EXPERIMENT MANUAL

JUMPERBOT

THAMES & KOSMOS

Franckh-Kosmos Verlags-GmbH & Co. KG, Pfizerstr. 5-7, 70184 Stuttgart, Germany | +49 (0) 711 2191-0 | www.kosmos.de
Thames & Kosmos, 301 Friendship St., Providence, RI, 02903, USA | 1-800-587-2872 | www.thamesandkosmos.com
Thames & Kosmos UK Ltd, Goudhurst, Kent, TN17 2QZ, United Kingdom | 01580 212000 | www.thamesandkosmos.co.uk

Safety Information

The jumperbot can generate more force than you might expect. Therefore, for the jumperbot and the models that are powered by the spring, please always be careful that fingers, other body parts, or delicate objects are not harmed by the movement of the spring when it winds up or releases.

WARNING. Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Store the experiment material, particularly the battery-powered motor, and assembled models out of the reach of small children.

WARNING. Only for use by children aged 8 years and older. Instructions for parents or other supervising adults are included and have to be followed. Keep the packaging and instructions as they contain important information.

Safety for Experiments with Batteries

››› The wires are not to be inserted into socket-outlets. Never perform experiments using household current! The high voltage can be extremely dangerous or fatal!

››› For operation, you will need two AAA batteries (1.5-volt, type AAA/LR03) or two AAA rechargeable batteries (1.2-volt, min. 1100 mAh), which are not included in the kit due to their limited shelf life.

››› The supply terminals are not to be short-circuited. A short circuit can cause the wires to overheat and the batteries to explode.

››› Different types of batteries or new and used batteries are not to be mixed.

››› Do not mix old and new batteries.

››› Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel-cadmium) batteries.

››› Always insert batteries in the right polarity orientation, pressing them gently into the battery compartment.

››› Always close battery compartments with the lid.

››› Non-rechargeable batteries are not to be recharged. They could explode!

››› Rechargeable batteries are only to be charged under adult supervision.

››› Rechargeable batteries are to be removed from the toy before being charged.

››› Exhausted batteries are to be removed from the toy.

››› Dispose of used batteries in accordance with environmental provisions.

››› Be sure not to bring batteries into contact with coins, keys, or other metal objects.

››› Avoid deforming the batteries.

With all of the experiments that use batteries, have an adult check the experiment or model **before use** to make sure it is assembled properly. Always operate the motorized models under adult supervision.
After you are done experimenting, remove the batteries from the battery compartments. Note the safety information accompanying the individual experiments!

Notes on disposal of electrical and electronic components

The electronic components of this product are recyclable. For the sake of the environment, do not throw them into the household trash at the end of their lifespan. They must be delivered to a collection location for electronic waste, as indicated by the following symbol:

Please contact your local authorities for the appropriate disposal location.

Dear Parents,

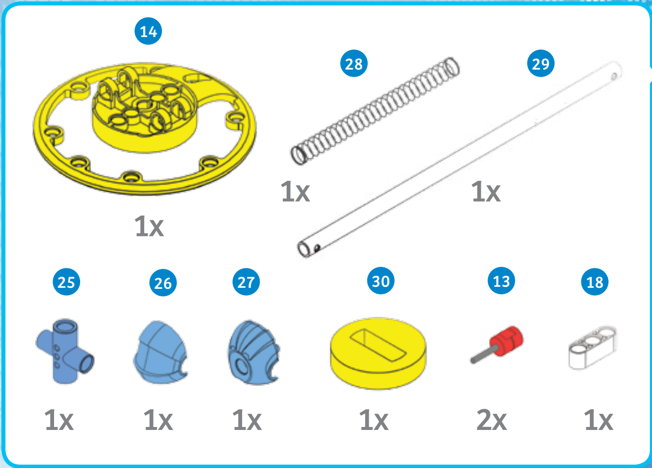
Before starting the experiments, read through the instruction manual together with your child and discuss the safety information. Check to make sure the models have been assembled correctly, and assist your child with the experiments. **We hope you and your child have a lot of fun with the experiments!**

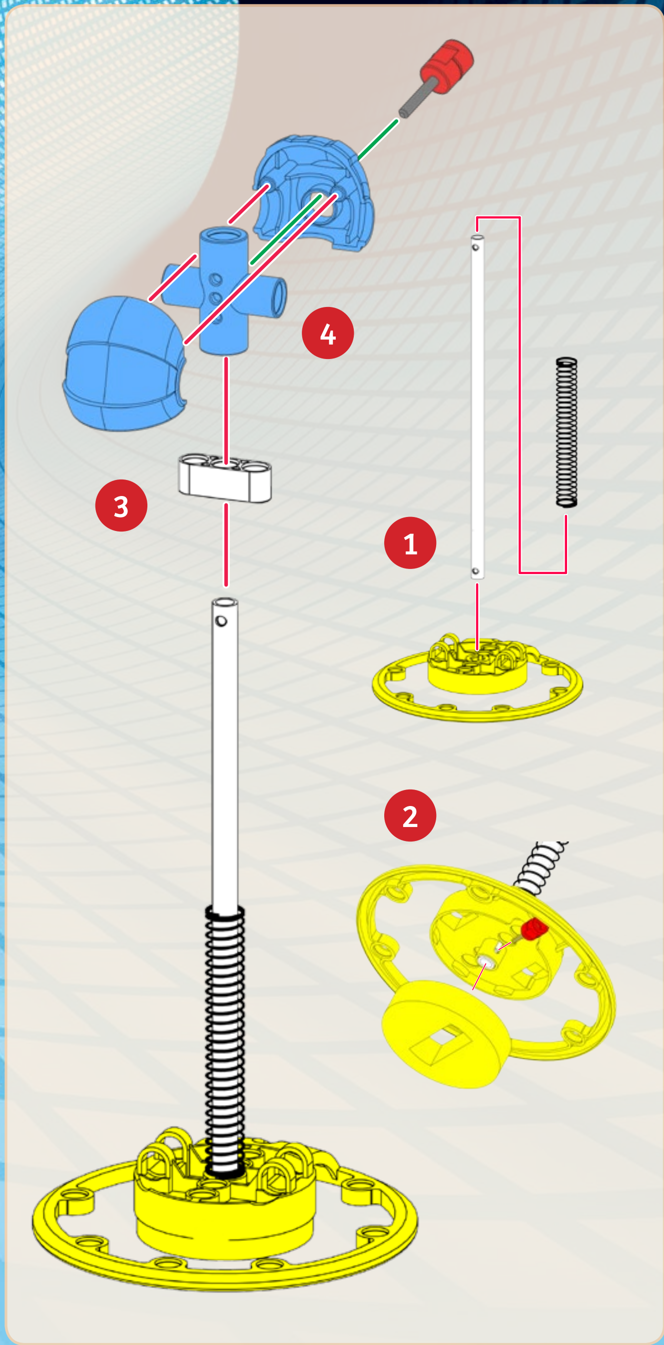
An experiment to help you hit the ground running

Let's start by observing some unexpected forces...
Check it out, and prepare to be surprised!

Discover the power of springs

YOU WILL NEED





HERE'S HOW

1. Insert the clear tube into the yellow circular base and slide the spring over the clear tube.
2. Use an anchor pin with metal pin to secure the tube to the base. Fit the foam cushion over it.
3. Slide the 3-hole wide rod over the tube.
4. Assemble the head from the visor, large tube-cross connector, and helmut back. Slide it over the tube and secure it to the tube with the second anchor pin with metal pin.
5. Press down on the 3-hole wide rod to push the spring down all the way to the bottom and then let it go. You can see how you are able to "charge" the spring with plenty of power by compressing it. The head keeps the 3-hole wide rod from flying all the way off the tube.

WHAT'S HAPPENING?

