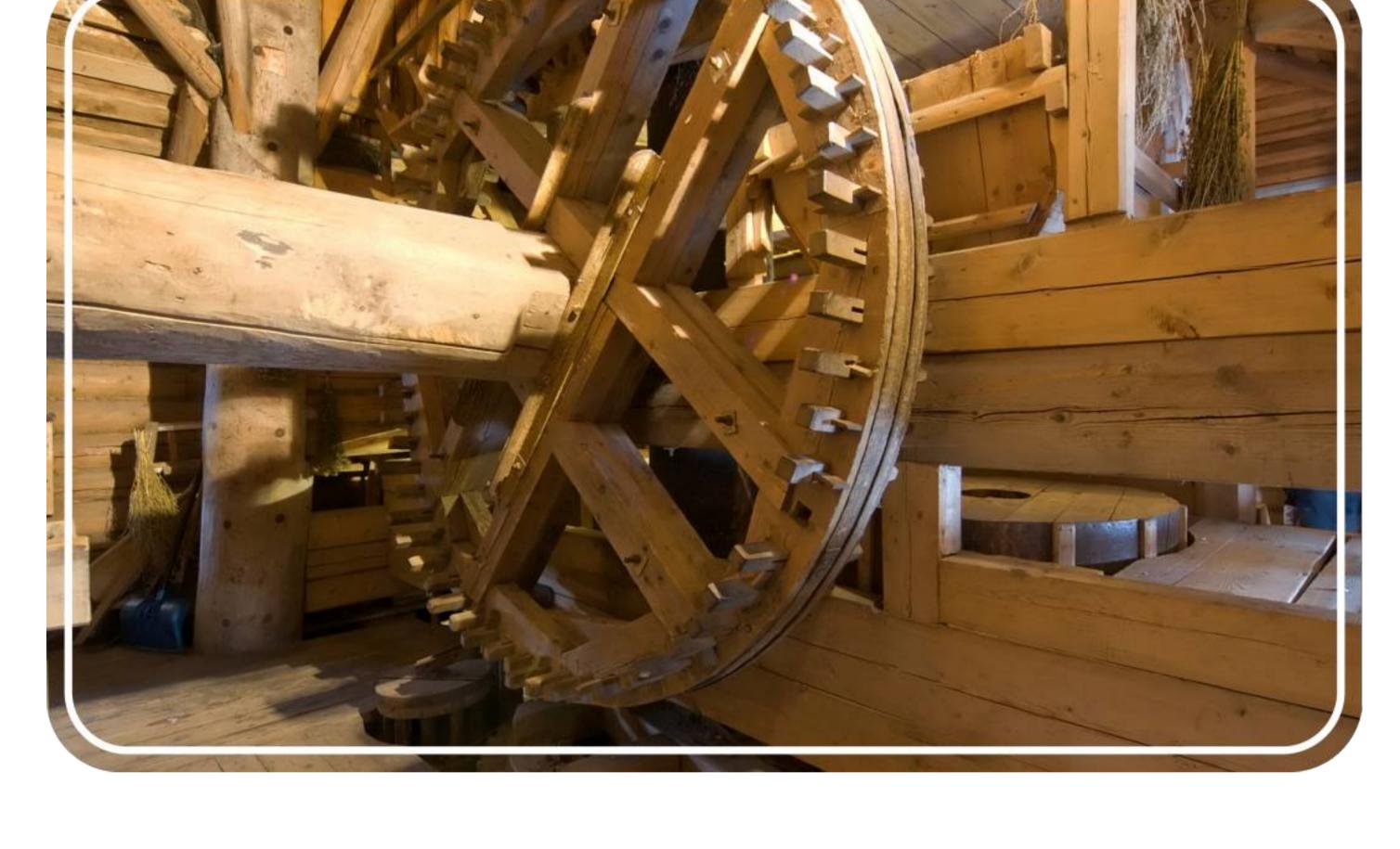
Travelling with an aircraft for holidays or for business is a very common activity. Airplanes are made to combine fast transportation and safety. The development of aviation is considered as one of the highlights in human history, since it has totally changed the way we travel around the Earth. Are you interested to become a pilot? Which forces affect a flight? How do helicopters fly?



Read through the pages of the booklet to gain useful information and amazing facts about helicopters. Follow the building instructions, contained in this booklet, to build your own models. Finally, take the quiz to test your newly acquired knowledge.

