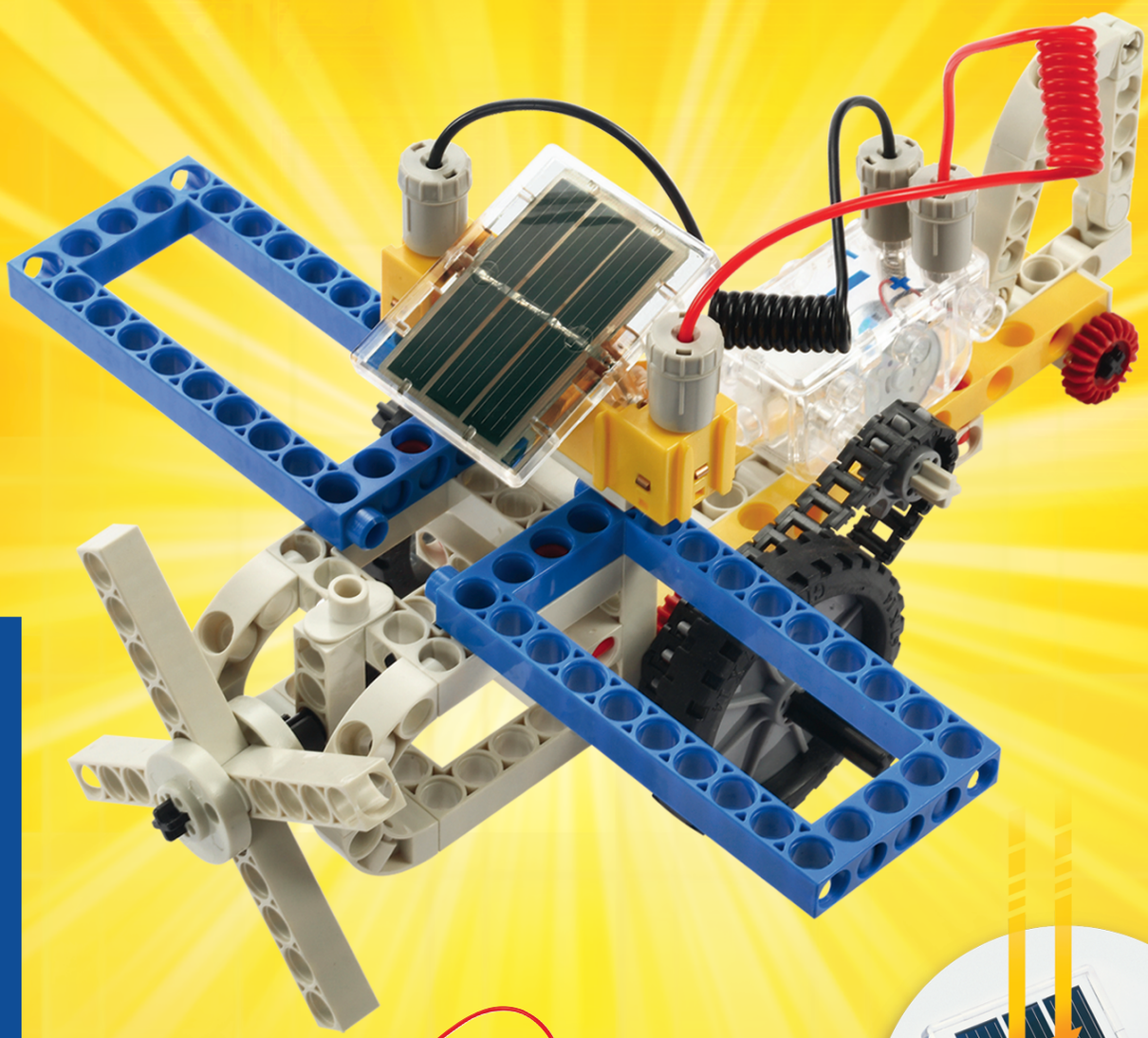
EXPERIMENT MANUAL

SOLAR POWER



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GENERAL ADVICE AND WARNINGS FOR PARENTS AND USERS

1. Please read these instructions, follow the safety rules, and keep them for reference. We recommend that you make the models in the order given. You will then be able to better understand the assembly and operation of the parts.
2. This kit has been designed for children over 8 years of age. It aims to help children discover solar power and how solar cells work in a hands-on way as they build fun models.
3. Discuss the safety warnings and possible risks involved with the children before allowing them to build these models.
4. Do not insert the wire connectors and other components into any electrical sockets, which will cause serious damage. Only the recommended batteries are allowed for use in this kit.
5. Cleaning:
   - Clean only with a cloth that is slightly dampened with water.
   - Never use soap or detergent.

WARNING TO PARENTS

This toy is not suitable for children under 3 years of age. It contains small parts that a child could swallow. This toy must be kept out of the reach of very young children.

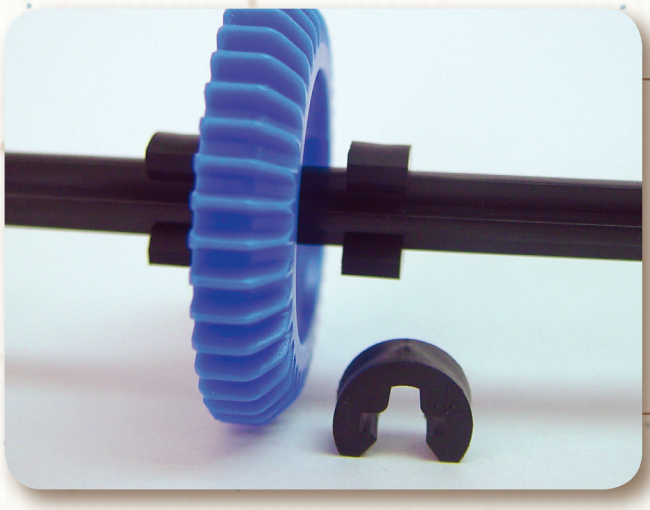
SAFETY GUIDELINES:

1. Don't expose the solar panel to a high temperature light bulb for a long time, so as to avoid a short circuit.
2. While activating the solar vehicles with a light bulb, keep your hands away from the bulb to avoid any harm that could be caused by accidentally touching the hot light bulb.
3. Please experiment with an incandescent light bulb that is at least 60 Watts, or the sunshine outside on a sunny day. An electric flashlight, fluorescent lights, and most low-voltage halogen bulbs are too weak to activate the solar vehicles.
4. Regular, non-rechargeable batteries must not be recharged.
5. The rechargeable batteries can only be charged under the supervision of an adult.
6. Do not force open the battery.
7. Do not throw the battery into the fire.
8. Pay attention to the correct polarity.
9. Do not short-circuit batteries. They could explode!
10. Do not mix new and used batteries.
11. The exhausted batteries must be disposed of as hazardous waste.
12. Remove the batteries when you do not use the kit for a long period of time.
13. Misuse of batteries can cause them to leak, which damages and corrodes the area around the battery, creating the danger of fire, explosion, and personal injury.

SOLAR POWER | Parts List

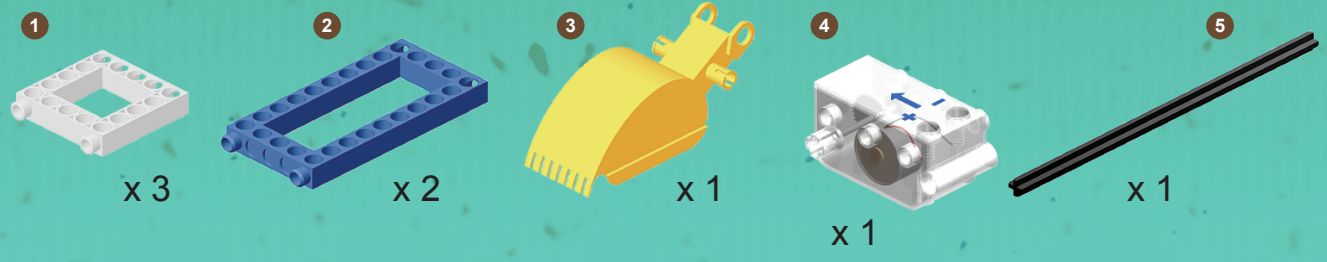
No	PARTS NAMES	PCS
1	SQUARE FRAME - GRAY	3
2	SHORT FRAME - BLUE	2
3	DIGGING BUCKET	1
4	REVERSIBLE MOTOR/GENERATOR	1
5	EXTRA LONG AXLE	1
6	LONG AXLE	2
7	SHORT AXLE	2
8	MOTOR AXLE	1
9	WHEEL AND TIRE	2
10	LARGE GEAR - YELLOW	4
11	MEDIUM GEAR - BLUE	5
12	SMALL GEAR - RED	3
13	LARGE SPROCKET - GRAY	2
14	MEDIUM SPROCKET - GRAY	2
15	SMALL SPROCKET - GRAY	2
16	3-HOLE ROD - GRAY	8
17	5-HOLE ROD - GRAY	6
18	PART SEPARATOR TOOL	1
19	3-HOLE DUAL ROD - GRAY	3
20	LONG 7-HOLE DUAL ROD - YELLOW	3

No	PARTS NAMES	PCS
21	11-HOLE ROD - GRAY	3
22	CONCAVE BLOCK - GRAY	6
23	SPOKED ROUND BLOCK - GRAY	2
24	CURVED ELBOW ROD - GRAY	5
25	AXLE LOCK	2
26	SHAFT PIN	4
27	SHAFT PLUG	5
28	ANCHOR PIN	20
29	HINGE - GRAY	4
30	ROD CONNECTOR	3
31	DRIVE CHAIN UNIT - BLACK	53
32	TWO-TO-ONE CONVERTER - GRAY	2
33	90 DEGREE CONVERTER R - GRAY	8
34	90 DEGREE CONVERTER L - GRAY	1
35	WIRE CONNECTOR - RED	1
36	WIRE CONNECTOR - BLACK	1
37	ADJUSTABLE SOLAR PANEL	1
38	BATTERY HOLDER	1
39	BATTERY CHARGER	1
TOTAL		177



Axle locks are used to keep gears and axles from slipping.

It's easy to put axle locks onto axles without removing gears or axles.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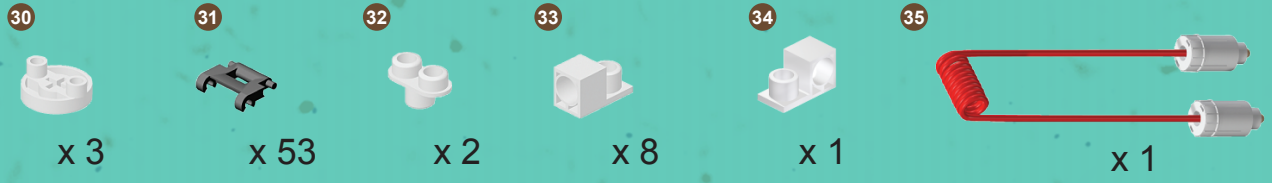
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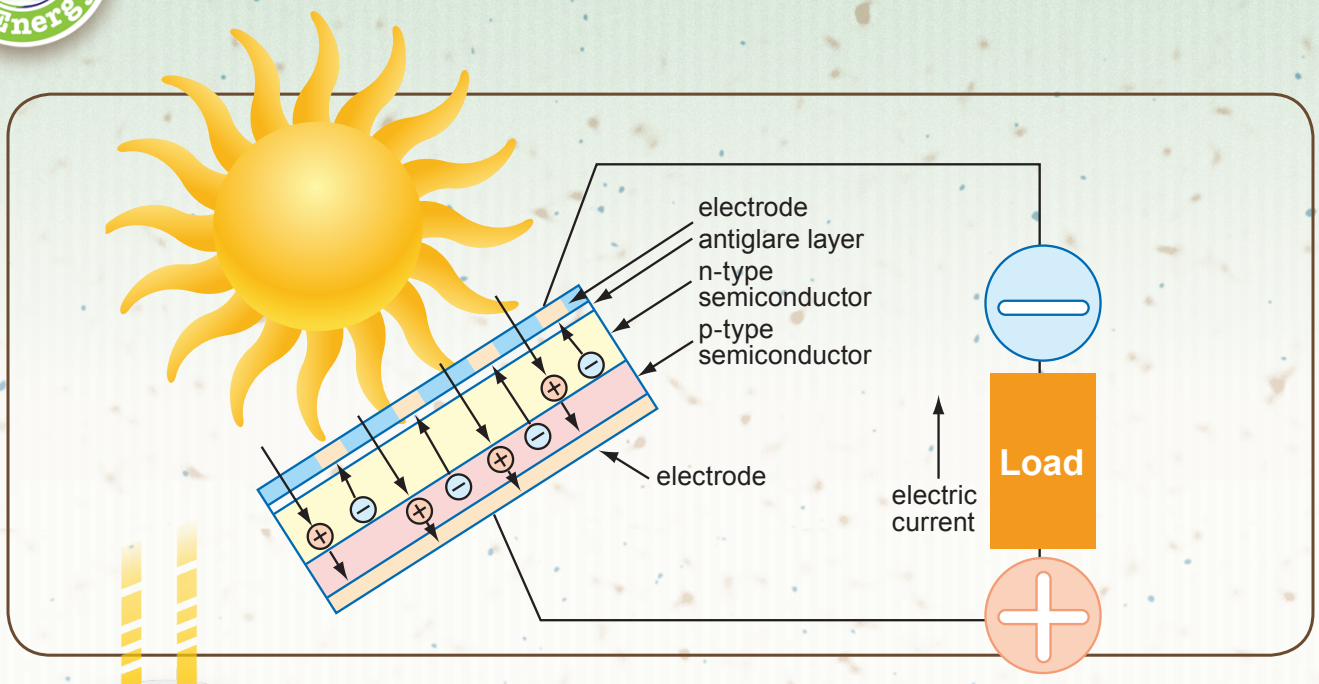
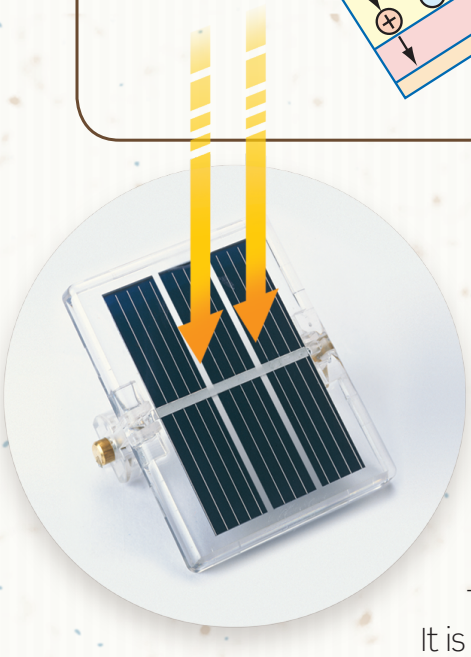