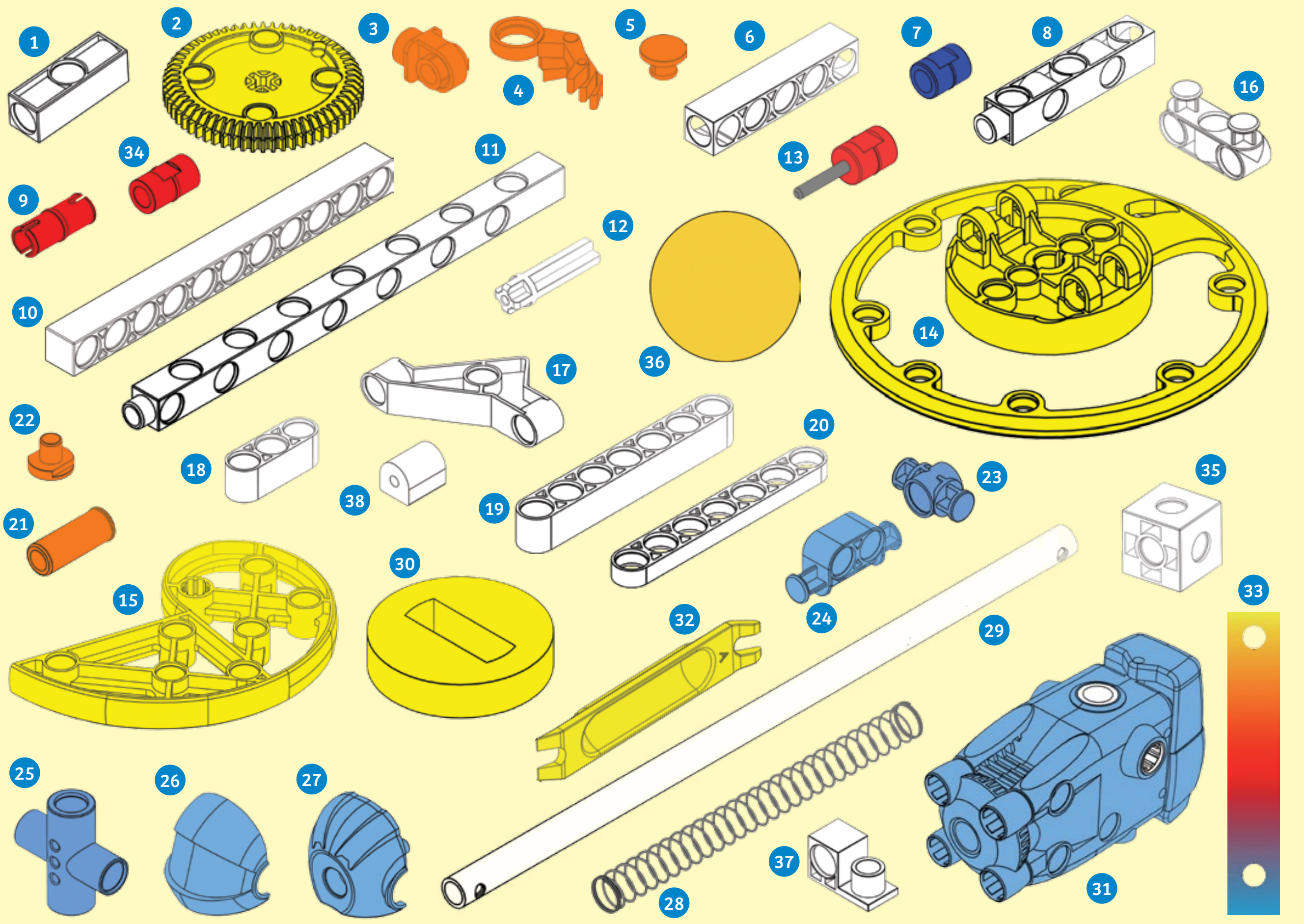
First of all, you can see how much force can be stored inside the spring. This will be used to give your robot a nice jump-start a little later on.
Second, you can see how important it is to keep the spring and its force under control. If the two anchor pins weren't holding it in place, the spring and the 3-hole wide rod would shoot off through the air as soon as you let it go, which could be dangerous.

WANT TO KNOW MORE?
Then come with us into the world of spring-loaded science...

›› KIT CONTENTS

GOOD TO KNOW! If you are missing any parts, please contact Thames & Kosmos customer service.
Any materials not included in the kit are indicated in *italic script* under the "You will need" heading.

The parts in your kit:



Checklist: Find – Inspect – Check off

✔	No.	Description	Count	Item No.
○	1	3-hole cross rod	2	714 127
○	2	Large gear	2	715 047
○	3	Wrist (for hand)	2	715 672
○	4	Hand	4	715 673
○	5	Rivet (for hand)	4	715 674
○	6	5-hole rod	2	714 179
○	7	Short anchor pin	11	714 129
○	8	5-hole dual rod	2	715 675
○	9	Joint pin	4	702 524
○	10	11-hole rod	2	714 282
○	11	Long rod	2	715 676
○	12	Motor shaft	3	715 677
○	13	Anchor pin with metal pin	2	715 678
○	14	Circular base	1	715 679
○	15	Large snail cam	2	715 680
○	16	3-hole dual rod with anchor pins	1	715 681
○	17	Angled arm	4	715 682
○	18	3-hole wide rod	1	715 683
○	19	7-hole wide rod	2	715 684
○	20	7-hole flat rod	4	715 685
○	21	Joint pin without ridge	10	715 686
○	22	Cap for joint pin without ridge	10	715 687
○	23	1-hole cross-connector with anchor pins	2	715 688

✔	No.	Description	Count	Item No.
○	24	2-hole rod with anchor pins	4	715 689
○	25	Large tube cross-connector	1	715 690
○	26	Visor (for head)	1	715 691
○	27	Helmut back (for head)	1	715 692
○	28	Spring	1	715 693
○	29	Clear tube (205 mm)	1	715 694
○	30	Foam cushion	1	715 695
○	31	Motor unit	1	715 696
○	32	Part separator tool	1	702 590
○	33	Printed scale card	1	715 697
○	34	Anchor pin	2	702 527
○	35	6-hole cube connector	1	715 756
○	36	Ball (40 mm)	1	715 757
○	37	90-degree converter - X	1	715 051
○	38	Pin cap	1	715 806

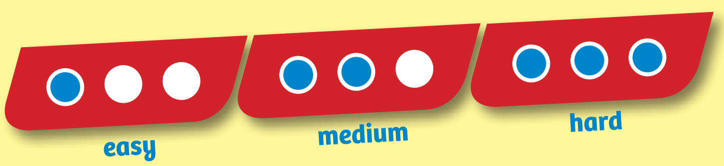
You will also need:
A small screwdriver, two AAA batteries (1.5-volt, type AAA/LR03) or two AAA rechargeable batteries (1.2-volt, min. 1100 mAh), sheet of paper, pen, ruler, books, bookshelf board or the like, handkerchief, 3 rubber bands, tape measure, pocket calculator, table tennis ball, paper tissue, note pad, kitchen scale, reference weights such as full unopened food packages of 125, 250 and 500 grams, objects for weighing (between 200 and 800 grams in weight), building blocks, paper cup, water, stopwatch, safety pin

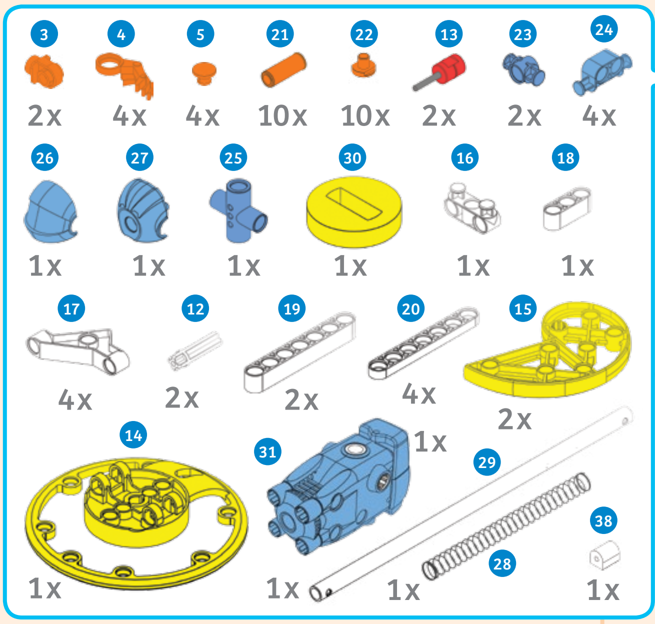
››› TABLE OF CONTENTS

TIP!
You will find supplemental information in the "Check It Out" section on Page 24.

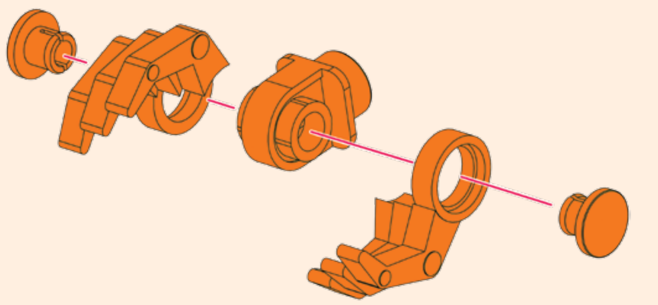
What do a shock absorber, a ballpoint pen, and your jumperbot have in common? All of them use springs. And they are all capable of absorbing shocks or storing energy. For example, in the first experiment you "charged" the spring with energy by compressing it. When you then let go of the spring, the stored energy was converted into motion. But this experiment kit will also teach you other ways you can use springs. For example, did you know you can use them to make a scale? Curious? Then get ready, set — jump!