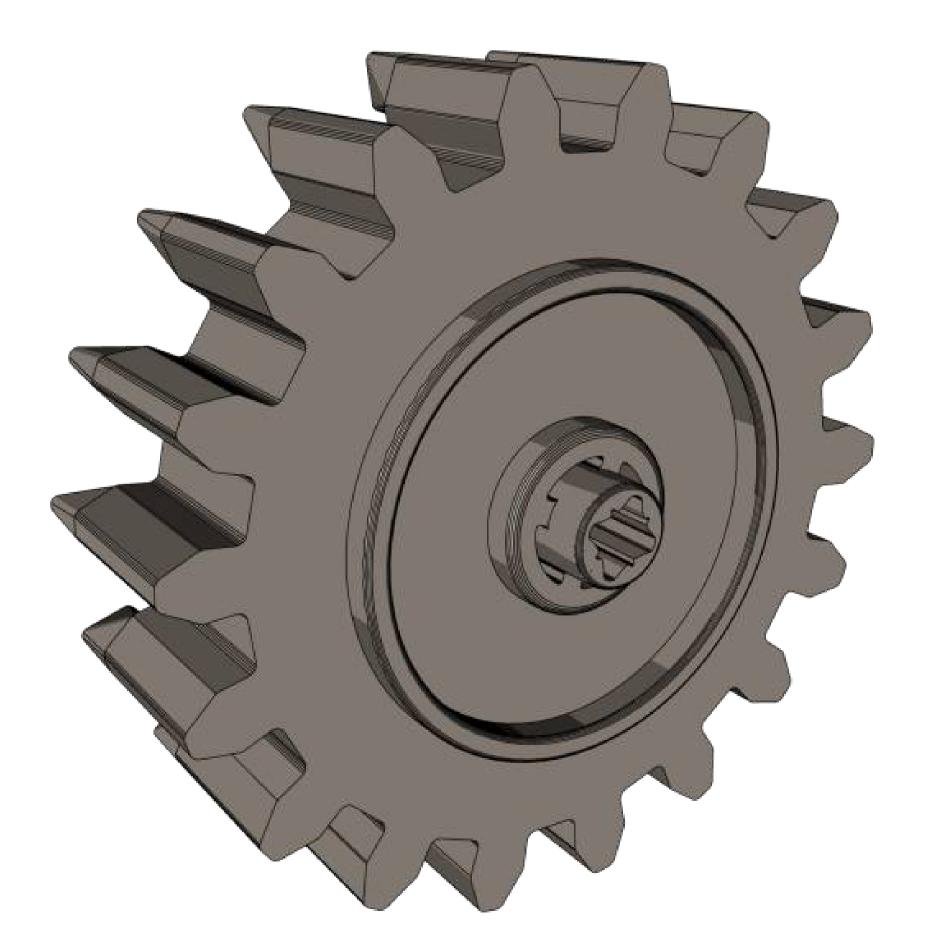
History of gears

Large gears were used during ancient times, first by Greeks and then by Romans in their watermills. They consisted mostly of the waterwheel and of toothed gearing which was able to transfer the water power to large machines. Such machines were the saw mills used for cutting huge stones and the trip hammers for crashing, pounding or forging metals and grain mills. Similar mills were also found in China from 30 A.D. Those gears were quite large and powerful. The earliest historic reference of gears dates back to 50 A.D. in the works of the famous inventor Heron of Alexandria.

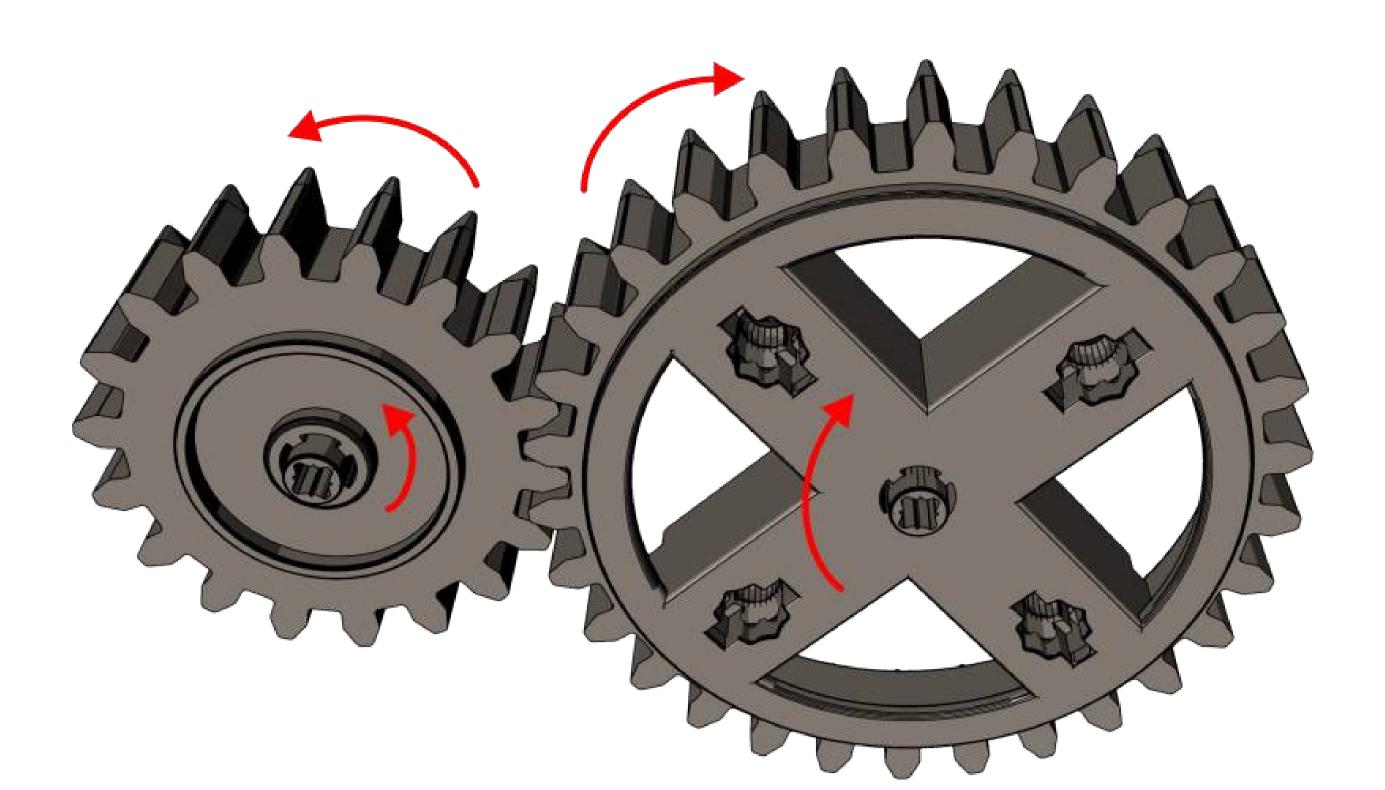


Definition of gear

Gears are wheels with teeth around their circumference, enabling them to mesh with each other. They belong in the category of simple machines which means they can increase the applied force and have a mechanical advantage. Gears can be found in almost all machines that have moving parts and we use them if we want to: transfer motion from one position to another; reverse the direction of rotation; increase or decrease the speed of rotation; change the axis of rotation; decrease or increase the force of a machine.