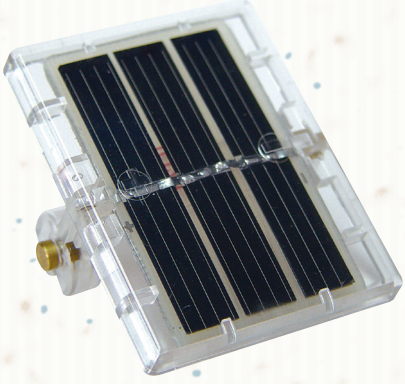


A solar cell is a device that uses an electronic component called a semiconductor to convert light energy into electrical energy.

In a solar cell, electrons in the semiconductor are excited into motion when they are exposed to light energy. The solar cell is designed to make the electrons flow in a specific direction, creating a negative pole on the side where there are more electrons and a positive pole on the side where there are fewer electrons, or more "empty holes" for electrons. This results in a voltage and an electric current.

The current and the voltage of a single standard solar cell are weak. It is common to strengthen them by wiring solar cells together in series or in parallel.

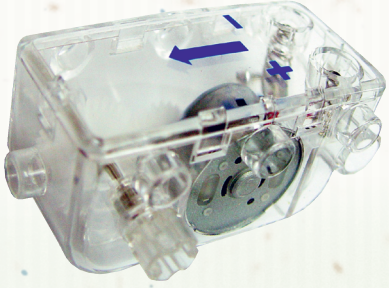
ADJUSTABLE SOLAR PANEL



The adjustable solar panel in this kit has several solar cells.

They are integrated into the black strips located under the protective layer of clear plastic. If you turn the panel over, you can see the individual cells very clearly. This solar panel is just the same as the big ones that you can see on the roofs of some houses, except that it is smaller and produces less electricity.

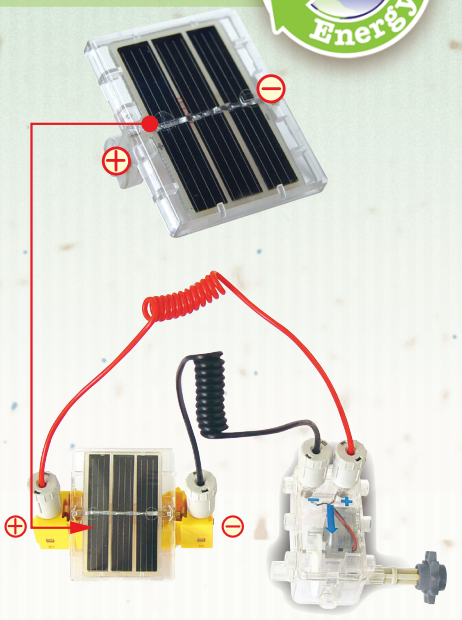
REVERSIBLE MOTOR/GENERATOR



The reversible motor can be activated by the electricity produced by the adjustable solar panel or a battery (size AA) mounted in the battery holder.

The reversible generator can generate electricity using mechanical (turning) energy too.

ACTIVATING THE REVERSIBLE MOTOR

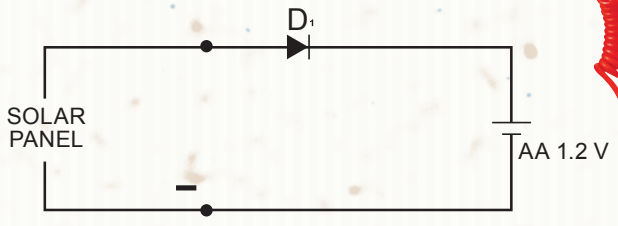


You can experiment to activate the reversible motor as the pictures show.

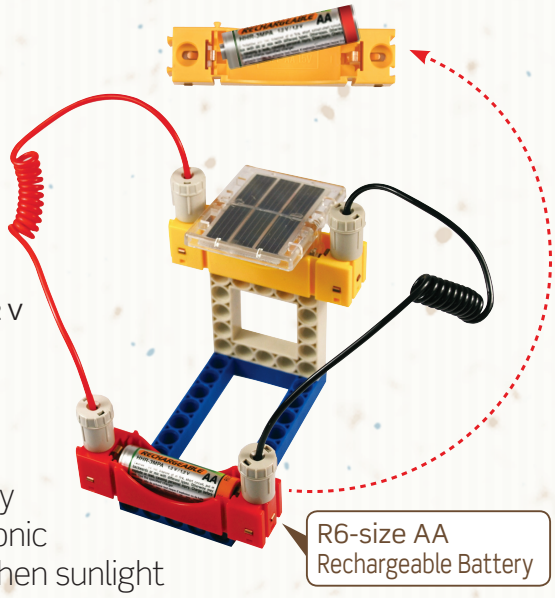
1. Mount the adjustable solar panel on the battery holder.
2. Connect the battery holder and reversible motor with the wire connectors. Make sure you pay attention to the plus (+) and minus (-) symbols on the battery holder, the solar panel, and the motor when you attach the wire connectors. The red wire is the positive wire and the black is the negative.
3. Insert the motor axle into the reversible motor and mount a small sprocket on the axle.
4. Take your model into bright sunlight and orient the adjustable solar panel toward the sun to drive the reversible motor. You can clearly see the sprocket turning on the motor axle.

OPERATING THE BATTERY CHARGER WITH THE SOLAR PANEL

There is a diode inside the red battery charger.



For example:  electronic symbol: 



A diode allows electric current to flow in only one direction. The electronic symbol for the diode (the arrow) indicates the direction in which the electric current can flow. Generally speaking, only if the electric current is forward current with a voltage of 0.7 V, will it be able to pass through the diode. However, when the electric current flows in the opposite direction (as in the case when the positive and negative poles of the solar panel or the wire connectors are reversed), it will be blocked, which is shown by the electronic symbol. When sunlight shines on the solar panels, electric current is produced and flows to the positive pole of the rechargeable battery, and slowly charges the battery. As the sunlight disappears, although the voltage the solar panel decreases, the diode prevents the stored electric current from flowing backward and draining out again.

TIPS FOR DESIGNING YOUR OWN SOLAR MODELS

1. Become familiar with the example models shown in this manual.
2. Brainstorm ideas for the mechanism you want to build and write them down.
3. Coordinate the power source and the mechanism on paper.
4. Determine the size of the mechanism.
5. Make every connection as accurately and securely as possible. Reduce the friction of connections as much as possible.
6. Experiment on the mechanism and make modifications to get proper movement. Then attach the motor.
7. Complete the project by reviewing the things you learned.

TIPS!

When the sunlight is not strong enough, you can remove the adjustable solar panel from the battery holder and insert a AA battery (sold separately) to run the model. It is possible to add more battery holders with adjustable solar panels (from another kit) or AA batteries (sold separately) connected in series to increase the power. Solar panel and battery can work together.

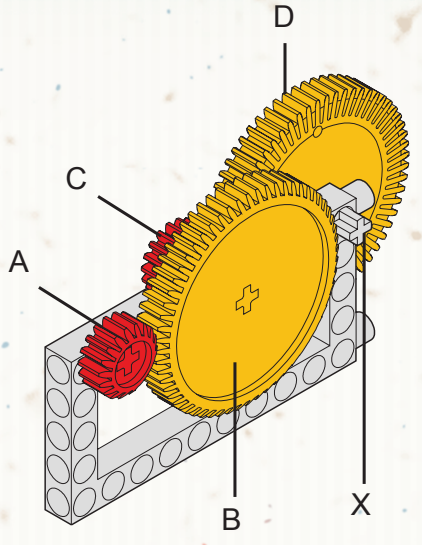
The gear set contains both spur and bevel gears. This kit contains "spur gears," which mesh in the same plane and regulate the speed or the turning direction of the shafts, and "bevel gears" (the beveled edges of the gears) which mesh together at right angles to the initial turning plane of the gears and shafts to change the plane of rotation.

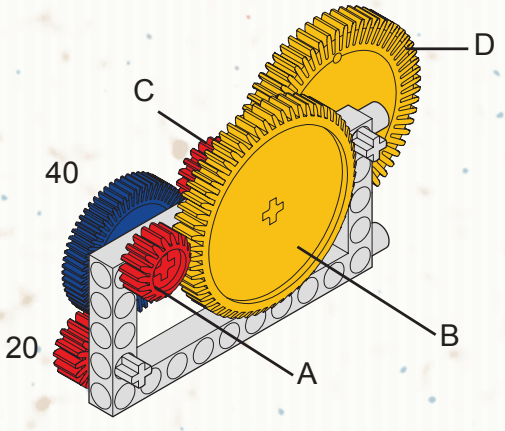
1. Use two red 20-tooth gears and two yellow 60-tooth gears to build the assembly shown here. You will need to use axles to put the gears on the frame. Gear B is on the same axle as gear C.
2. How many times do you have to turn the small gear A in order to make the second large gear D turn once?

   The small gear A turning the large gear B yields a 3-to-1 gear ratio. The second small gear C is directly driven by the axle attached to gear B, and it produces another 3-to-1 gear ratio with the second large gear D.

   Did you find out that you had to turn the small gear A nine times to turn the second large gear D once?

   The overall gear ratio of the system is 9 to 1. (A gear ratio of 3 to 1 multiplied by another ratio of 3 to 1 yields a total gear ratio of 9 to 1).
3. Add a third red 20-tooth gear to the short drive axle at (x). Why does the system lock up?
4. Add a blue 40-tooth and a red 20-tooth gear to the system as shown. Can you work out mathematically what the gear ratio of system would be? Count the number of turns. Were you right?





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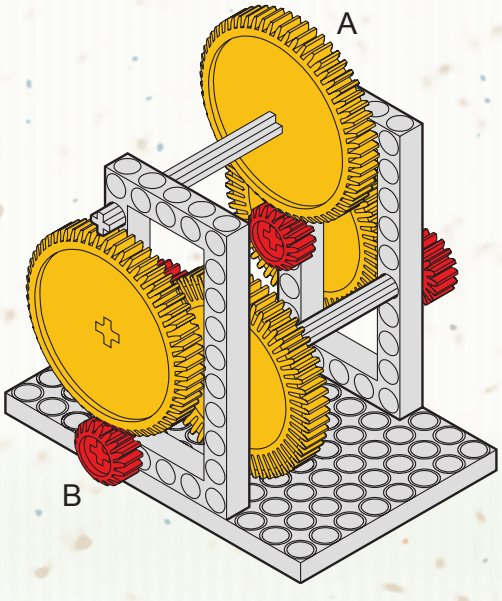
1. This gear box uses a combination of red 20-tooth gears and yellow 60-tooth gears. There are four pairs of red 20-tooth and yellow 60-tooth gears. Each pair produces a gear ratio of 3 to 1.

   The overall gear ratio would then be
   3 x 3 x 3 x 3 = 81.

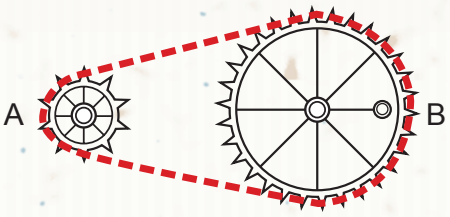
   If gear B is turned 81 times then gear A would turn once.
2. If gear A could be turned once then gear B would turn 81 times! Can you add another pair of gears to make a ratio of 243 to 1?