TIP!
At the top of each model assembly page, you will find a red bar:
››› It shows how difficult the model's assembly will be:

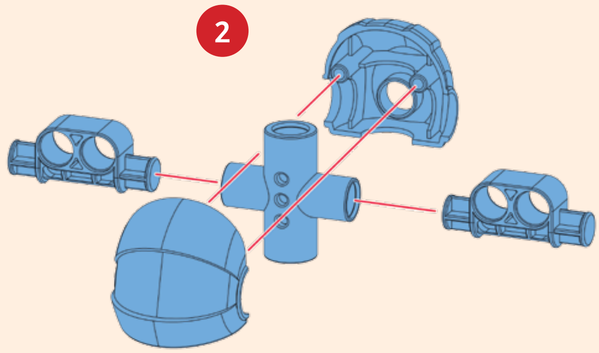




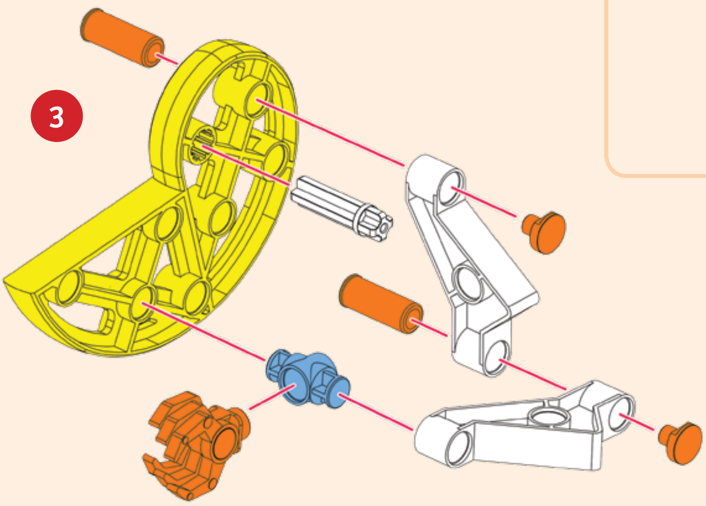
1 x 2



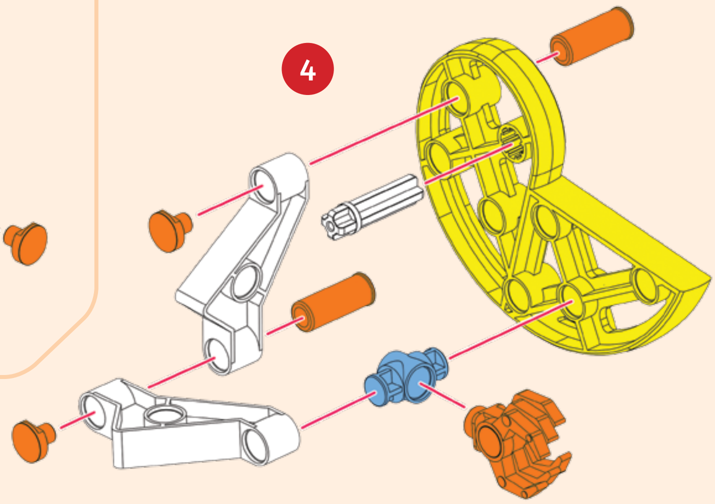
2



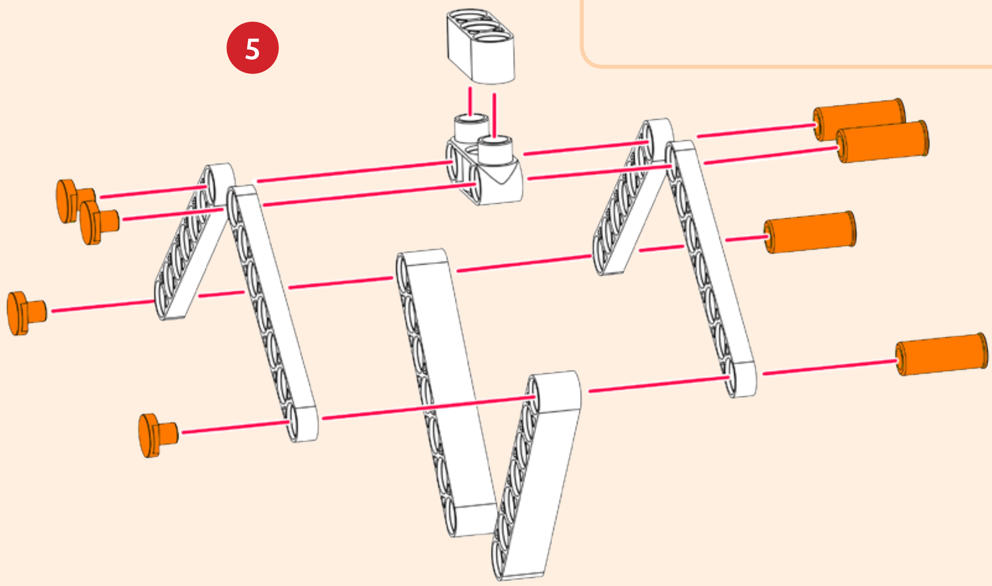
3



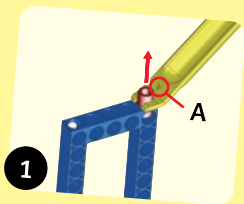
4



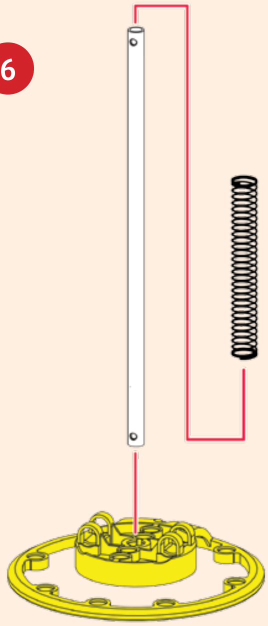
5



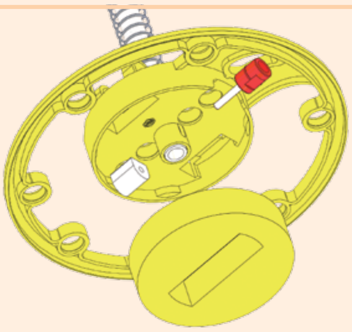
Tip: The part separator tool
In the kit, you will find a little tool called the part separator tool. The tool can be used to pry various pins out of holes and separate other parts that are stuck together.