The Engino medium size gear



Two gears rotating in reverse

The teeth of the gears are the most essential elements and their design will determine the efficiency of gear transmission. As we have seen in ancient times, gear teeth were made of wooden beams and were big and bulgy. Later on, during the Hellenistic times, when the "antikythera mechanism" was created, gears were made of bronze with high precision. Nowadays, gears have very complex shapes to minimize friction and optimize performance, depending on the application.

A gear isolated can not really do anything! It has to be connected with other gears in order to transfer power. Gears have teeth that connect them and this type of connection is called meshing. The gear that is rotated by a motor or in general by any power source is defined as the "driver" gear and the other gear that follows is the "driven". If more than two gears mesh in a more complex system this is called gear train.



Gear terminology

The ideal profile design allows the teeth to mesh while touching only at a single point.

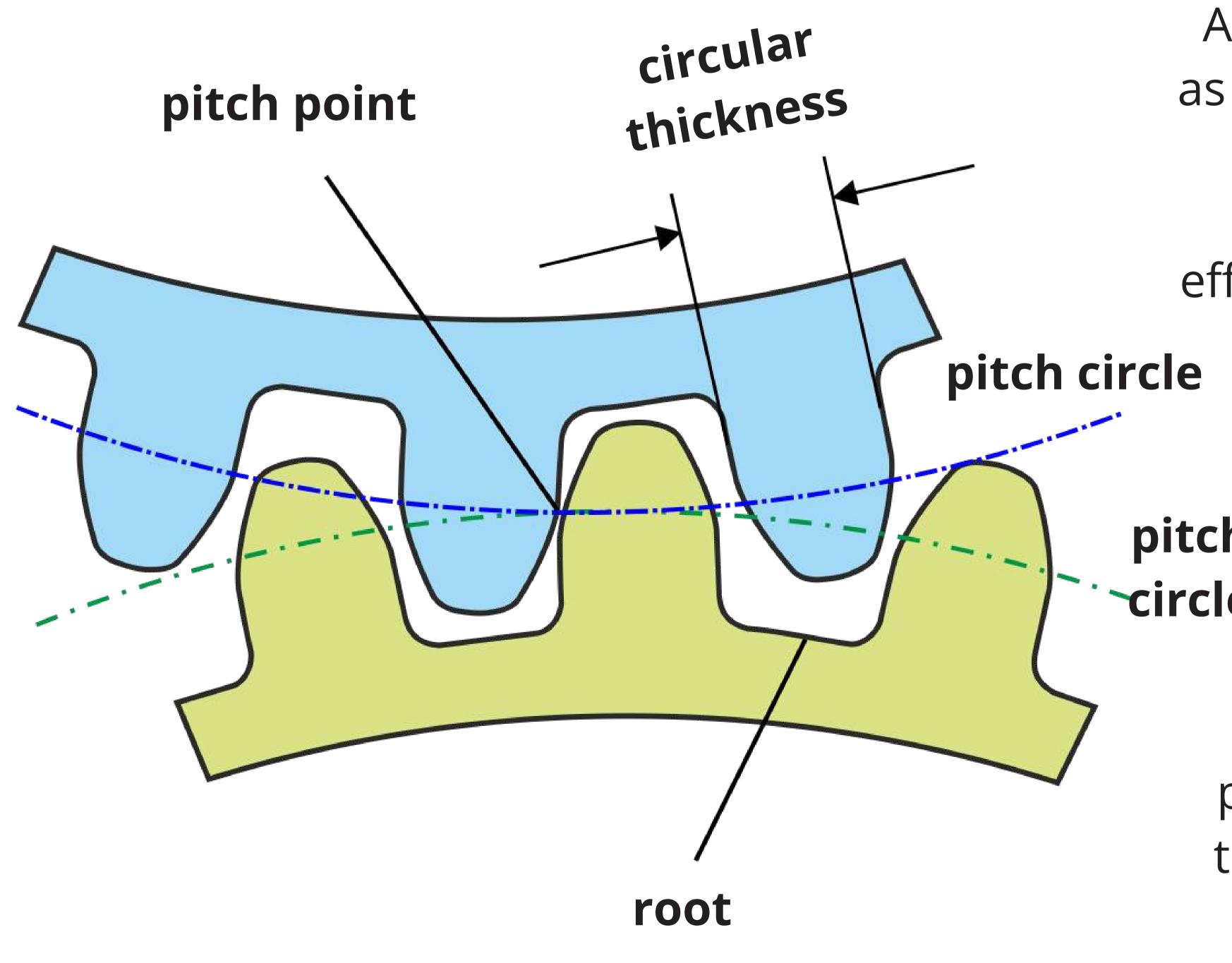
As the gears rotate, the teeth should move as if they were rolling on each other instead of sliding. This rolling motion minimizes friction and wear, making gears the most efficient mechanism for transferring power.

The major types of profiles used are the involute, cycloidal and circular arc or Novikov. The Engino gear teeth are pitch designed with an involute profile.

circle

A common term in all profiles is the pitch which refers to the distance between any point on one tooth and the same point on the next tooth. The pitch circle is the circle with radius up to around half the teeth's height, where the gear teeth make contact with each other as they rotate. Pitch point is the teeth contact point and root is the

bottom part of the wheel.