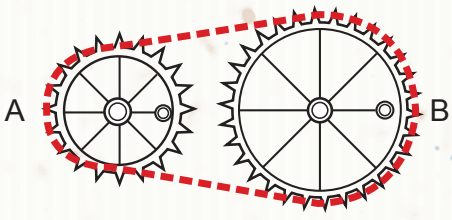
1. The power transmission in chain gear systems depends on chains instead of the direct meshing of gears. Chains must fit on the teeth of chain gears. Gears used with chains are called sprockets. The "working" diameters of the sprockets in this kit are about 10 mm (10-tooth), 20 mm (20-tooth) and 30 mm (30-tooth). Try to ensure that when connecting drive chains they are neither too tight nor too loose so that the motion of one is transmitted efficiently to the other. If the chain lengths do not exactly fit, opt for adding an extra chain segment: a chain that is a little loose will work better than one that is too tight. However, the chain has to be tight enough so that it does not fall off the sprockets. Chain gear systems can be found in normal bikes or escalators.

2. Connect a 10-tooth sprocket to a 30-tooth sprocket as shown.

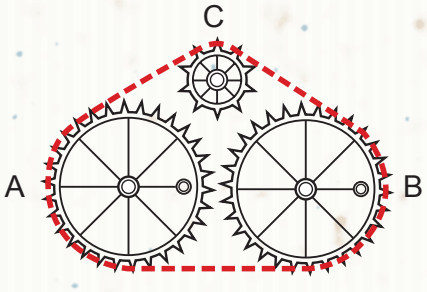
3. Use a pencil point, or something similar, to turn sprocket B.
   Which direction does sprocket A turn?
   Would this be the same if A and B were two gears meshing?
   How many times do you have to turn A for B to rotate once?
   The gear ratio of these two sprockets would be __ to __ ?



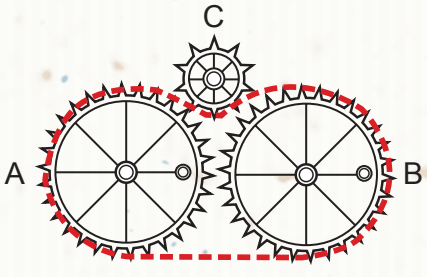
4. Repeat the experiment for the two assemblies below and make a table of your results for all three.



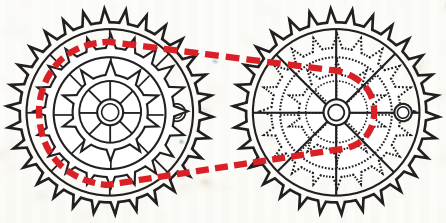
5. Try chaining a 10-tooth sprocket and two 30-tooth sprockets together as shown. Turn A clockwise.
   What happens to B and C?
   Do they turn in the same direction?
   Do they turn at the same speed?



6. Now try to chain the 10-tooth sprocket C as shown.
   Turn A clockwise. What happens to B and C?
   Do they turn in the same direction?
   Do they turn at the same speed?



7. By connecting two sets of chain gears together three speeds can be obtained.
   This system is widely used in the transmission on bicycles by adding a gear shift in between.



SOLAR POWER | Tips and Tricks for Building the Models

1. Both anchor pins and joint pins can be used to join rods and frames. (Fig. 1-1)
   But only a joint pin can allow a rod to rotate on a frame as shown. (Fig. 1-2)
2. Use a long axle to push the joint pin out of the rod. (Fig. 1-3)
3. Frames can be connected directly to each other end to end. (Fig. 2)
4. When attaching a gear or a wheel onto a frame with an axle, be sure to leave a gap of about 1 mm between the gear or the wheel and the frame. This will decrease the friction caused during operation so that the model will run more smoothly. (Fig. 3)
5. Make sure that when you connect the drive chains they are neither too tight nor too loose so that the motion of one sprocket is transmitted efficiently to the other. If the chain lengths do not exactly fit the distance between sprockets, making the chain a little looser will work better than making it too tight.
6. Chain links can be connected with each other, end to end, to make a drive chain of a desired length.
7. Make sure that you attach the chain links together with the smooth side always on the inside, so that the transmission can run efficiently and smoothly. (Fig. 4)
8. Use the end "A" of the part separator tool to pry off an anchor pin. (Fig. 5)
9. Use the end "B" of the part separator tool to remove the battery as Fig. 6 shows.

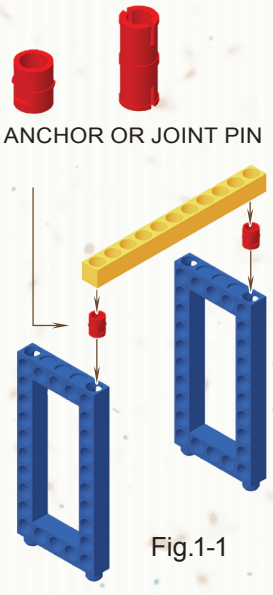


Fig.1-1

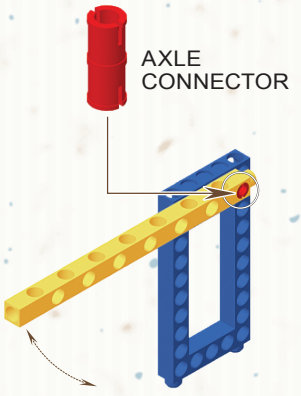


Fig.1-2

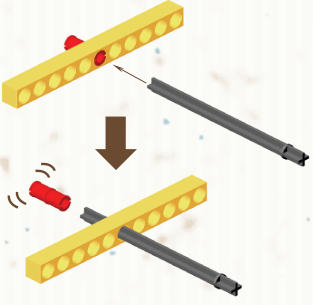


Fig.1-3

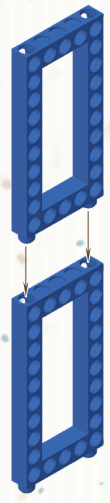


Fig.2

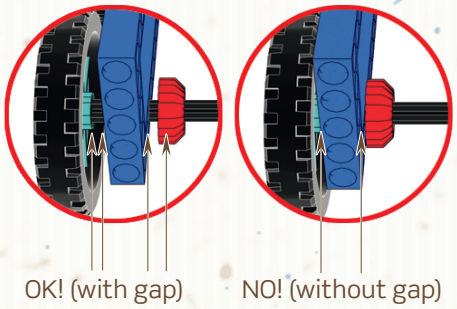


Fig.3

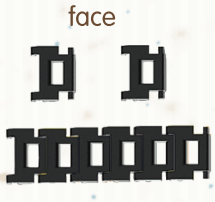


Fig.4

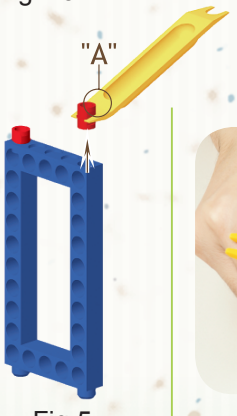


Fig.5

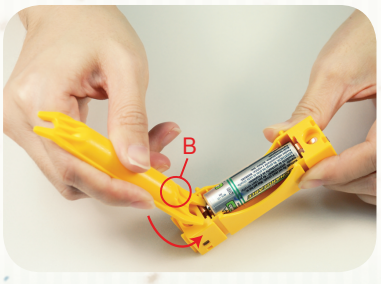
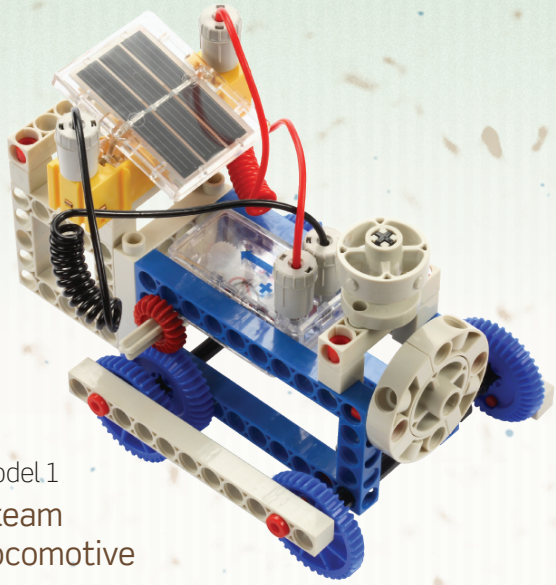
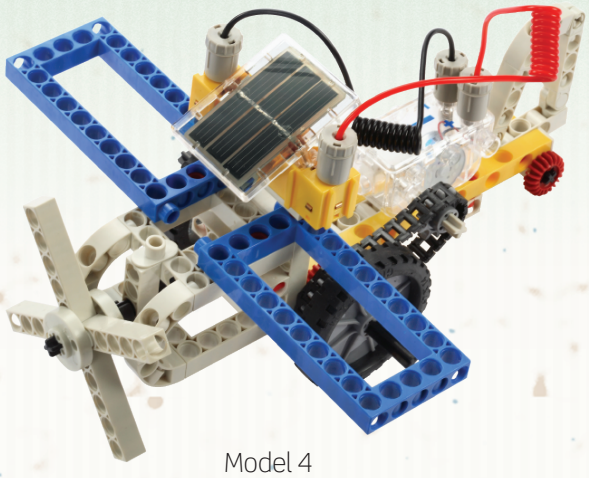