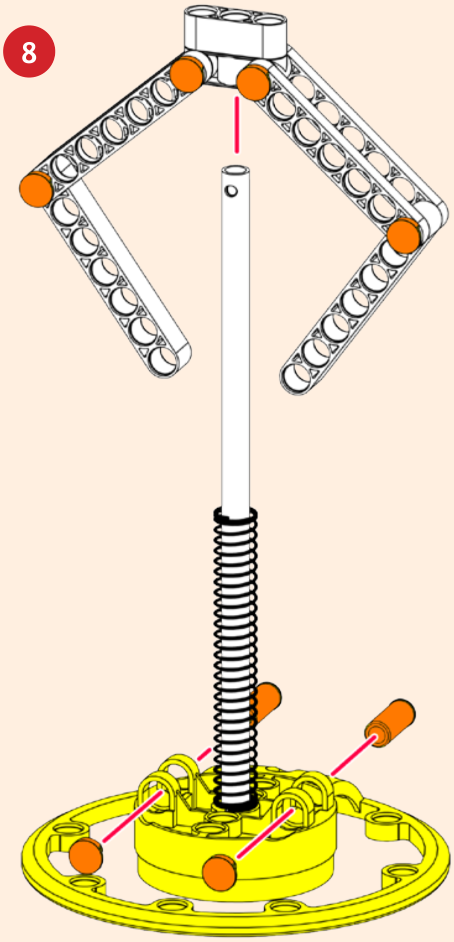
6



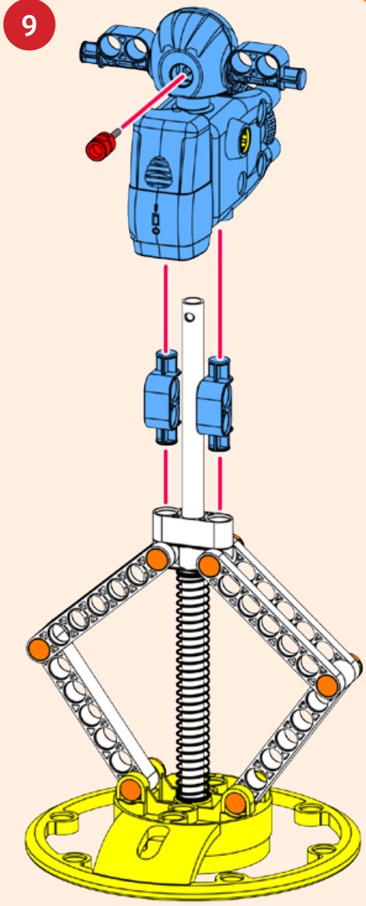
7



8

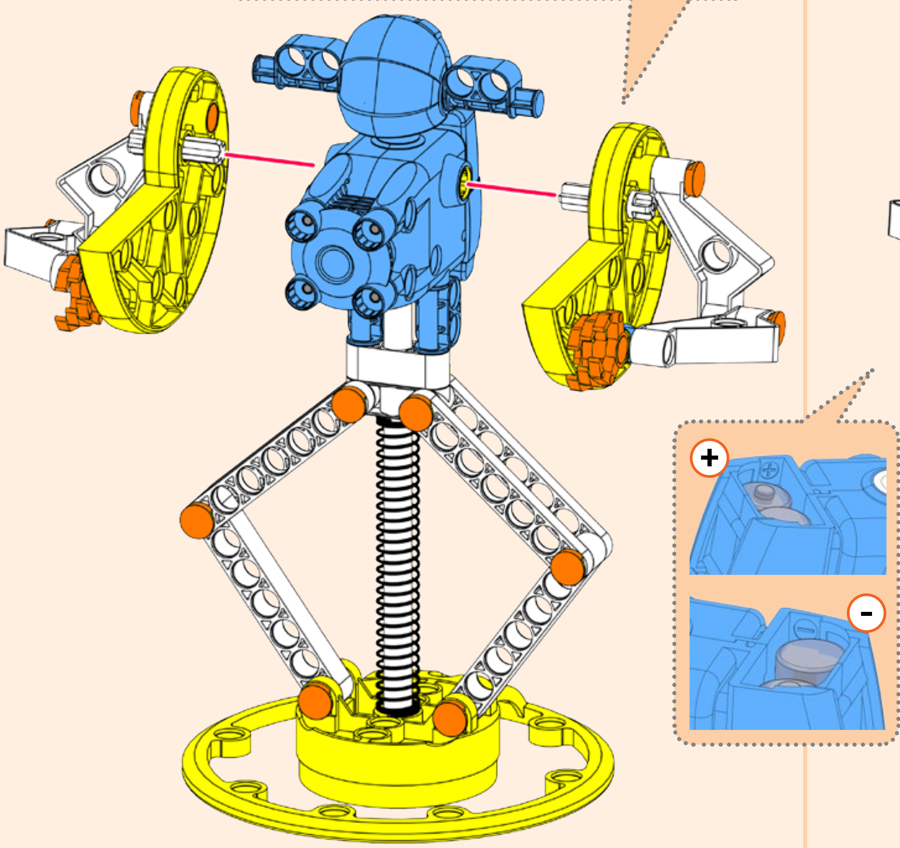


9



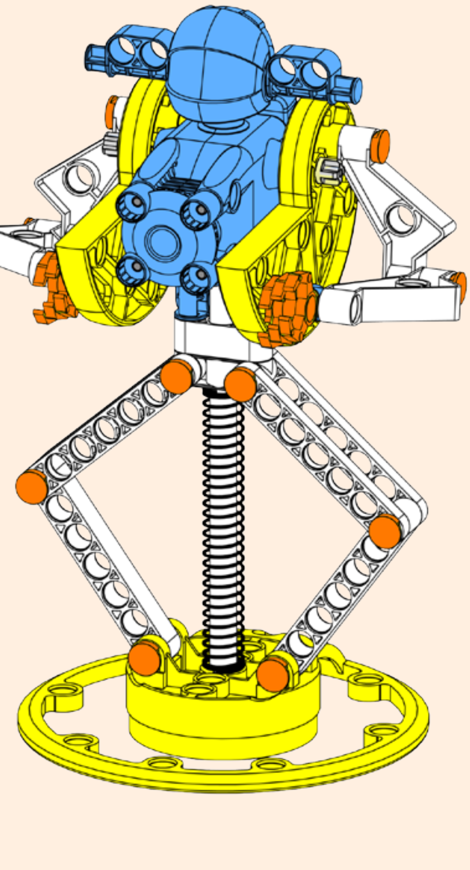
10

Make sure the yellow snail cams are aligned with each other, and make sure the hands are not sticking out so far that they interfere with the cams' turning.



11

Done!



EXPERIMENT 1

Jumping Jumperbots!

YOU WILL NEED

› **The assembled jumperbot**
› *Small screwdriver*
› *Two AAA batteries or two AAA rechargeable batteries*
› *Sheet of paper*
› *Pen*
› *Ruler*

HERE'S HOW

1. Open the battery compartment of the motor by unscrewing the little screw. Insert two AAA batteries oriented according to the polarity indicator markings. Replace the cover and tighten the screw.
2. Activate the switch on the back of the battery compartment and perform a test run.
3. As soon as you are familiar with the way your jumperbot jumps, you can start to get to know its capabilities in a little more detail: How high can it jump, and — most importantly — how far? Take a sheet of paper and draw a scale with one-centimeter markings. The starting point is at 0 cm, and the finish line might be 20 or 30 cm.
4. Place your jumperbot at the 0-cm starting line and start him up.
5. How far is the farthest jump? And how many hops does your robot need to get to the finish line?

WHAT'S HAPPENING?

The movement of the snail cams against the ears of your jumperbot pushes the robot's upper body downward, compressing the spring. In the process, the spring "stores" potential energy. As soon as the snail cam's notches rotate past the ears, the spring pushes open, loosening and releasing its stored energy. Potential energy is converted into kinetic energy — and the jumperbot jumps.

The cushion beneath the base shifts the jumperbot's point of gravity further downward, which helps him to stand better. The cushion also ensures a softer landing.

DID YOU KNOW?

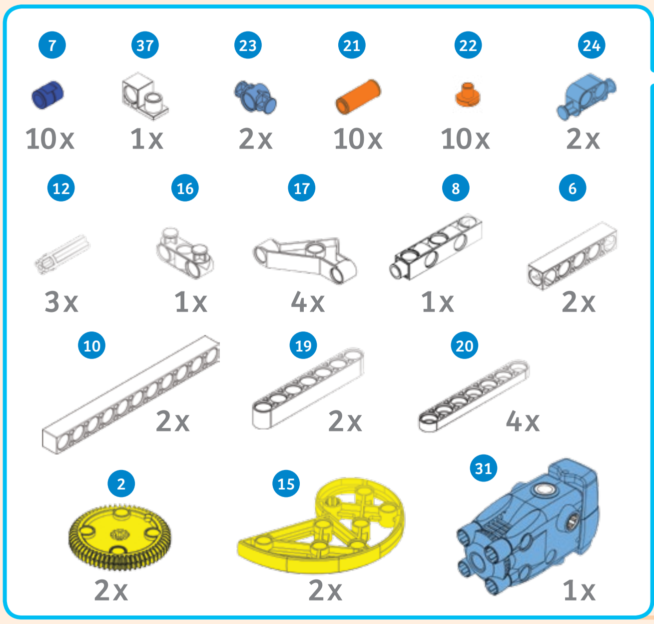
When talking about energy, you have to distinguish between two very important kinds: potential energy and kinetic energy.

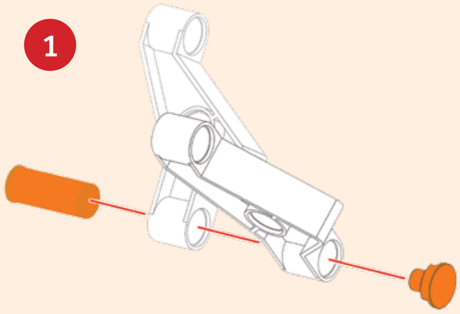
A hydroelectric power plant offers an example from everyday life. The stored water is held at a higher level by the dam. That gives it a lot of stored, or potential, energy. You can convert this into kinetic energy (literally, "movement" energy) by opening a sluice or lock, letting the water rush into the valley below. This rushing water is in turn used to drive a turbine, which then produces electricity.

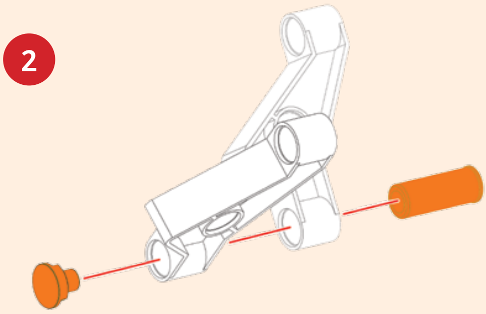
LET'S GO

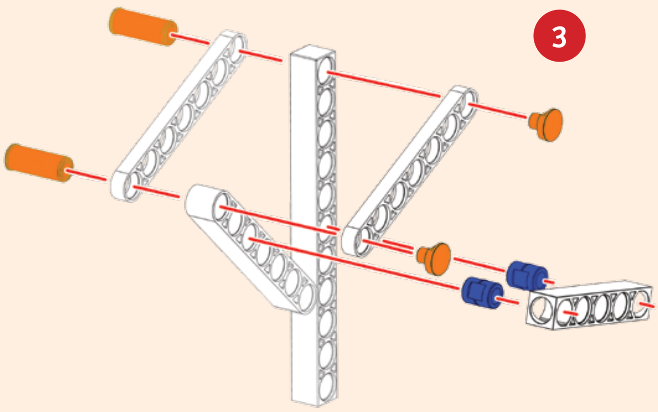
Stage a little competition with a friend: Who can make the jumperbot jump the farthest? Can you get it to leap over small barriers, or maybe over extra pieces from the experiment kit?