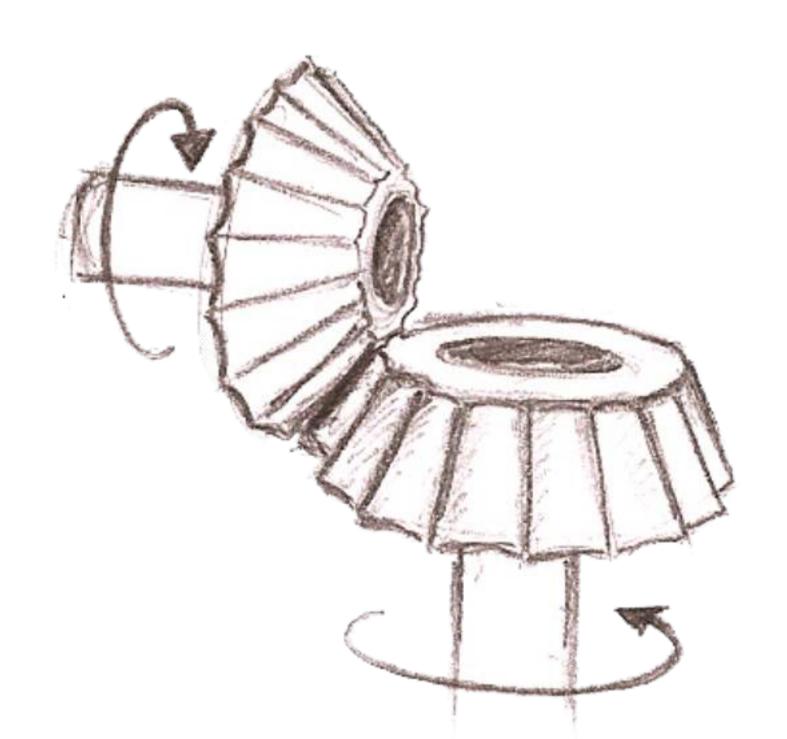


A diagram of how two gears with an involute teeth profile mesh

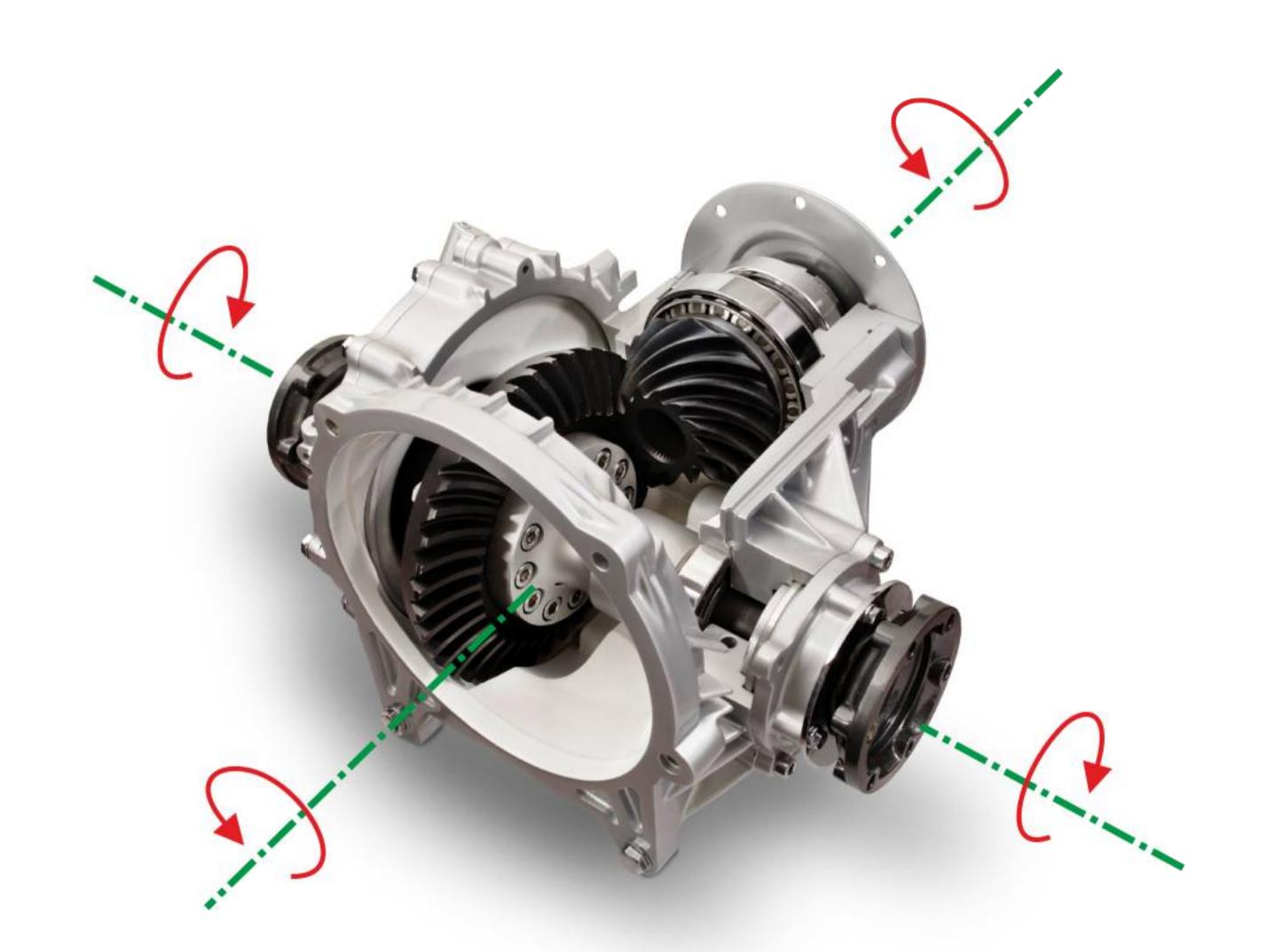
07

Changing axle's direction

In most machines the output direction of movement is not the same as the input direction. This is yet another feature of simple machines: the ability to change direction of motion. An ideal mechanism for this is linkages. However, when high speed is required with high precession, gears offer the best solution. How should the gear's shape be modified to effectively transfer rotation in a 90 degree angle?