Fig.6

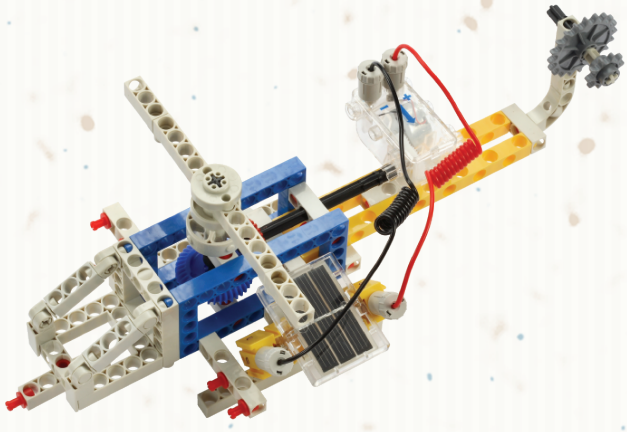


Model 1
Steam Locomotive



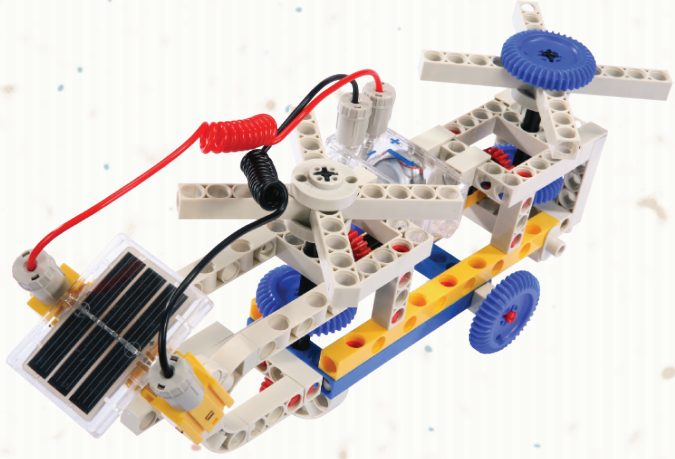
Model 4
Single-Prop Plane

Model 2
Bulldozer



Model 5
Helicopter

Model 3
Backhoe



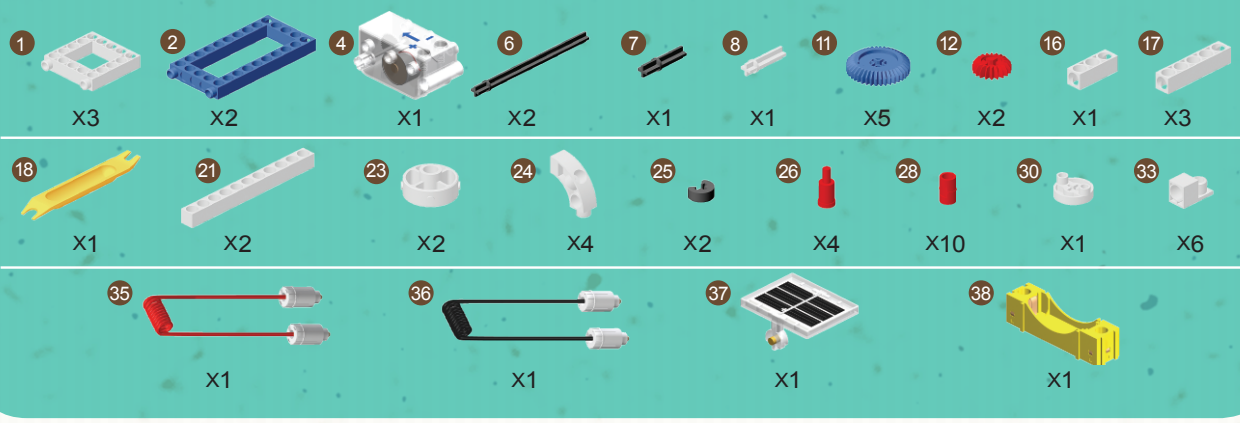
Model 6
Twin-Prop Helicopter

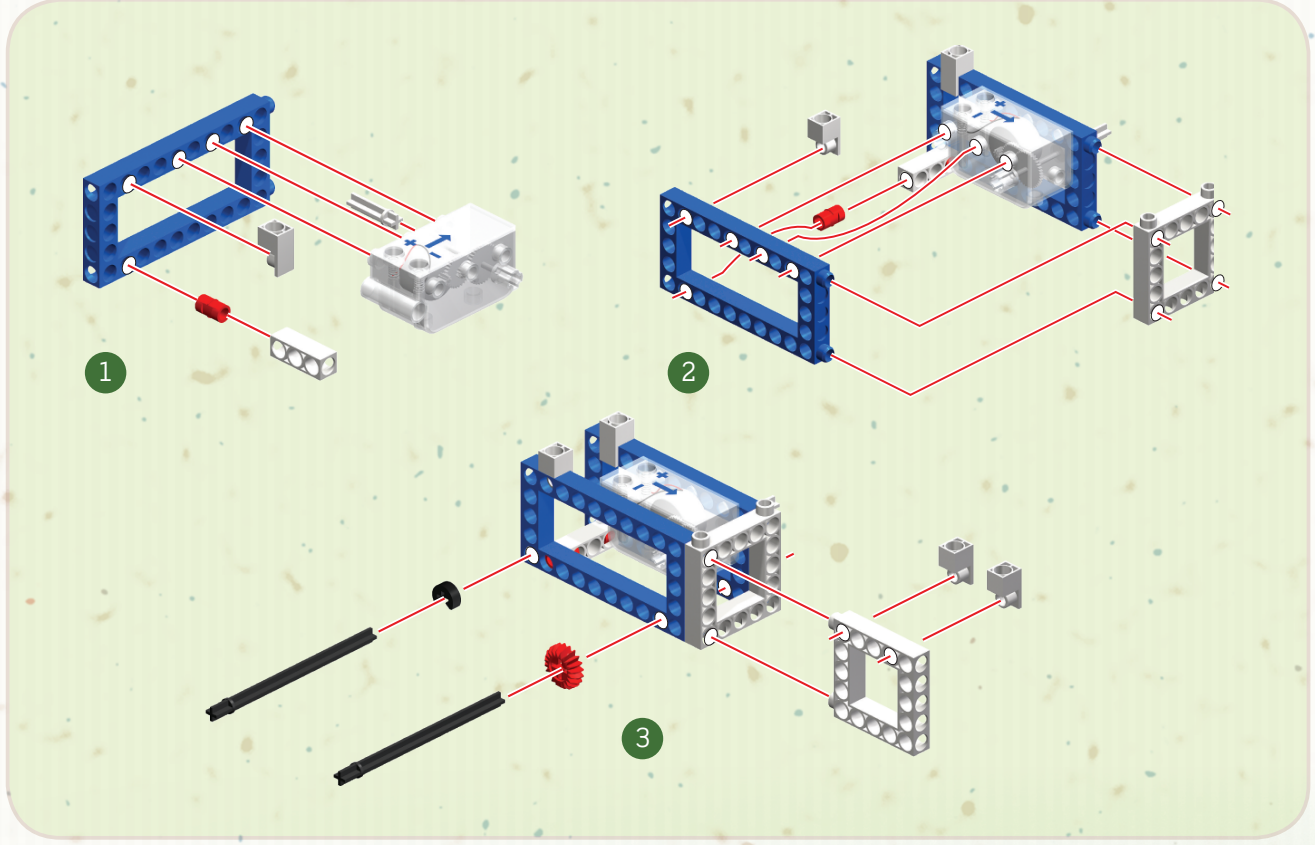
DID YOU KNOW...

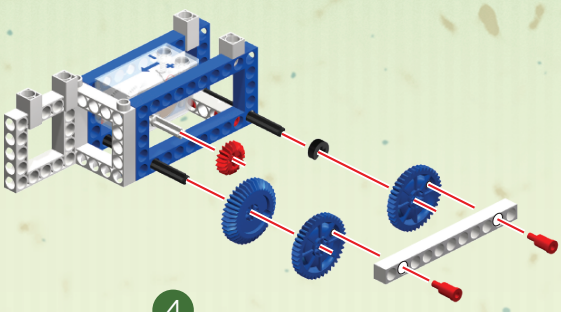
The first steam locomotive started with the combination of the steam engine and rail vehicles in 1781. The steam locomotive powers its wheels with mechanical energy generated from steam produced by heating water with burning wood or coal. George Stevenson, an English engineer, created a steam locomotive called "Rocket" in 1829, which could move at a speed of 30 miles per hour (47 km per hour). The speed of man-made machines began to surpass that of horses.

The horizontal cranks fixed on the train wheels transmit power equally to each wheel. This is a feature unique to the locomotive.

Parts needed







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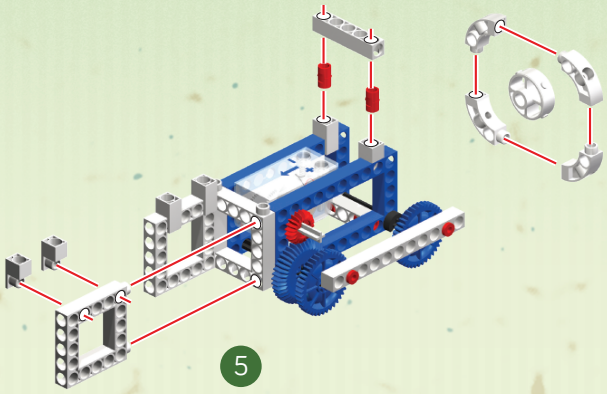

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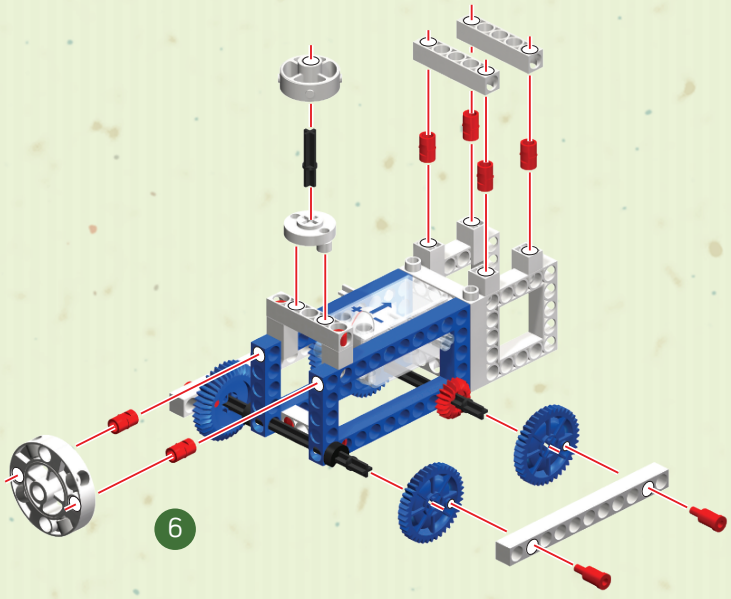

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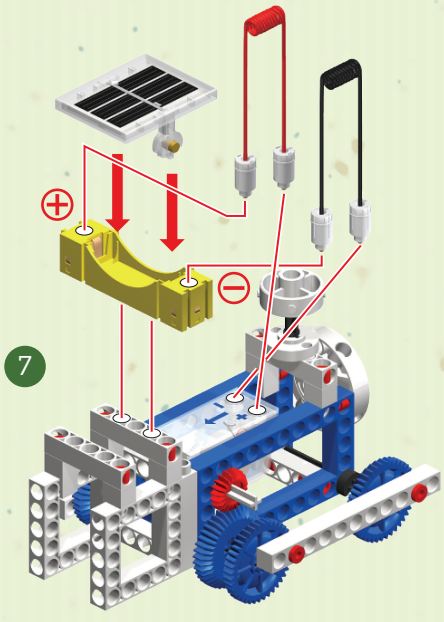

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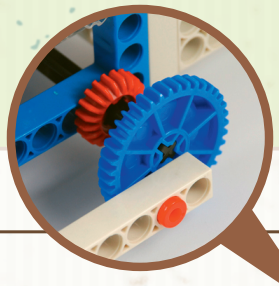
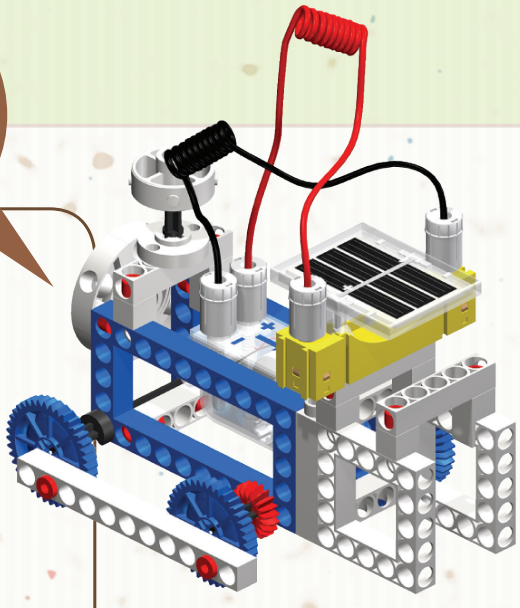


NOTE!

1. The long axle cannot stick out of the blue medium gear.
2. The gray rod should be kept parallel to the ground. If it is lop-sided, please rotate the front blue gear to adjust it.



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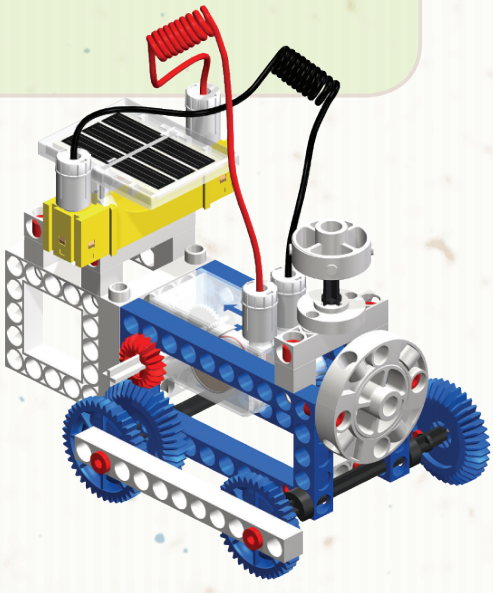


Front

Completed

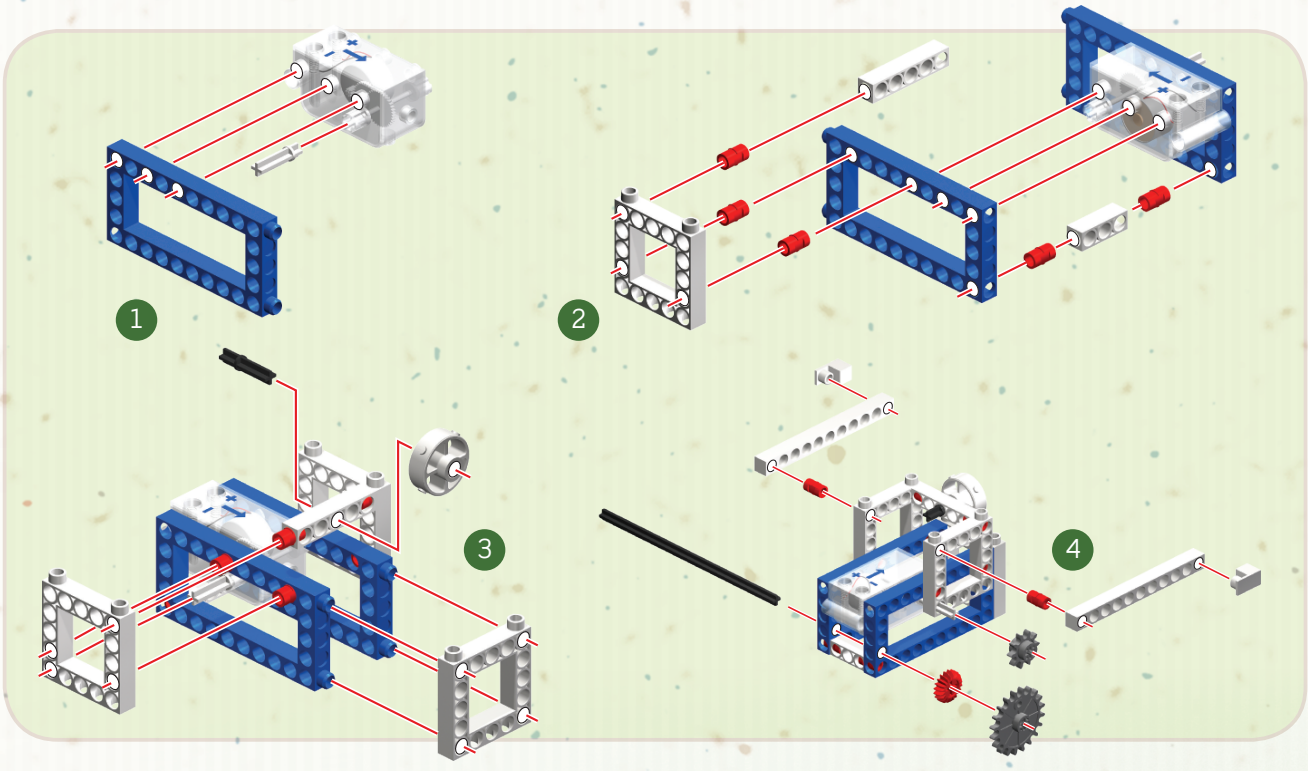
DID YOU KNOW...