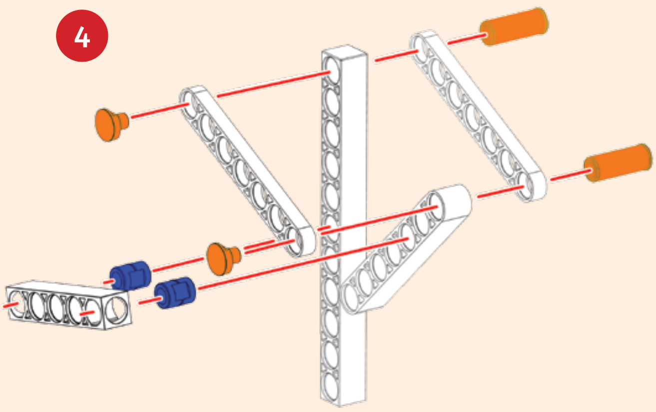
ALL-TERRAIN BOT

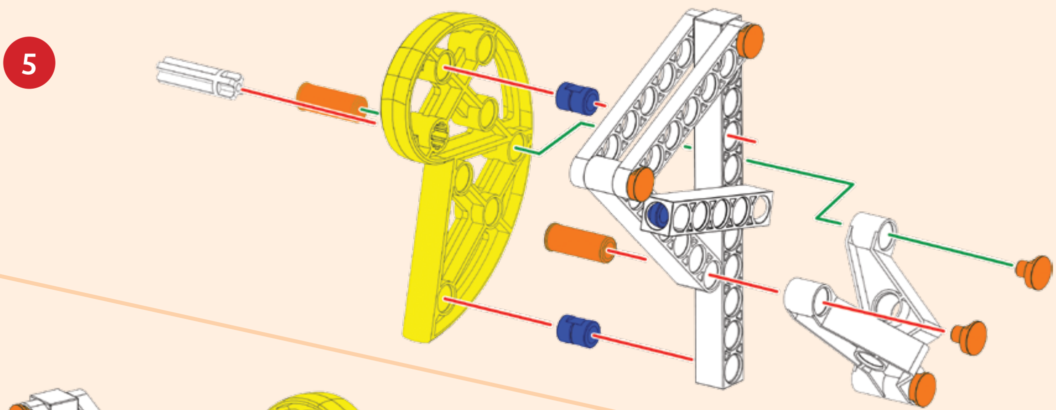


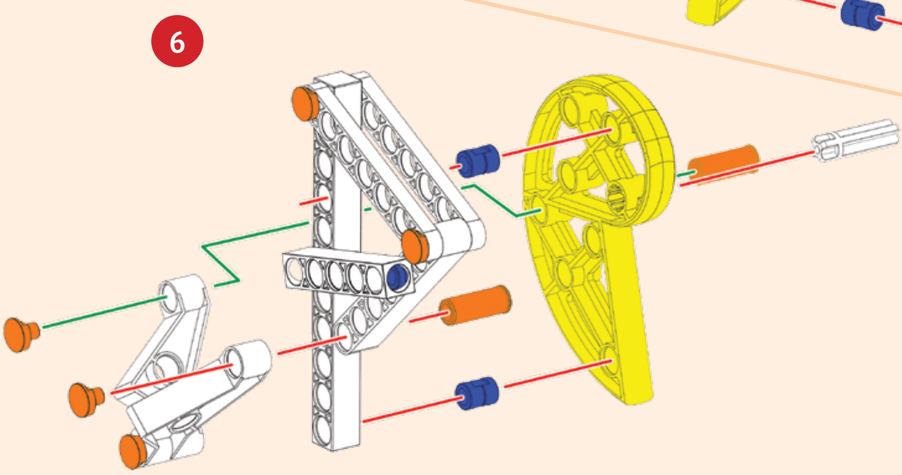




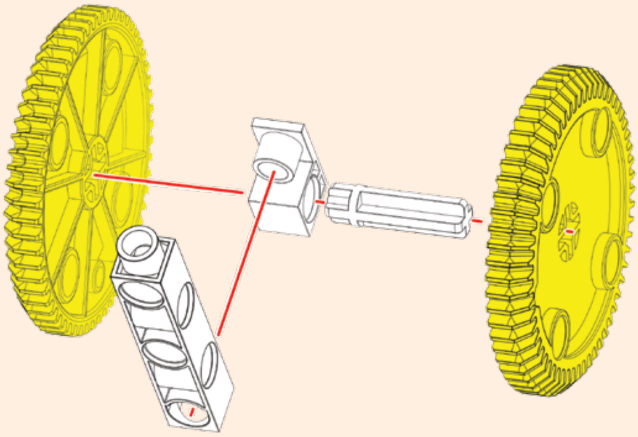




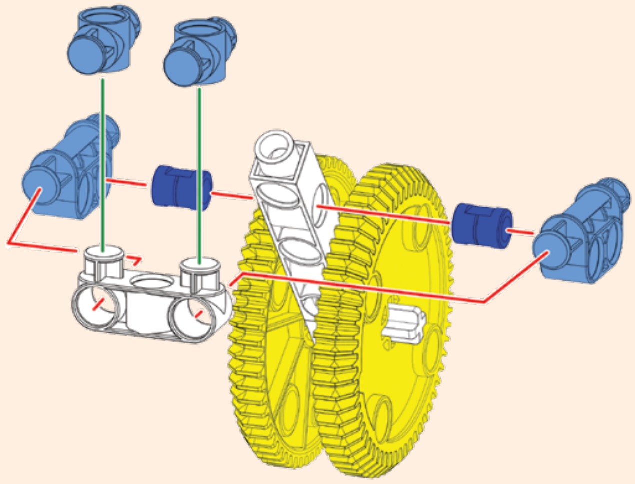




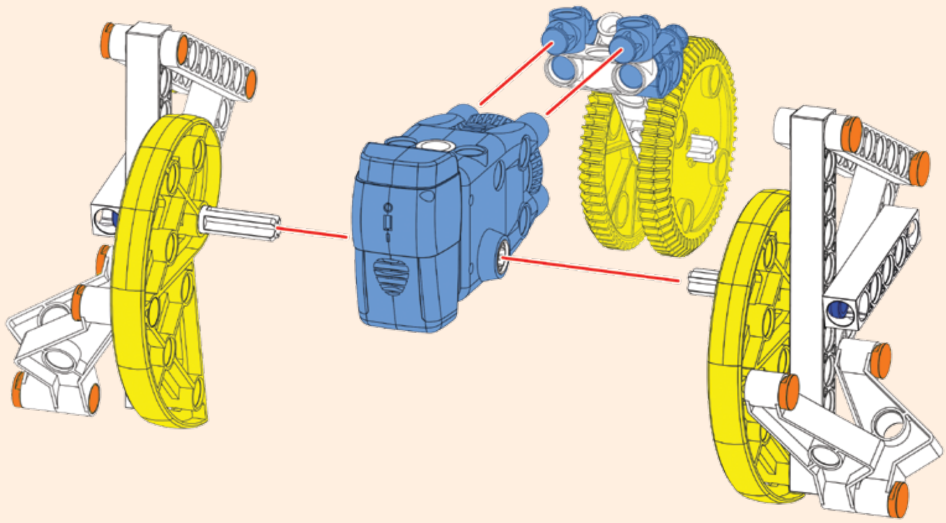
7



8

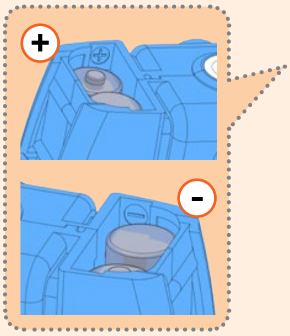


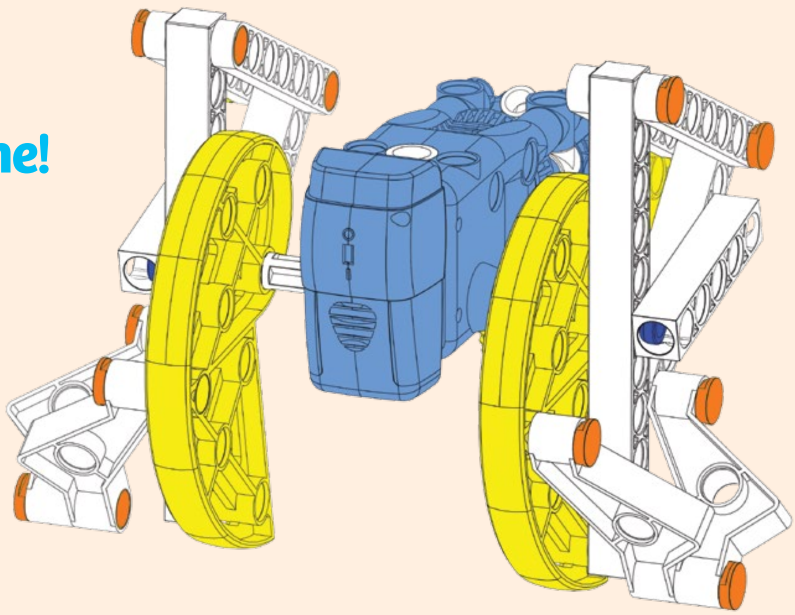
9



10

Done!





EXPERIMENT 2

Climbing over obstacles with the all-terrain bot

YOU WILL NEED

- **The assembled all-terrain bot**
- *Small screwdriver*
- *Two AAA batteries or two AAA rechargeable batteries*
- *Various thick paperback books or wooden blocks*

HERE'S HOW

1. Open the battery compartment of the motor by unscrewing the little screw. Insert two AAA batteries oriented according to the polarity indicator markings. Replace the cover and tighten the screw.
2. Start the first test run with your all-terrain bot by turning on the switch.
3. Did everything go smoothly? If so, it's time for some real climbing tasks. Place larger and larger obstacles in your all-terrain bot's path, such as various sizes of paperback books or wooden building blocks.
4. How tall is the tallest "mountain" that your climbing robot can scale?

TIP!
Be careful not to give your climbing robot too smooth a surface to move across. If the ground is too smooth, it will slip.

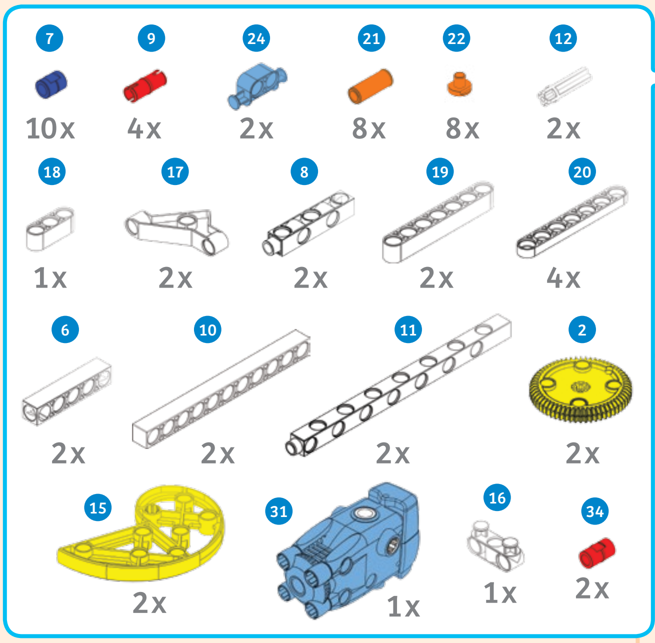
WHAT'S HAPPENING?