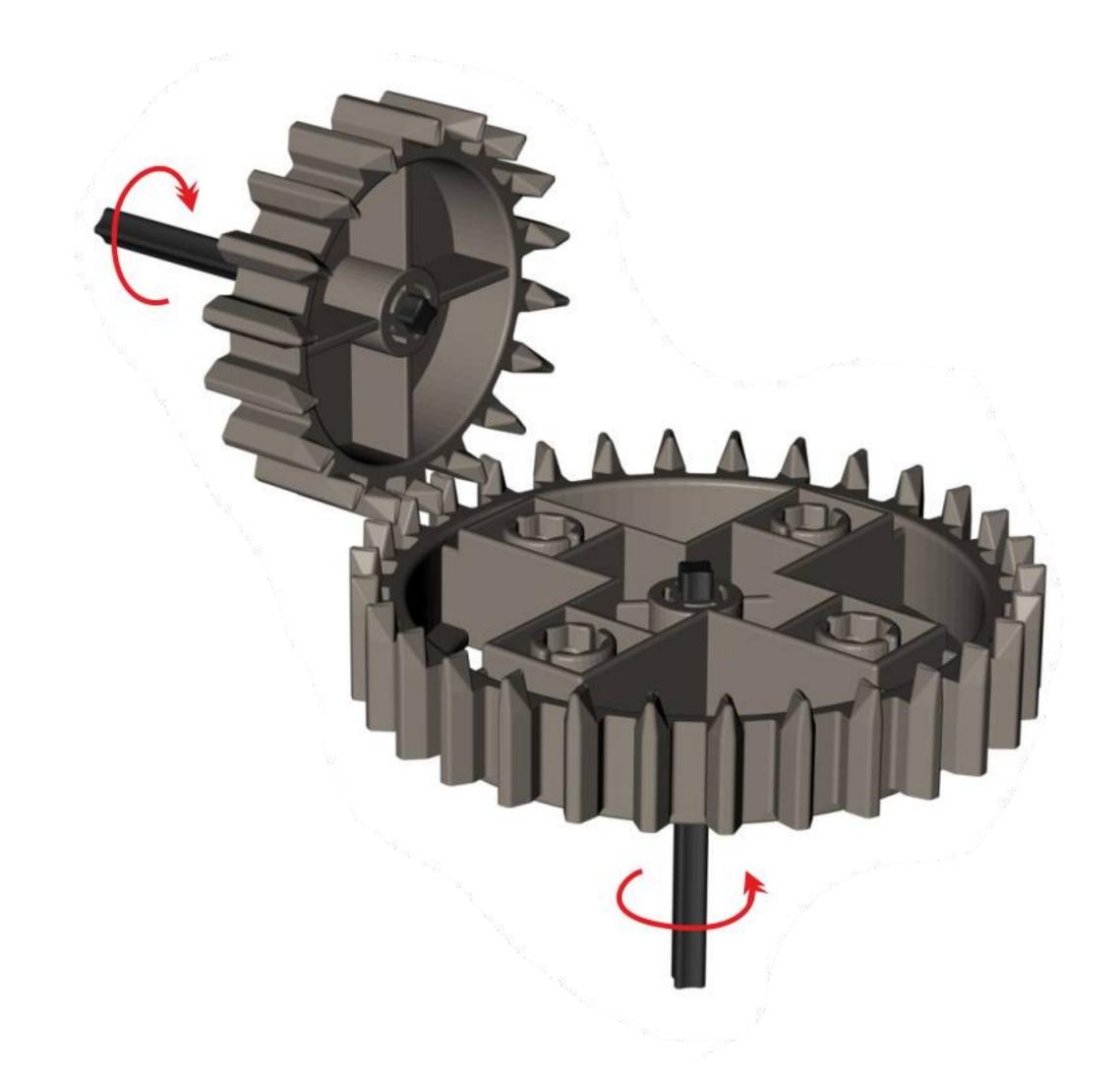
Gears transferring rotation in a 90 degree angle



The inside of a motor transmission with bevel gears of more efficient design

The common characteristic of the left and top picture is the shape of the teeth. This is a V shape which enables gears to mesh effectively when perpendicular to each other; that is when being at a 90 degree angle. This type of V-shaped gear is called bevel gear and it is one of the most useful type of gears as it has numerous applications. Take for example the traditional hand drill. This type of gear enables us to turn the crank in a direction that is easy for us. Do you notice also the difference in the diameter of the two bevel gears? Why do you think the hand drill gears are not of the same size?

The standard gears that mesh next to each other are called spur gears. However, the Engino gears are also able to transfer rotation in a 90 degrees angle, like bevel gears do. This type of gear is similar to peg gears used in mills in older times because it was easy to be manufactured from wood. Nowadays, such gears can be made with precession but they are inferior to bevel gears as they have more energy loss due to friction. But, like all machine elements every design has its purpose. The Engino gears belong in the category of crown gears because of their special shape.