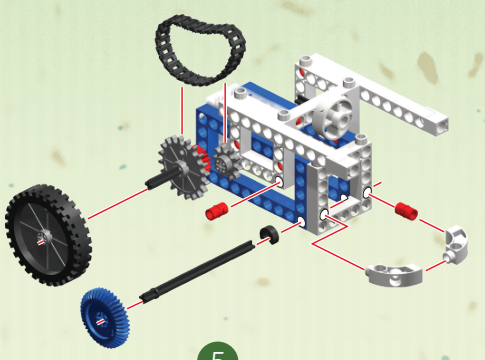
Benjamin Holt and Daniel Best each experimented with a variety of steam bulldozers for plowing fields in the late 1800s. In 1904, Benjamin Holt successfully developed the first steam powered bulldozer. In 1925, Holt's company and Best's company merged to become what is now Caterpillar Inc. Today, Caterpillar is famous worldwide as a construction machinery and heavy duty equipment manufacturer.

A bulldozer works by using a broad, steel blade in front to level mounds of earth or other materials with mighty mechanical power.

The word "bulldoze" first appeared in 1876. "Bull" means a male cow and "dose" is an old term that means to heat violently. "Bulldozer" used to describe a person who threatened others with violence. Later on, bulldozing was considered as a method to accomplish something. Today, "bulldozer" has come to describe the mighty machine that can level mounds.

Parts needed





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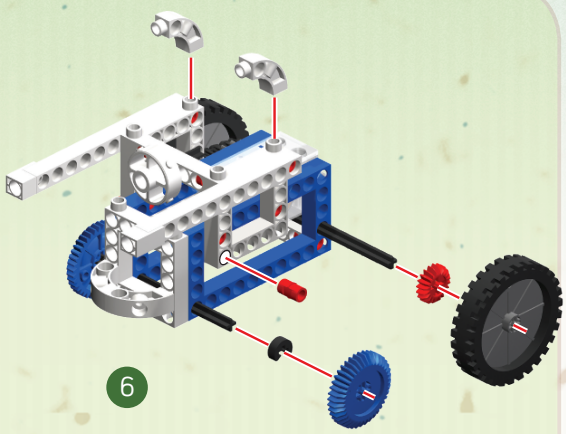

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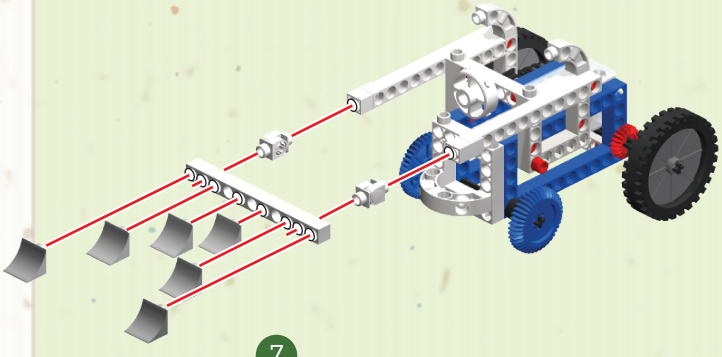

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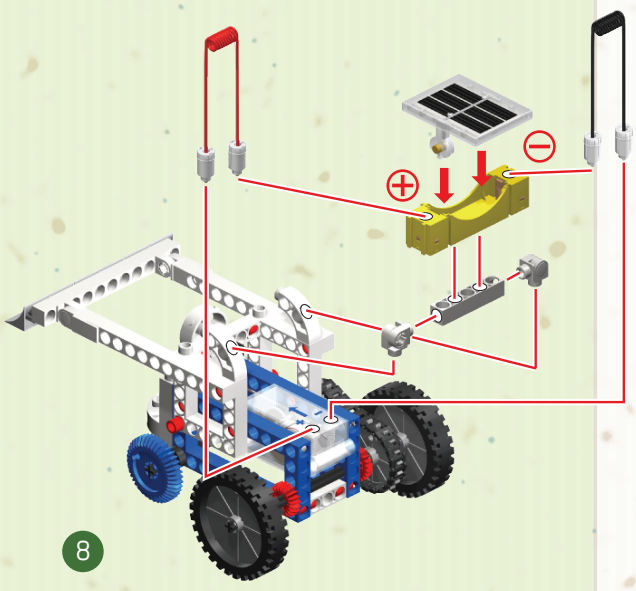

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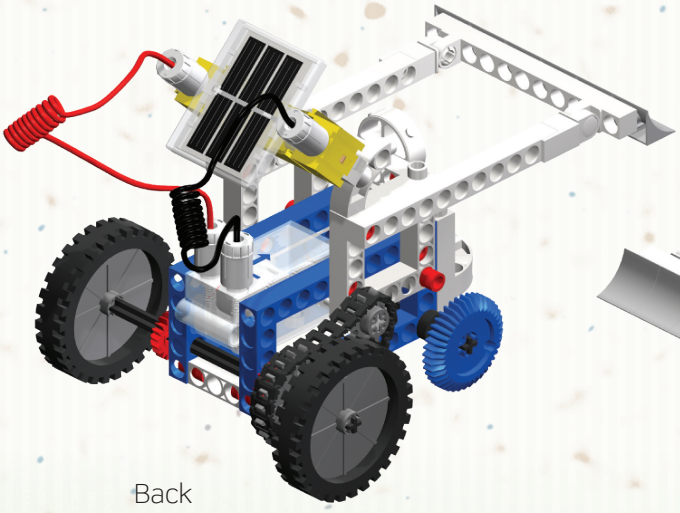

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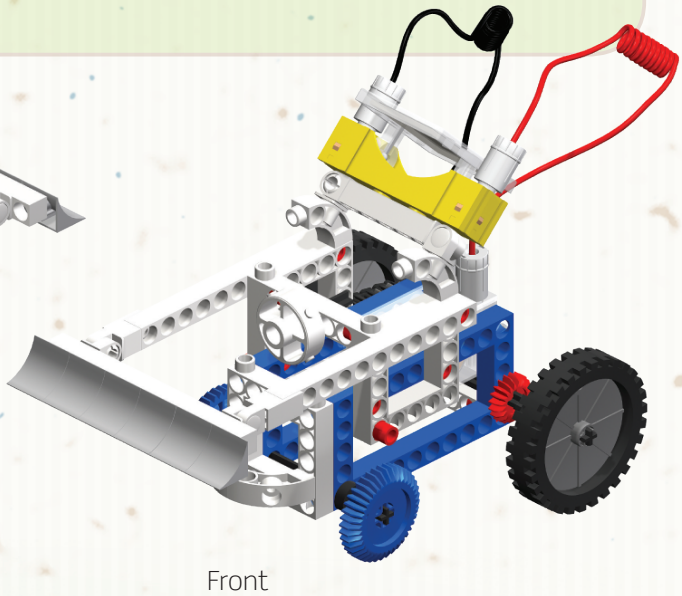


Front

Completed

DID YOU KNOW...

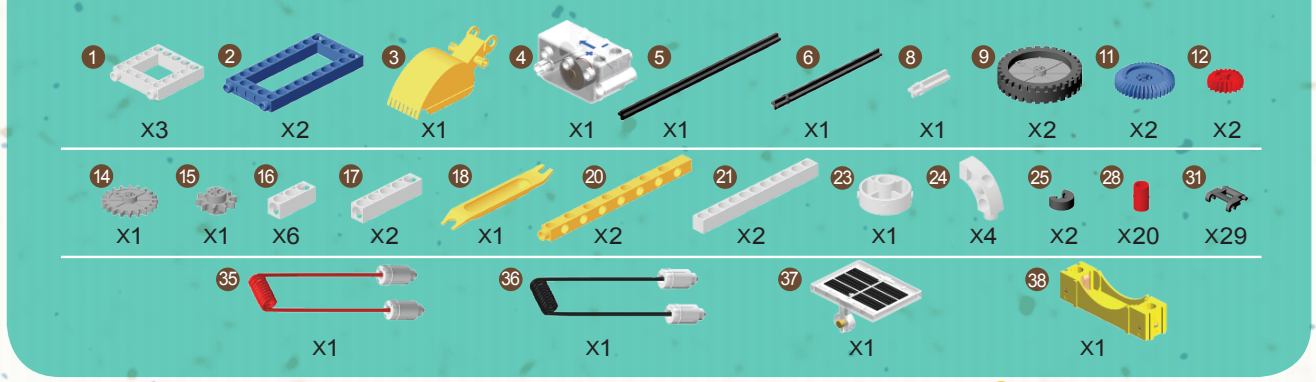
Early in the 16th century, Leonardo da Vinci designed a backhoe. However, the unsophisticated manufacturing technology of his time kept his backhoe design from becoming a reality.

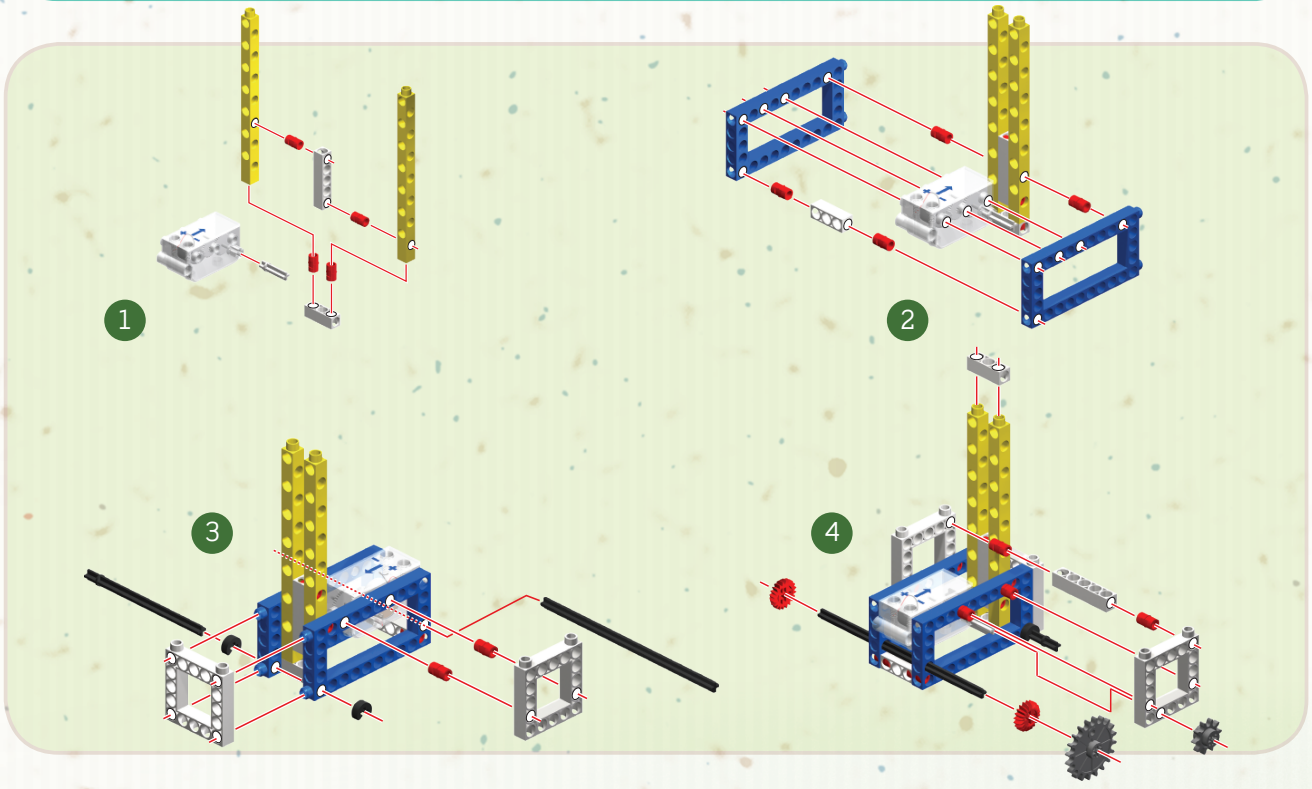
In 1835, William Otis succeeded in combining the steam engine and the mechanical hoe, and the backhoe finally became a reality.