Your climbing robot doesn't have any front wheels. They would just slip and spin against obstacles, and it wouldn't be able to get over them very easily. Instead, it would be better to have giant tires like a monster truck. Or, instead of wheels, the robot could have caterpillar treads. Tires or treads like that work by the same principle as the corners and edges of our snail cam wheels: They don't slip so easily, and can overcome corners or edges by hooking themselves onto the obstacles.

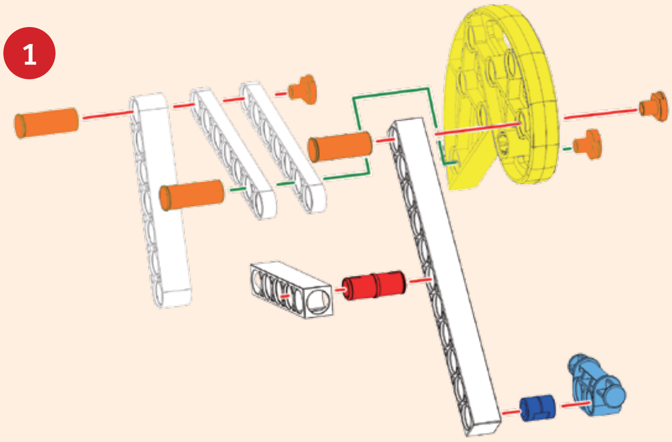
KEYWORD: FRICTION

If you want to skate on ice, you don't want any friction — just the opposite. Friction inhibits forward movement, so it just gets in the way. But sometimes you want friction. If the ground is too slick, for example, car tires can slip or spin because they can't get a grip. So then you need a little friction — or, more precisely, static friction, or "stiction." Every climbing robot needs it. So for a climbing robot, a rough surface is better than a smooth one.

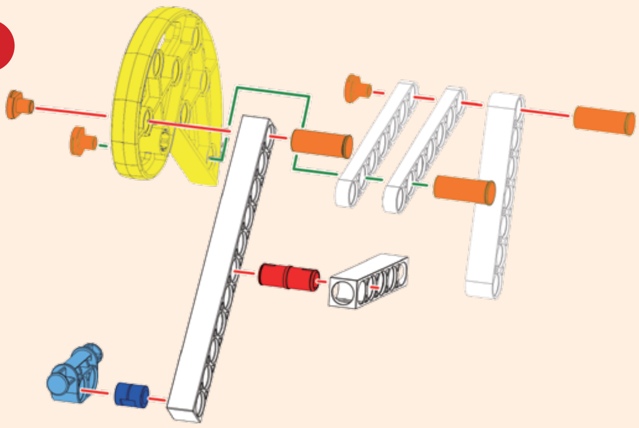
CRAB CRAWLER



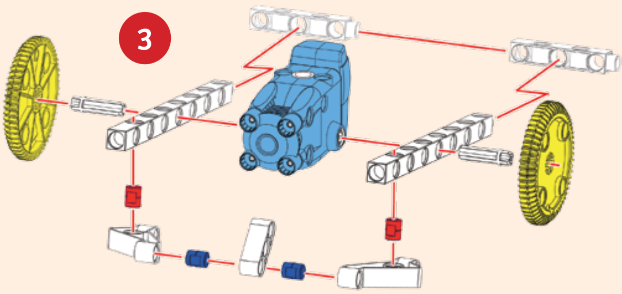
1



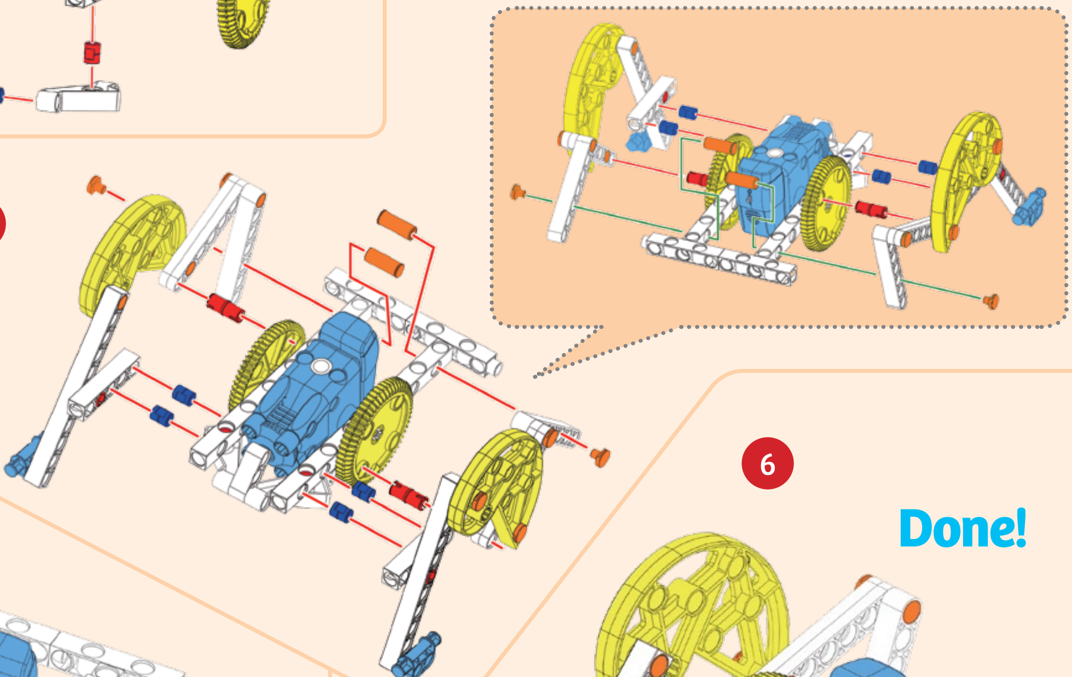
2



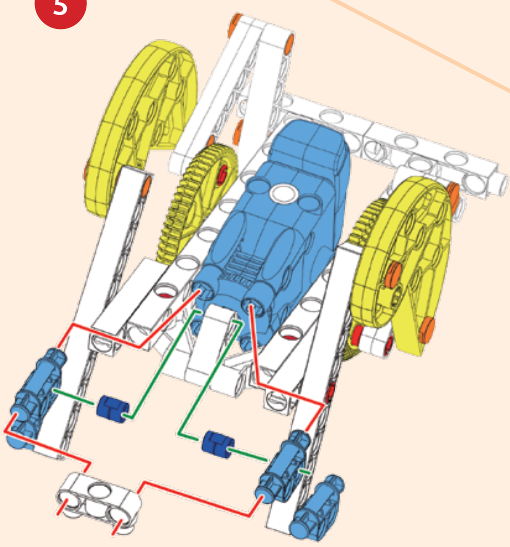
3

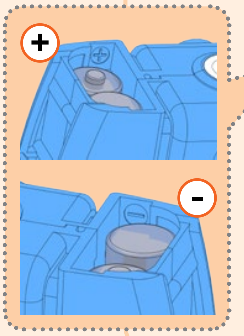


4



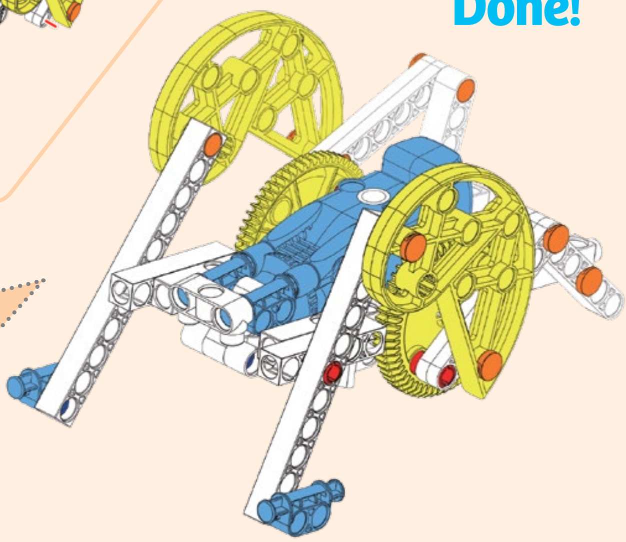
5



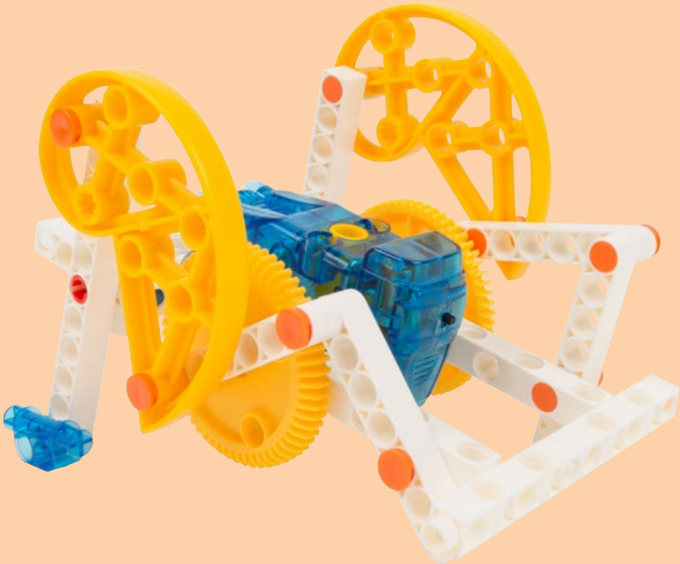


6

Done!