The Engino® crown gears

Helicopters

Helicopters are a special category in aviation as they can manoeuvre with more versatility compared to aircrafts. Their ability to take-off and land in vertical direction, and to hover over a specific position during a flight makes helicopters more useful in certain scenarios.



Chinook

The chinook is an iconic helicopter of the US army. It is distinguished for its ability to be operated either at a snowbound location, forested or desert area. It can carry up to 10 tons of load due to its two powerful engines that rotate the two sets of rotor blades. Due to its large fuselage, it can carry up to 55 troops!



Aerial firefighting

The manoeuvre abilities of helicopters are very useful in cases of emergency or for reaching areas with limited access. A great example is the use of helicopters for firefighting since they can reach the burning area, drop water on specific locations, and rescue people or animals that may be in danger.



Ever Wondered?

Helicopters usually have 4 rotor blades. However, the number and size of blades depends on the amount of lift a helicopter is designed to generate. Hence, small helicopters may have two small blades while some of the more powerful helicopters, such as the Mi-26 helicopter, may feature up to eight large blades!



The science of Helicopters

The lift of a helicopter is achieved by the rotation of the main blades. In fact, the design of these blades is very similar to a wing of an airplane in order to create similar aerodynamic effects and thus generate the lift. The engine of the main rotor is very powerful and makes the blades spin in high speed.



Moment & Torque

When we apply a force on a beam or arm, we get a rotating effect which is called moment. "Moment" and "torque" are synonyms and are basic concepts in Physics and Engineering. Even though both terms express the same rotating effect, engineers use them according to the particular application. For example, "torque" is usually used to describe a rotational force like a turning screw-driver while "moment" is often used to describe a bending force on a rod. So, moment is the generator of rotation the same way as force is the generator of motion.

Newton's 3rd law of motion (Action and reaction)

To understand better how the helicopters are designed, we need to look closer at the physical laws. Newton's third law states that for every action, there is an equal and opposite reaction. This statement means that in every interaction, there is a pair of forces acting on the two interacting objects.



A gun "kicks" to the opposite direction of the bullet, as a reaction to a force.

Main blades rotation Direction of helicopter's body Main blades rotation Thrust from tail rotor

Torque effect

Similarly to the "kick" of a gun as a result to the motion of a bullet, the fast rotation of the blades results to the rotation of the helicopter's body in the opposite direction.

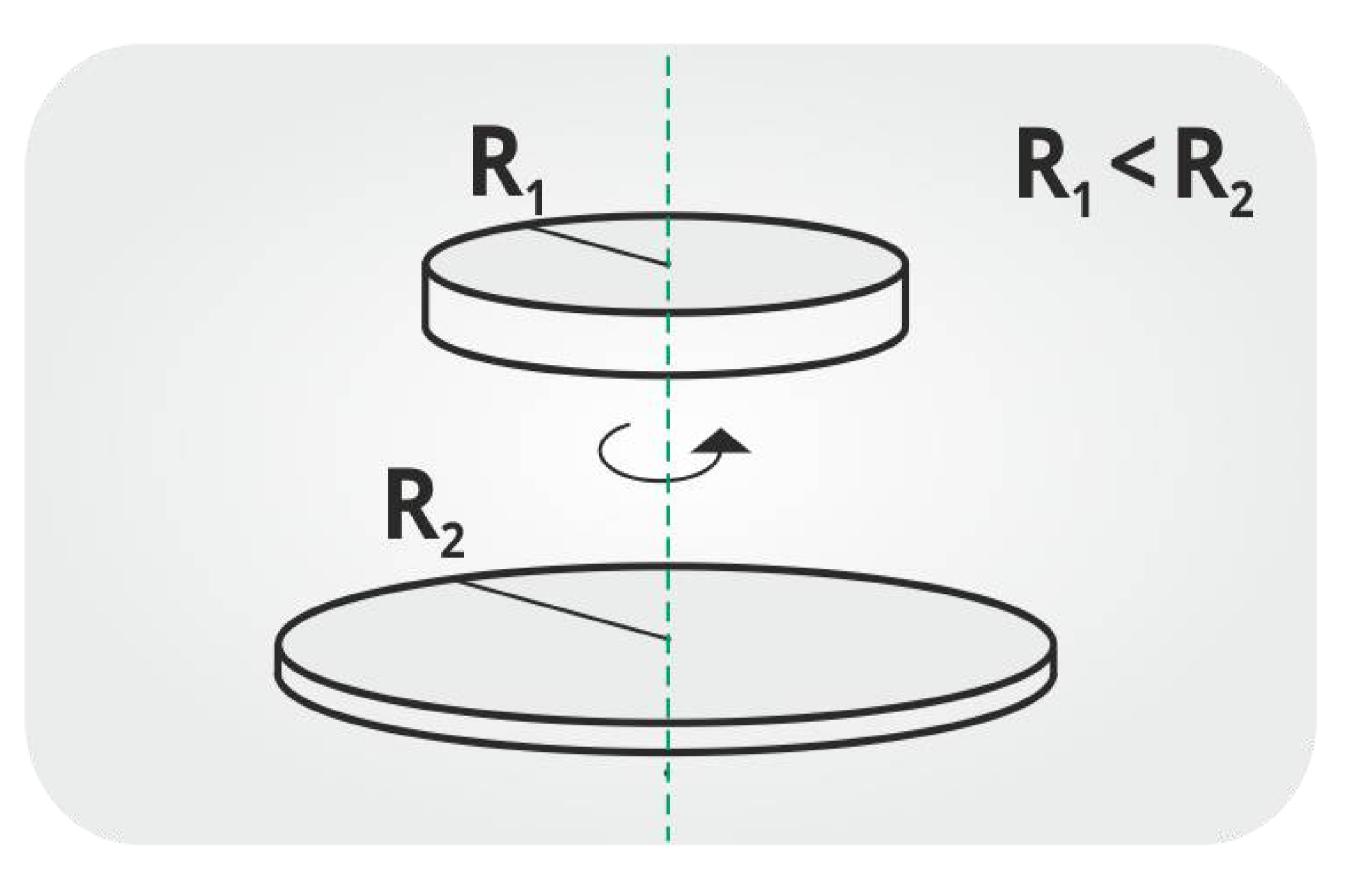
This phenomenon is called "the torque effect". You can observe this when a high torque motor rotates around itself once turned on.