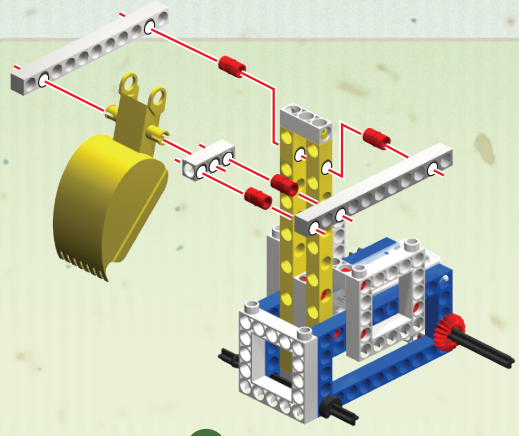
Not until early 1920 did oil-powered engines replace old steam engines. This was a radical innovation in science and technology because it paved the way for the constructed world we live in today. In 1928, a single-hoe backhoe powered by a diesel engine and an electric motor was invented.

In 1960, hydraulic-cable backhoes replaced electric-cable backhoes. Today, a backhoe is a powerful tractor-like machine with a mighty hydraulic powered digger. Similar machines can be outfitted with a hoe, pliers, piledrivers, or even an electromagnet to accomplish many jobs.

Parts needed







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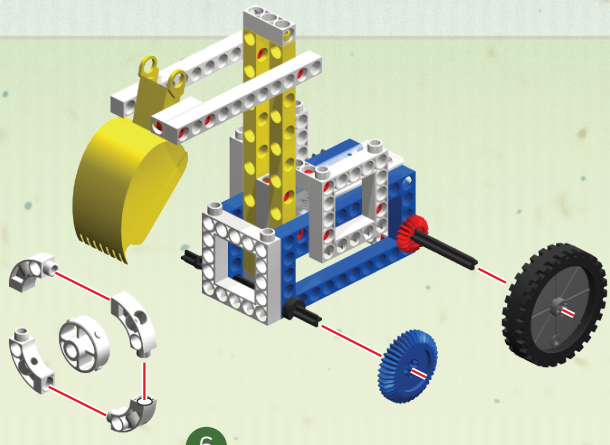

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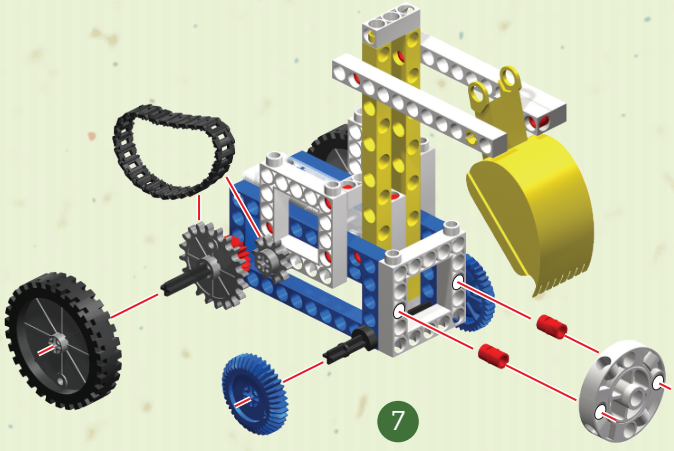

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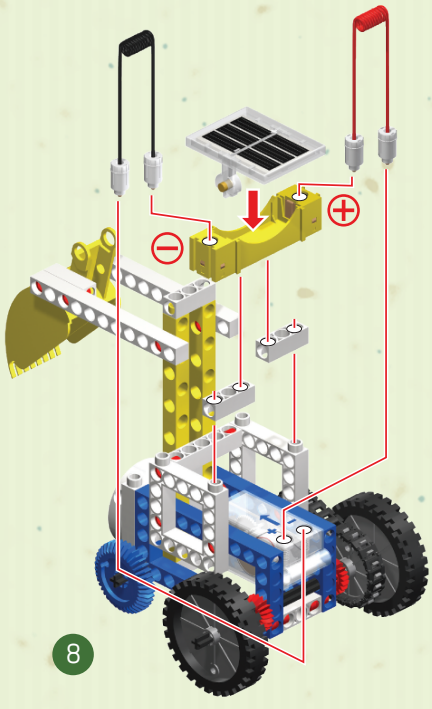

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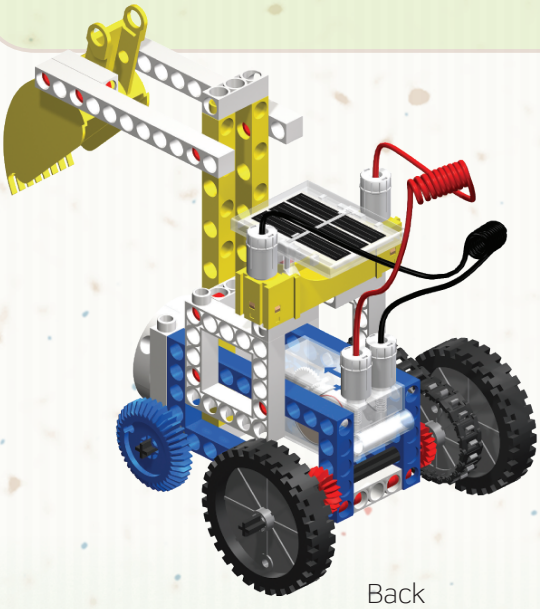

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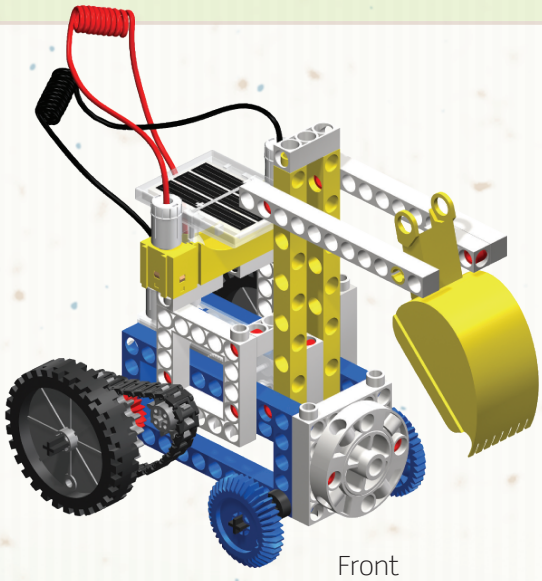


Front

Completed

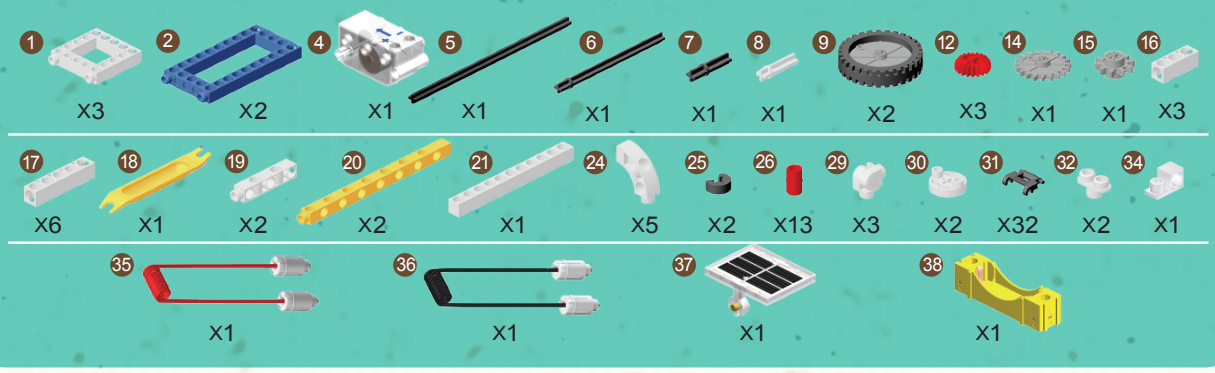
DID YOU KNOW...

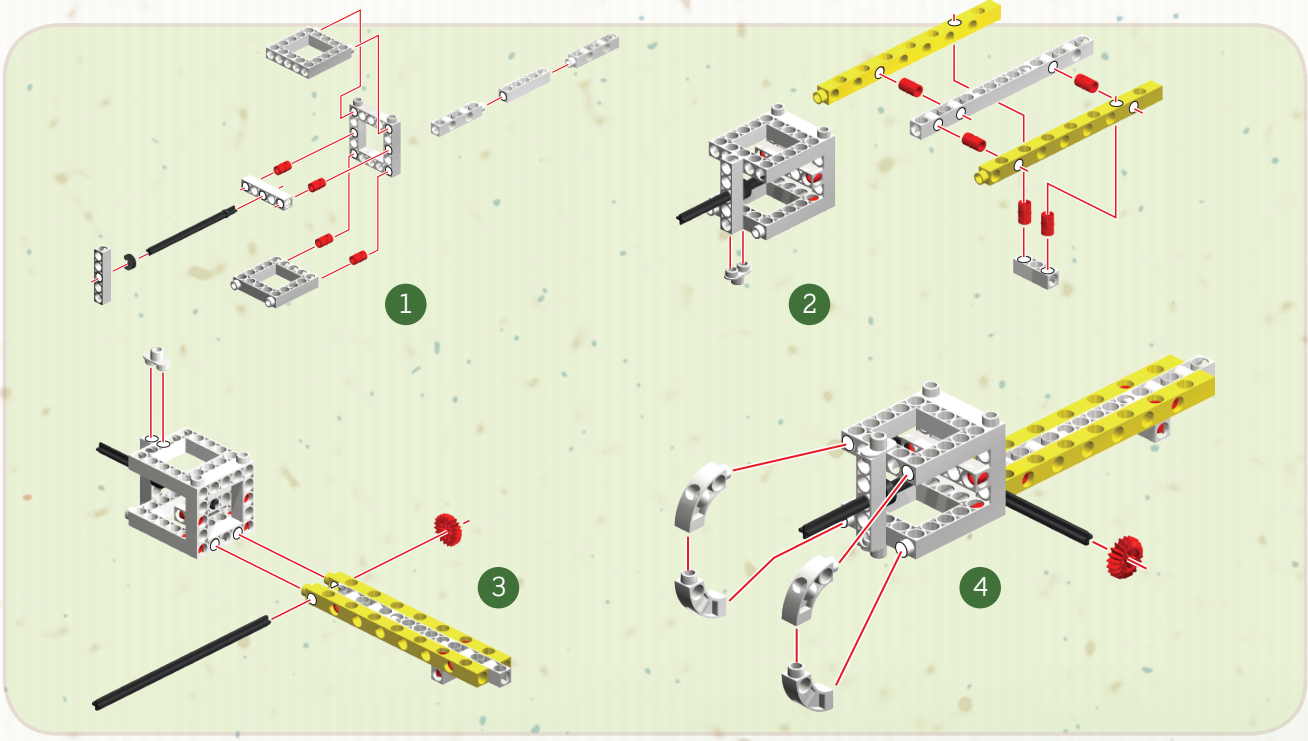
The world's first powered passenger airplane took flight in North Carolina on December 17, 1903. This airplane was named the "Flyer," and was invented by the Wright brothers, Wilbur and Orville.

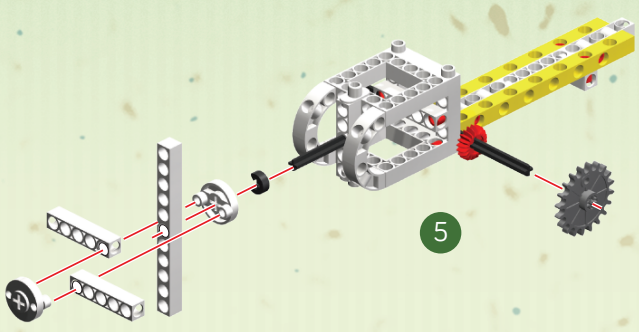
Wilbur Wright was born on April 16, 1867 and his younger brother, Orville, was born on August 19, 1871. They had a strong interest in mechanics and flight since childhood. They were engaged in a bike repair and manufacturing business.