EXPERIMENT 3



Scuttling with the crab crawler

YOU WILL NEED

- **The assembled crab crawler**
- *Small screwdriver*
- *Two AAA batteries or two AAA rechargeable batteries*
- *Bookshelf board or similar*
- *Handkerchief*
- *A few books*
- *3 rubber bands*
- *Tape measure or ruler*
- *Pocket calculator*

HERE'S HOW

1. Open the battery compartment of the motor by unscrewing the little screw. Insert two AAA batteries oriented according to the polarity indicator markings. Replace the cover and tighten the screw.
2. And now for the real challenge: Use a board with a length of about 80 or 100 cm to make an inclined ramp in front of your crab. Use a book to raise up one end of the board for the uphill end of the ramp.
3. See if your crab can crawl up the ramp. What is the steepest slant that it can handle? Try adjusting the steepness by using different numbers or thicknesses of books.
4. You can try using something like a handkerchief to give your crab a better grip. Wind it around the board and secure it in place with rubber bands. That way, it will be nice and tight and won't slip.
5. Set the model on a table or on the ground. How does it move?

WHAT'S HAPPENING?

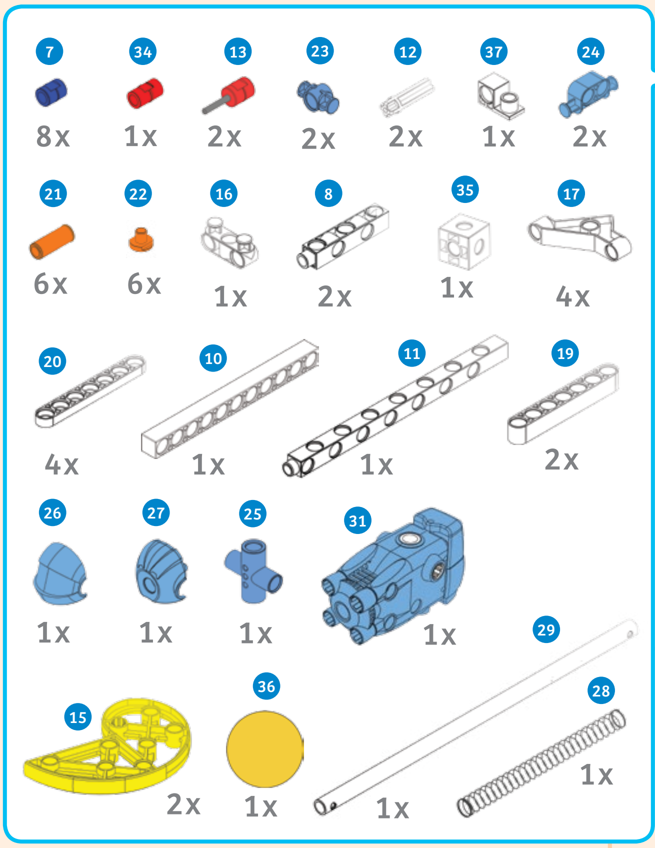
The crab's wobbling movement is made possible by the use of an eccentric mechanism. This is a control disk mounted on a shaft in such a way that its center point lies outside the shaft's axis. In the case of the crab, the shafts are the two motor axles and the control disks are the yellow gears. The snail cams, which also work by an eccentric principle, then convey the movement to the crab's "feet."

DID YOU KNOW?

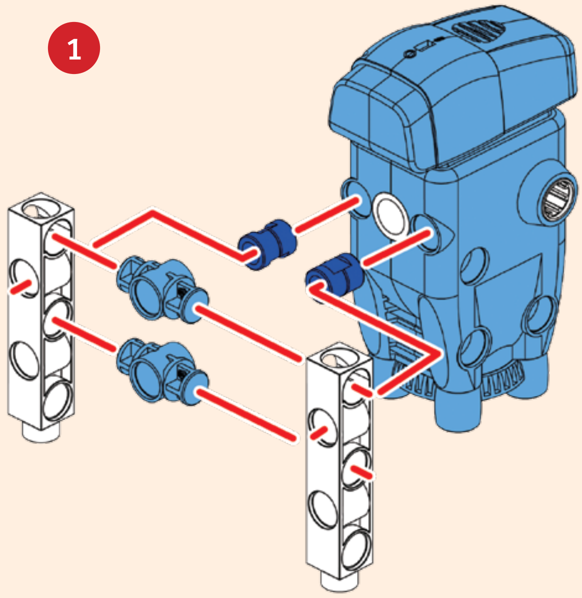
The degree of inclination of a ramp is also something that comes up in traffic signs. A sign indicating slope of 10%, for example, means that a stretch of road 100 meters in length will rise by 10 meters. So you divide 100 meters by 10 meters, to get 0.10 or (as a percentage) 10%.

So if you use a board 80 cm in length and raise it by 7 cm at one end, you have a slope of 8.75% (7:80 = 0.0875). Try climbing that kind of grade on your bike. Whew, pretty steep!