Therefore, the rotation of the helicopter's body needs to be controlled. This is counterbalanced thanks to the tail rotor which keeps the helicopter stable. These smaller blades create a perpendicular force against the torque and thus prevent the helicopter from unwanted rotation.

Tail rotor Tail rotor

Moment of Inertia

In circular motion, moment of inertia can be thought as the analogous of mass. Just like mass, moment of inertia describes how easy or hard an object will rotate, and how fast or slow it will stop. Surprisingly though, moment of inertia depends on the shape of the object. For instance, moment of inertia for a disk is much different if the same mass was shaped differently.



Moment of inertia is greater for a disk with larger diameter, even if total mass is same.

Did you know?

A quadcopter is essentially a helicopter with 4 sets of rotors! To counterbalance the torque effect, 2 rotors rotate in clockwise direction whereas the other two rotate anticlockwise! Drones are great for earth monitoring since the often carry a camera for aerial footage.



Drones are great monitoring tools

Another way to understand how moment of inertia is affecting rotation, is to take the example of a figure skater on ice. What happens when the arms come closer to the body while spinning? This will decrease the moment of inertia the skater. Since the total momentum has to stay constant, there is no other option than to increase the rotation velocity and make the skater spin faster!



A figure skater spins faster when arms are placed closer to the body

Physical Laws

Forces acting on an aircraft

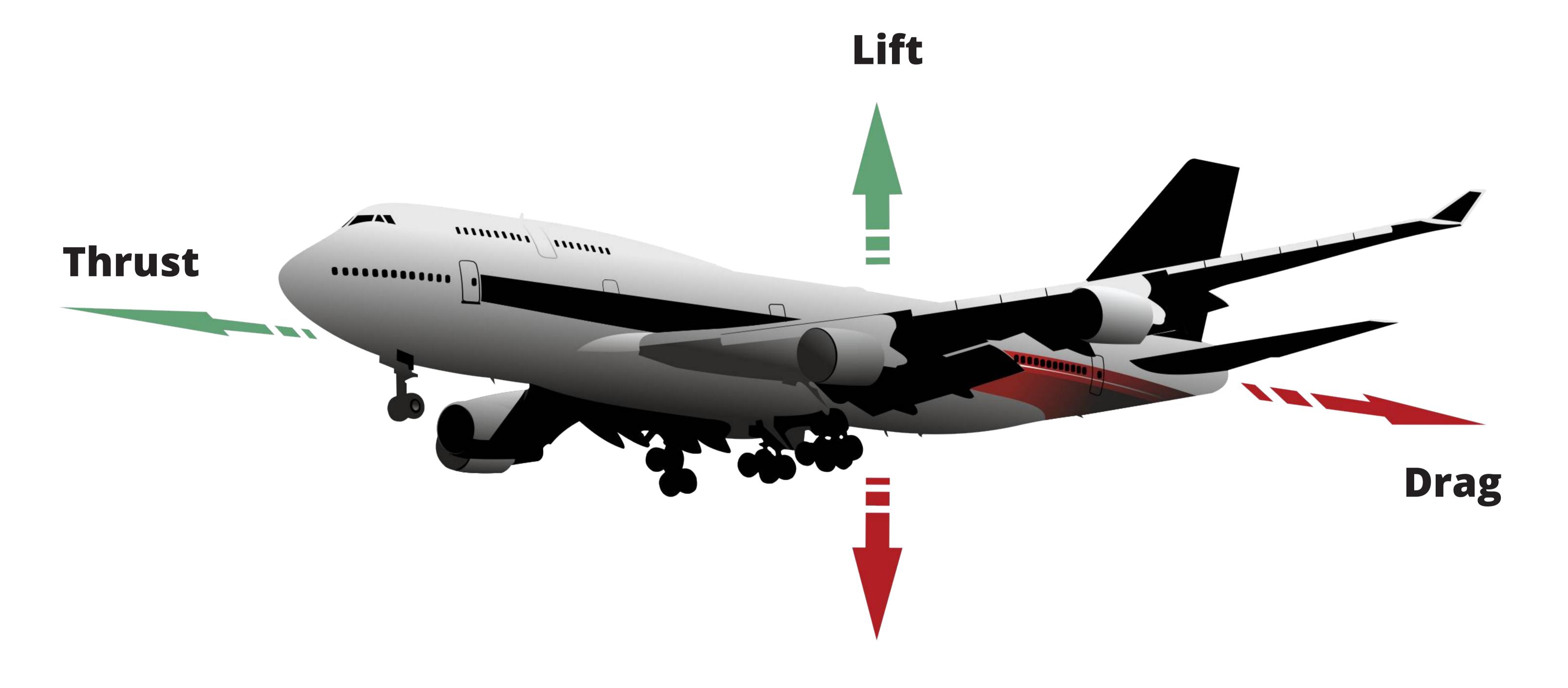
Thrust

The force that pushes an aircraft forward is called thrust. In order to keep a forward motion, the strength of this force must be more than the resistance caused by air. Small aircrafts might get thrust from a propeller, whereas large planes might get their thrust from jet or ramjet engines.