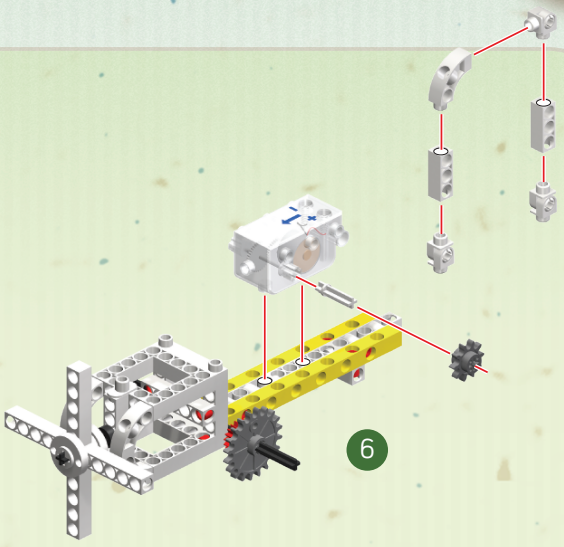
The Wright brothers had tested 1,000 and more gliding flights from 1900 to 1902, and made 200 and more different wings for about 1,000 wind tunnel experiments. As a result, they designed a wing shape with more lift, allowing them to produce the first airplane. This plane's wings were 13.2 meters long and had an elevator in the front and a rudder in the back. It was equipped with two two-blade propellers driven by chains, a sled-type landing gear, and a four-stroke engine weighing 150 lb (70 kg) that put out 8.8 kW of power. This airplane, famous in aviation history, is now displayed in the National Air and Space Museum in Washington, D.C.

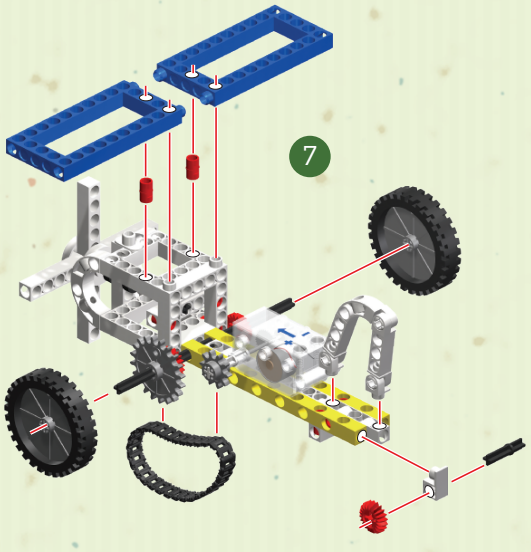
Parts needed

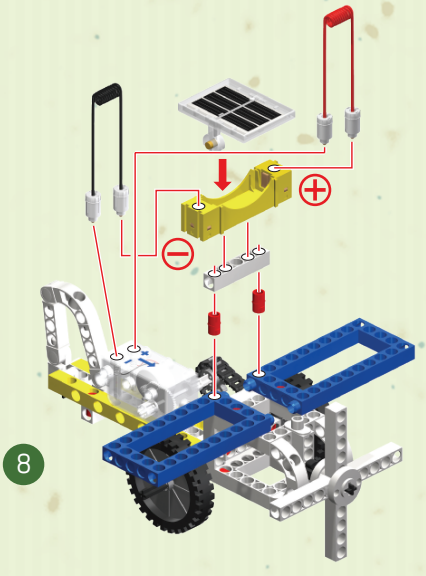


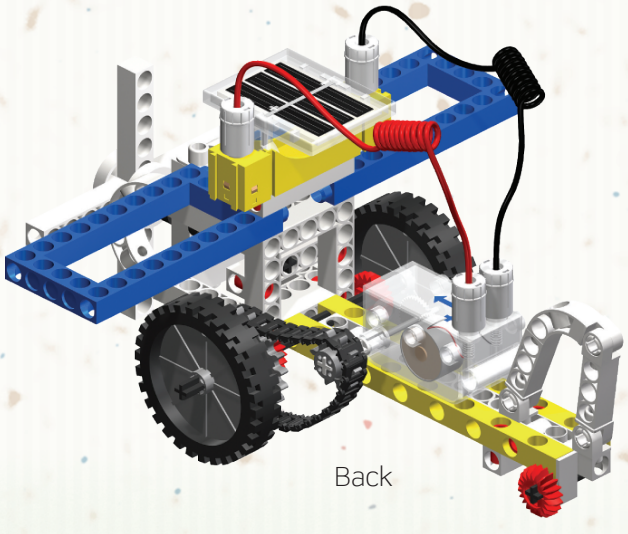












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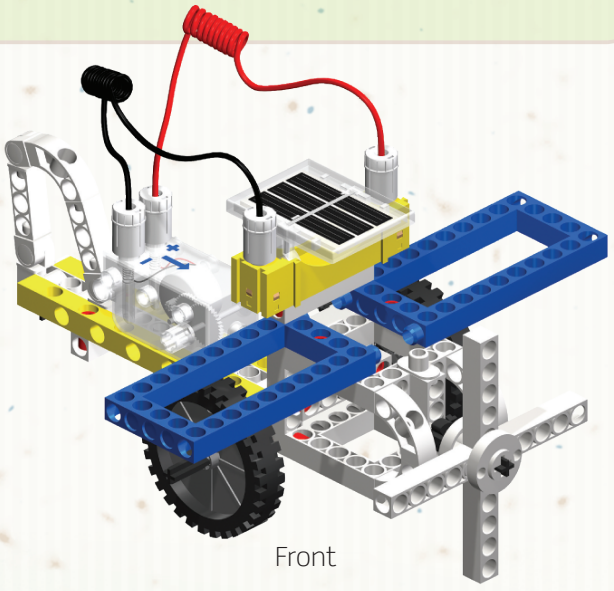


Front

Completed

DID YOU KNOW...

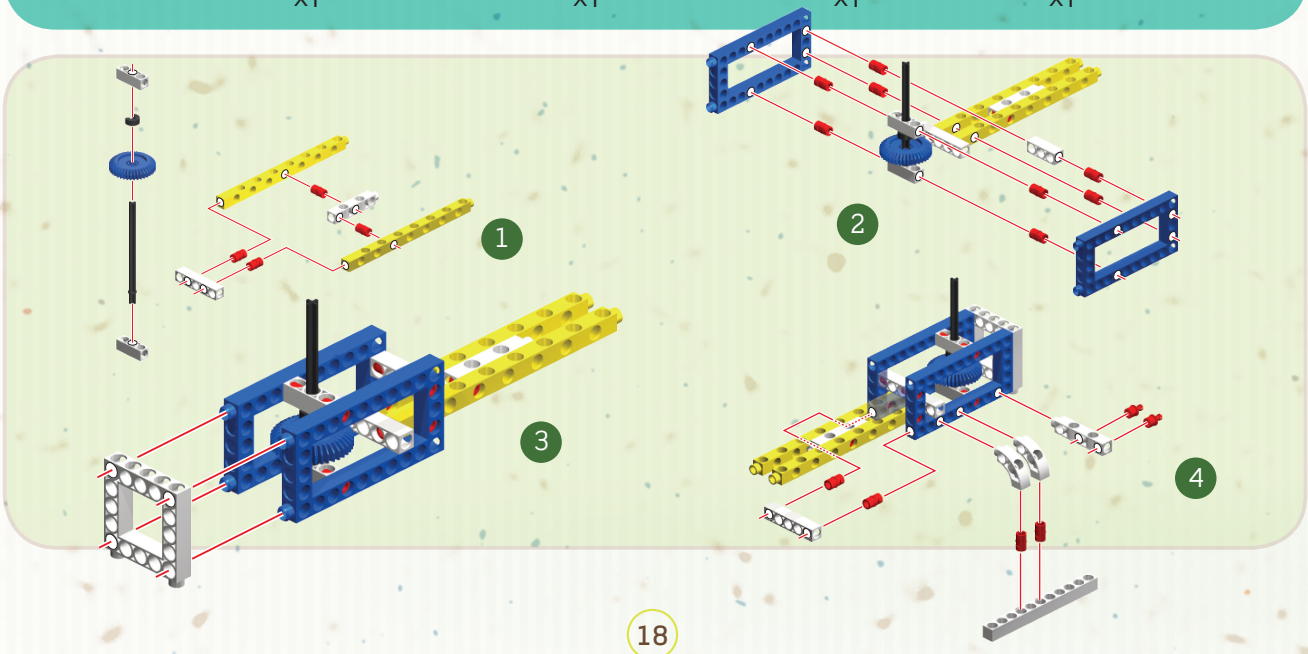
The concept of a helicopter can be traced back to the bamboo dragonfly, a Chinese children's folk toy popular in 400 B.C. Turning the vertical axle of the bamboo dragonfly can make it fly.

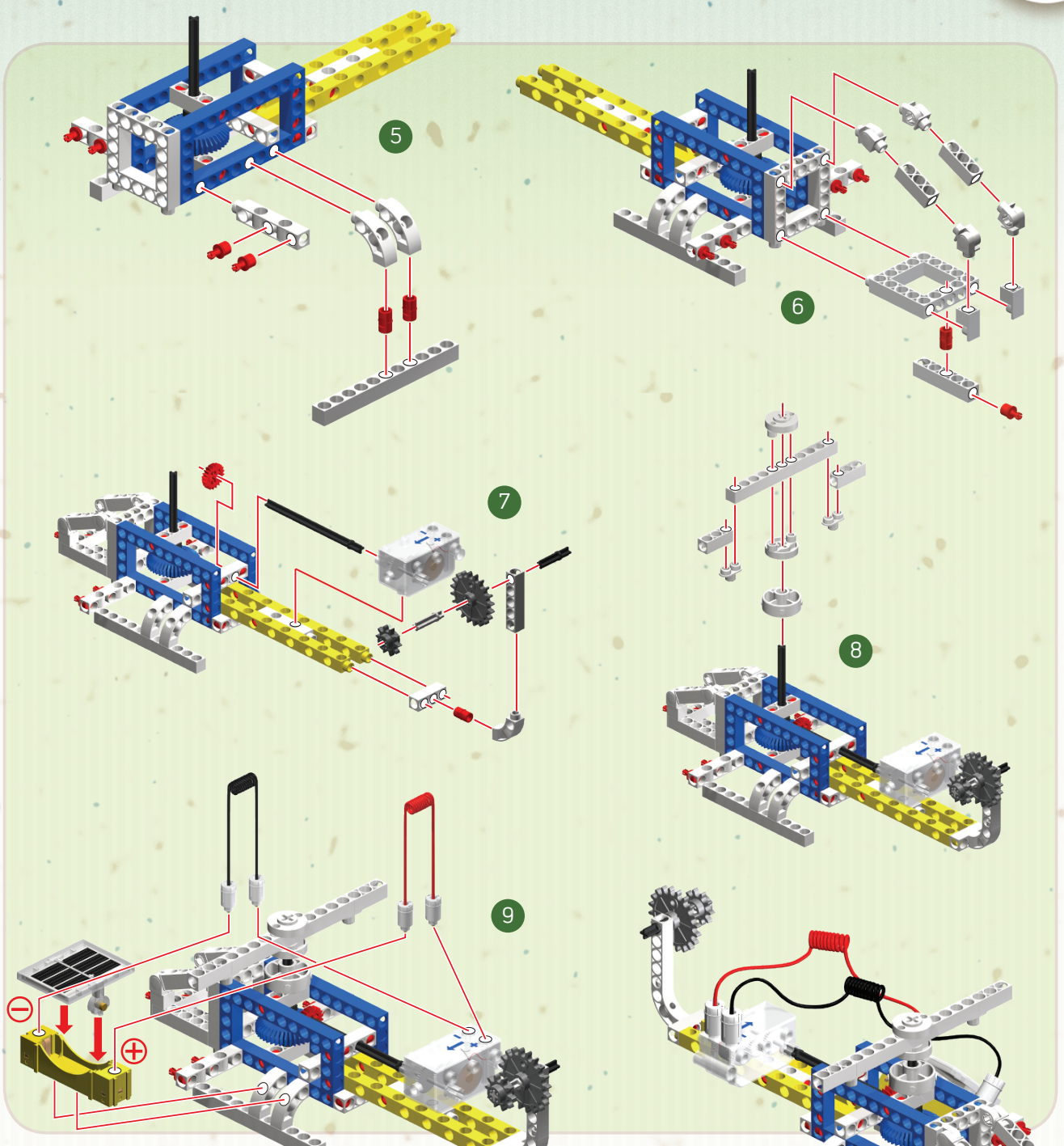
In 1861, Gustave de Ponton d'Amecourt created the word "helicopter." According to its definition, "helicopter" means "spiral wing" — a wing that spirals around an axle. If the axle is vertical, then the wing will be lifted vertically around the axle.

In 1880, Thomas Edison built an experimental motor-driven propeller. He realized that the helicopter needed an engine that was light weight but produced a lot of power. The ratio of weight to power was supposed to be 1 to 2 kg per horsepower. However, the steam engine at that time was not fit for flight, and therefore he started to develop the engine on his own. In the laboratory, he used cotton-dynamite to fuel the engine but then gave up due to a serious explosion.

In 1907, Louis Charles Breguet and Charles Richet built a helicopter that weighed 1,274 lb (578 kg) with 40 horsepower (hp). It had 4 propellers, each 8.1 m in diameter. This was the first pilot-operated helicopter. However, it could only make a short flight — staying about 60 cm above the ground for one minute or so, and needed to be steadied by four people. Even if the flight failed, Brequet is still regarded as the pioneer of the propeller blades used on helicopters. The propeller blades are kept close to the axle, helping solve the problem of asymmetrical lift caused when flying forward. Similar blades are still used today. On November 13, 1907, Paul Cornu flew his own helicopter, which became the first piloted, unassisted flight of a helicopter.

Parts needed





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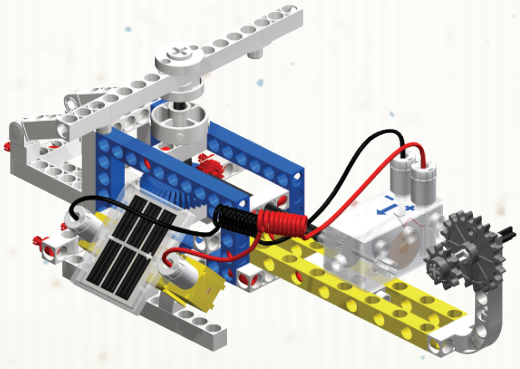
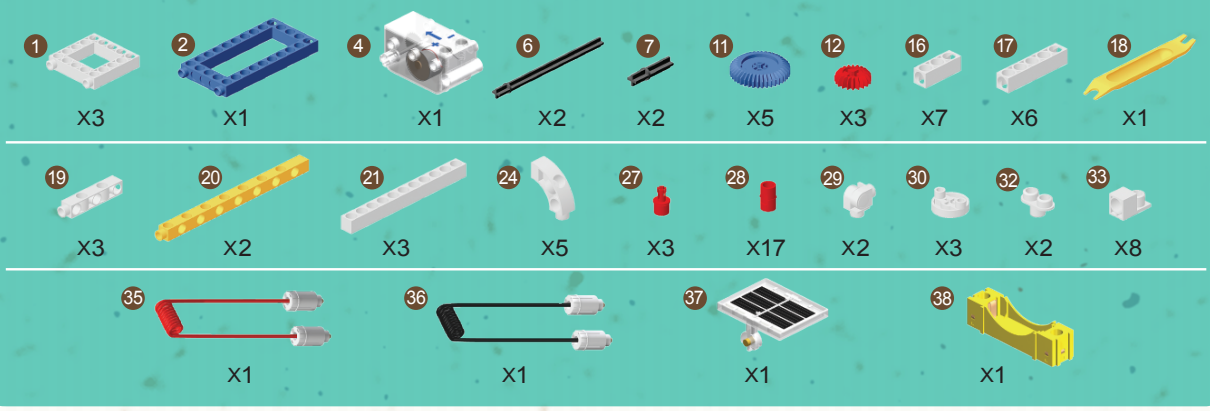
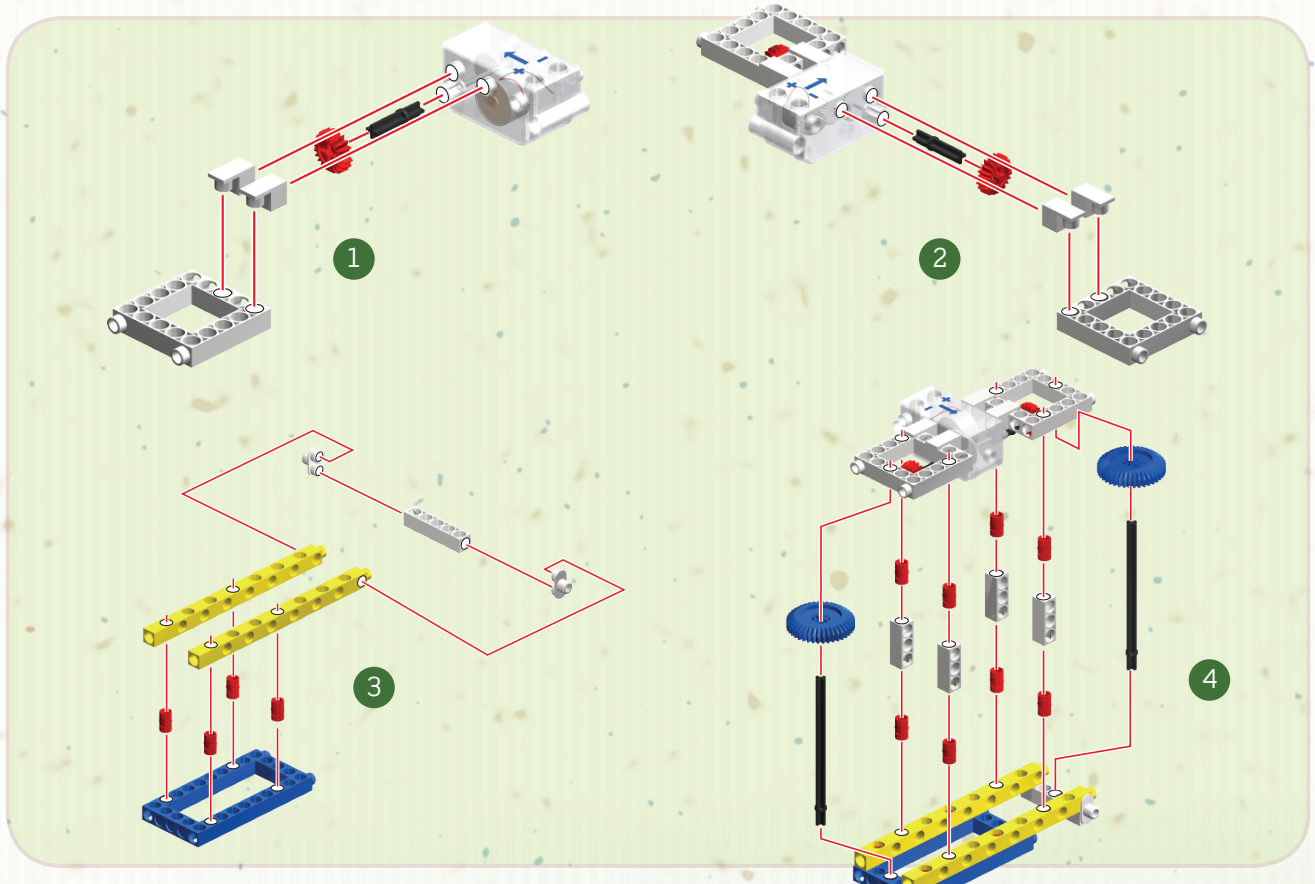


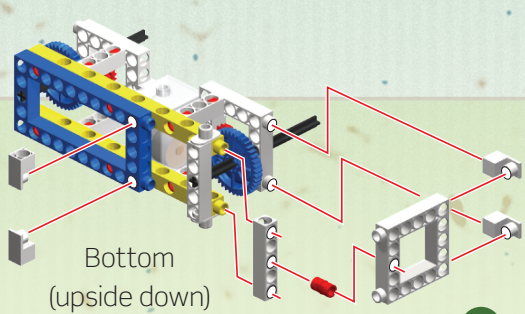
DID YOU KNOW...

The twin-prop helicopter is a jumbo helicopter. Its propellers come in several styles — in series, in line, and in parallel. It can carry lots of people and hoist heavy-duty machines or goods. The CH-47 Chinook is the most representative twin-prop helicopter, manufactured by Boeing Rotorcraft Systems. It was introduced in 1962 at the request of the U.S. Department of Defense to convey materials of 6,000 lb (2,700 kg) to a site 115 miles (185 km) away and then fly back with a load of materials of 3,000 lb (1,350 kg) without refueling, or to hoist and carry seven tons of materials outside the helicopter when flying to a site 23 miles (37 km) away, and then fly back without refueling after unloading the hoisted materials.

Parts needed







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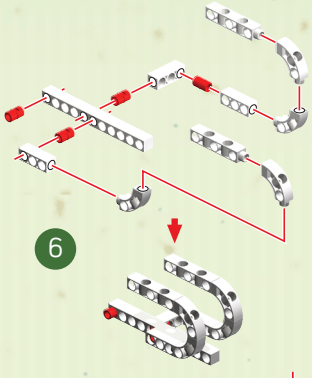

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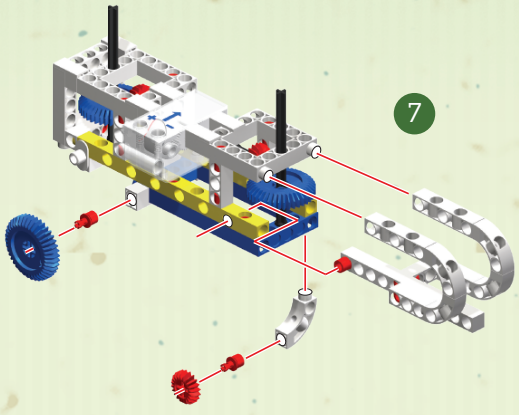

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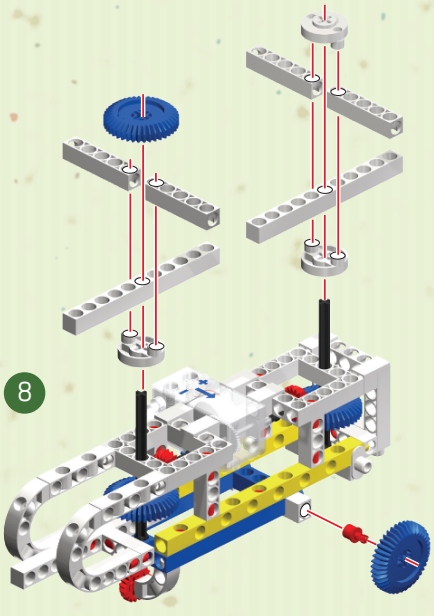

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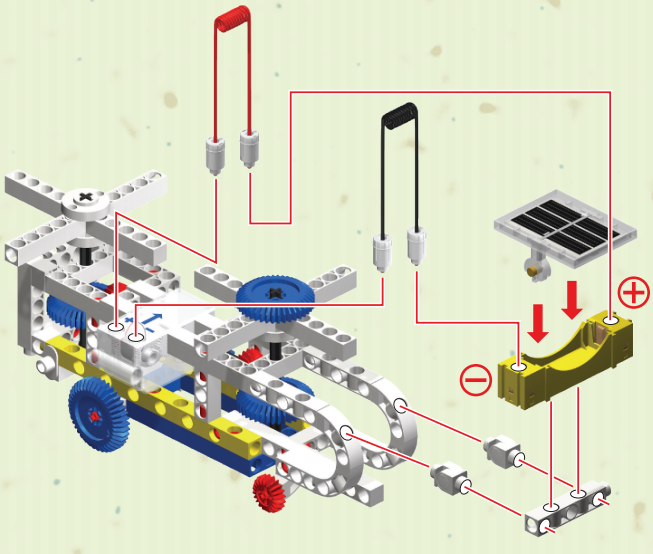

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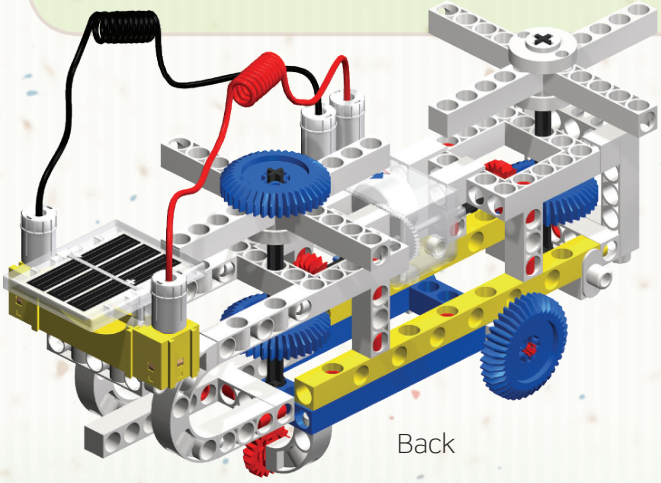

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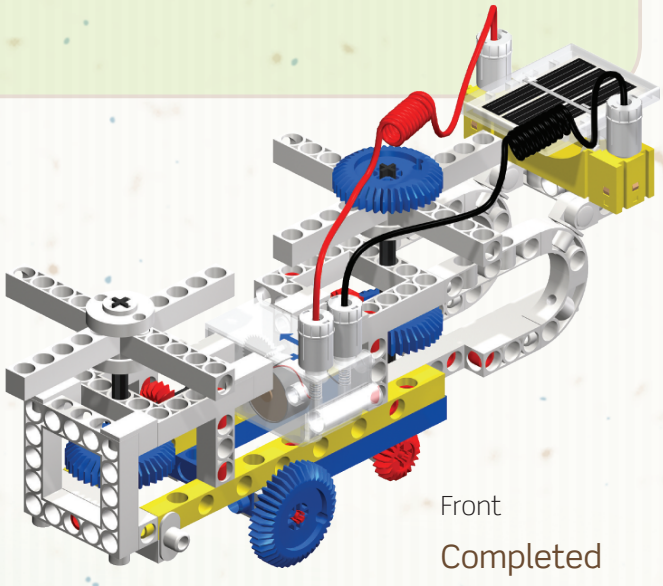

Front

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