For an airplane, lift comes mainly from its

Lift

wings. The curved shape on the upper side of a wing creates a low-pressure region which causes an upwards force. This is caused by Bernoulli's principle. It is absolutely necessary in order to counterbalance the force of gravity.



Drag

Drag is a force that tries to slow something down. It is generated due to collisions between the air and a moving object into it. It is harder to run through water than through air because water is denser than the air. In addition, a round and narrow surface will experience less drag compared to a flat and wide one. Another factor which affects drag is the velocity that something is moving in the air. Hence the more aerodynamic shape the airplane has, the less the drag it will have and save energy during flight.

Weight

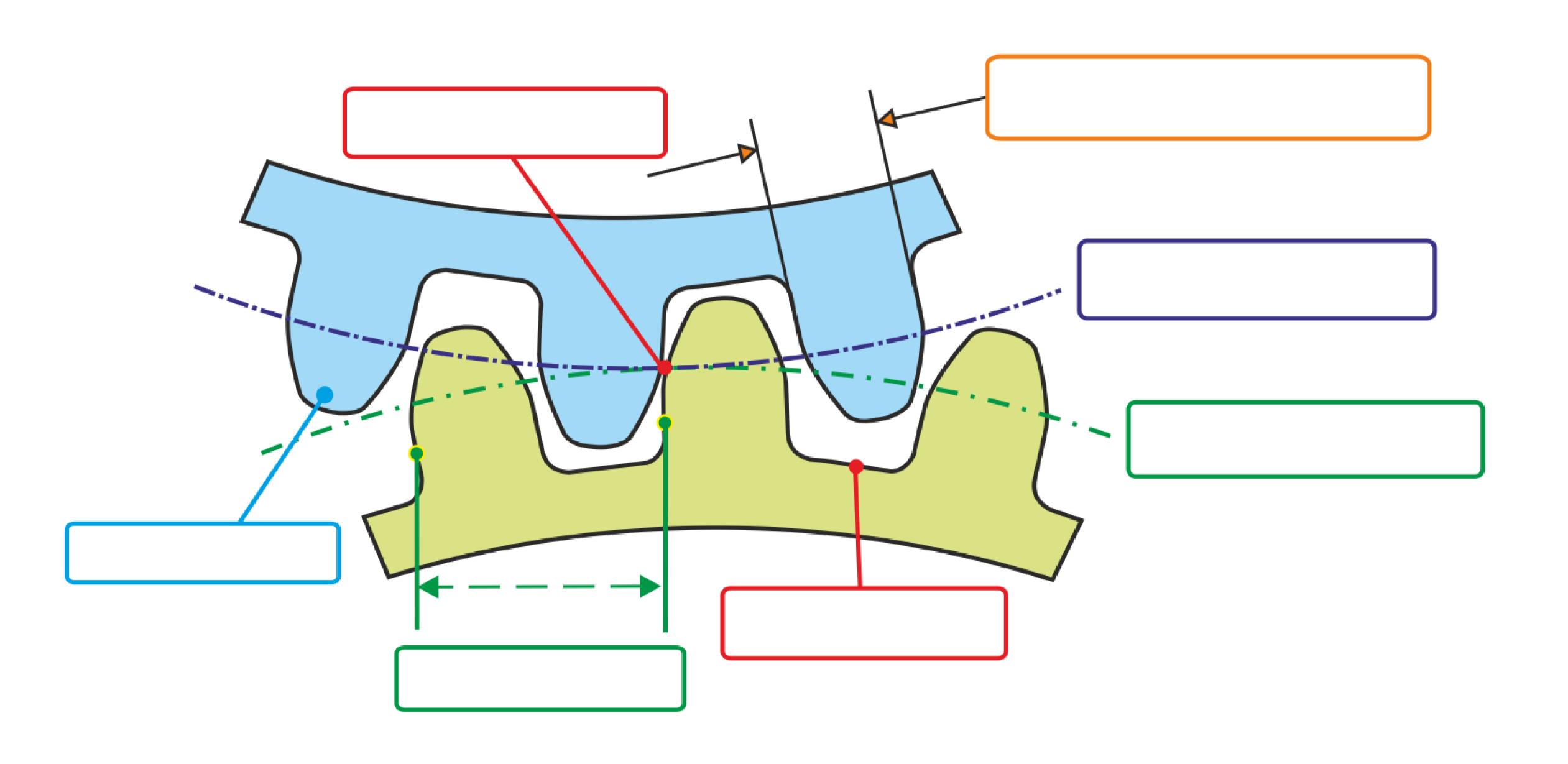
Weight

The force that pulls everything down to Earth, is called gravity and is the reason why objects have weight! To keep an aircraft up in the sky, a force must push it in the opposite direction from gravity. The more mass an object has, then the larger it weighs. For example, a kite needs significantly less upward push compared to a cargo plane.



Exercise 1. Complete the diagram using words from the box

root, pitch circle, pitch, pitch point, tooth, circular thickness, pitch circle



Exercise 2. Can you name four forces which are acting on an airplane during a flight?

Exercise 3. Can you answer the following questions correctly? Select True or False

a. A figure skater spins faster when arms are placed closer to the body.

True

False

b. Helicopters are not useful in cases of emergency such as firefighting, since they cannot reach the burning area.

True

False