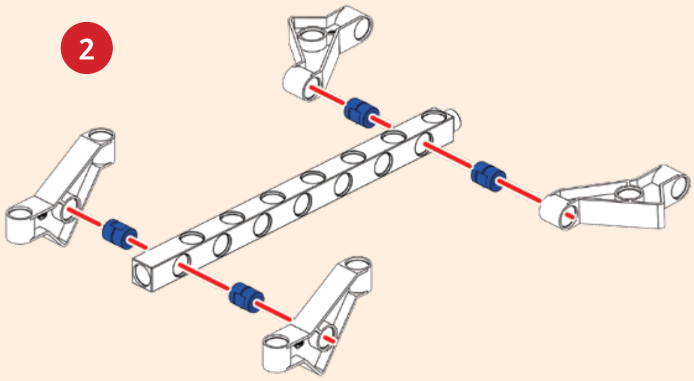
KICKING BOT



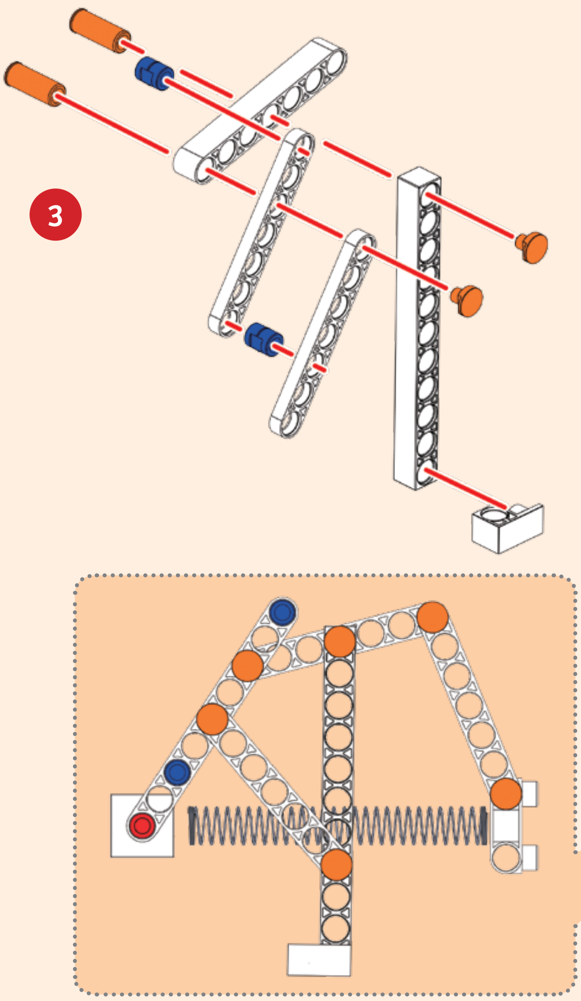
1



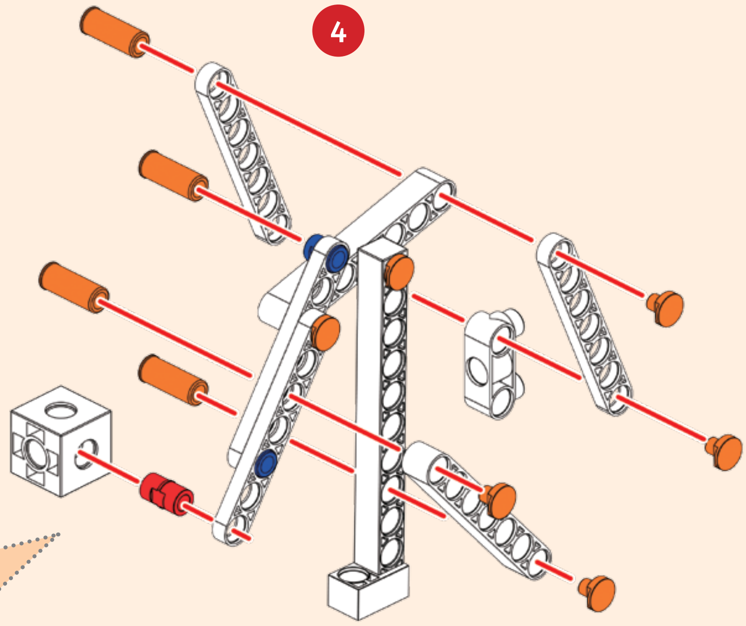
2



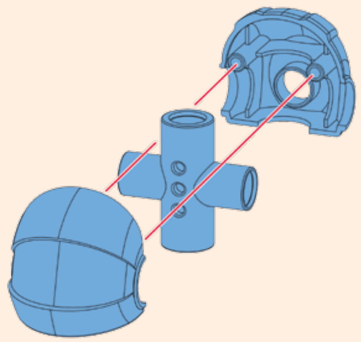
3



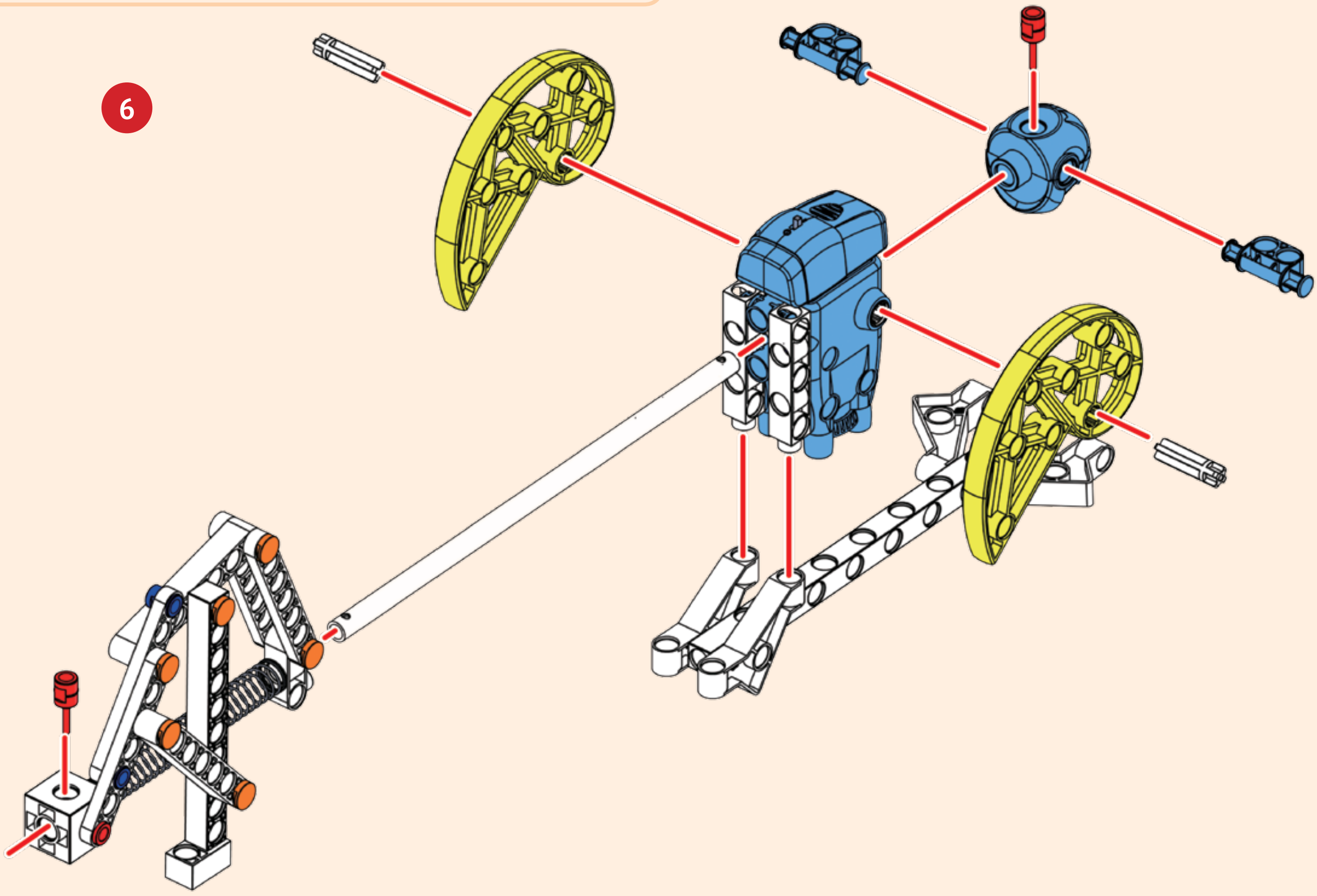
4



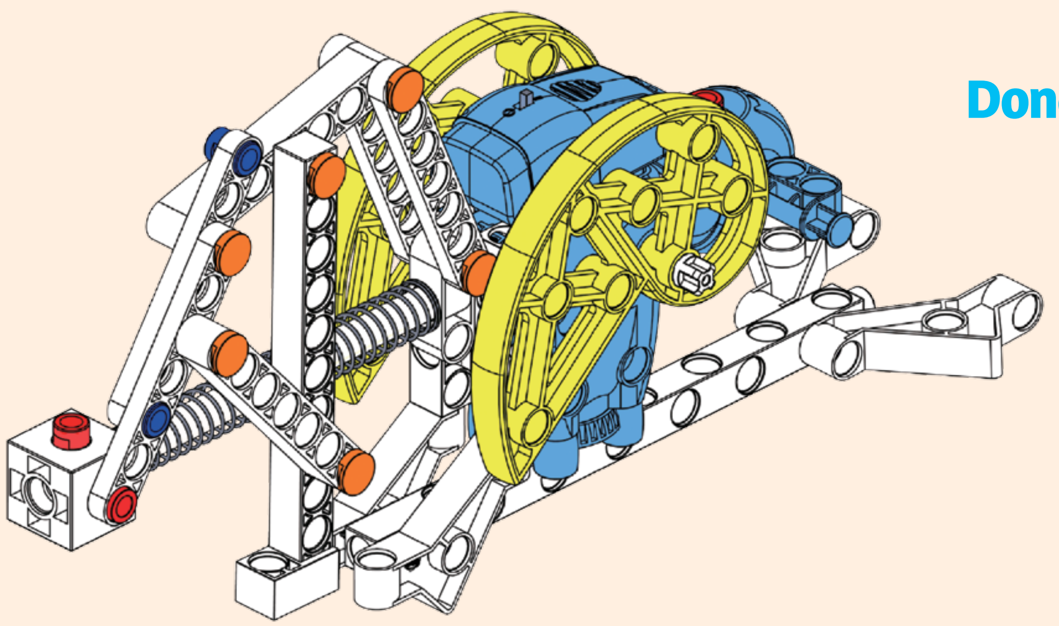
5



6



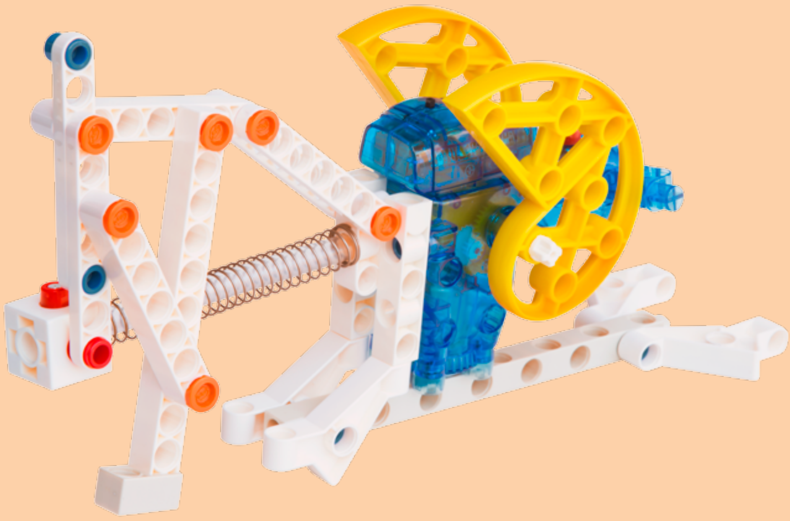
7



Done!

EXPERIMENT 4

A kicking machine



YOU WILL NEED

› **The assembled kicking bot**
› *Small screwdriver*
› *Two AAA batteries or two AAA rechargeable batteries*
› *Ping pong ball (table tennis ball)*
› *Measuring tape*
› *Paper tissue*

HERE'S HOW

1. Open the battery compartment of the motor by unscrewing the little screw. Insert two AAA batteries oriented according to the polarity indicator markings. Replace the cover and tighten the screw.
2. Perform a test run with your kicking soccer player. Place a ball in front of his "foot" (the shorter portion of the leg) and kick the ball away by switching on the robot.
3. Also try experimenting with other kinds of balls. How far will balls of different weights and sizes roll? Or try organizing a competition: Which one of you and your friends can manage the farthest kick?

TIP!
Experiment with different surfaces for the ball, such as a folded paper tissue, to help it sit properly in place before you kick it.

WHAT'S HAPPENING?

Your soccer player's kick is called momentum transfer in physics. You can easily picture momentum if you think of the impact of a boxer's glove against a punching bag. Momentum describes the movement of an object, both with respect to its strength and its direction.

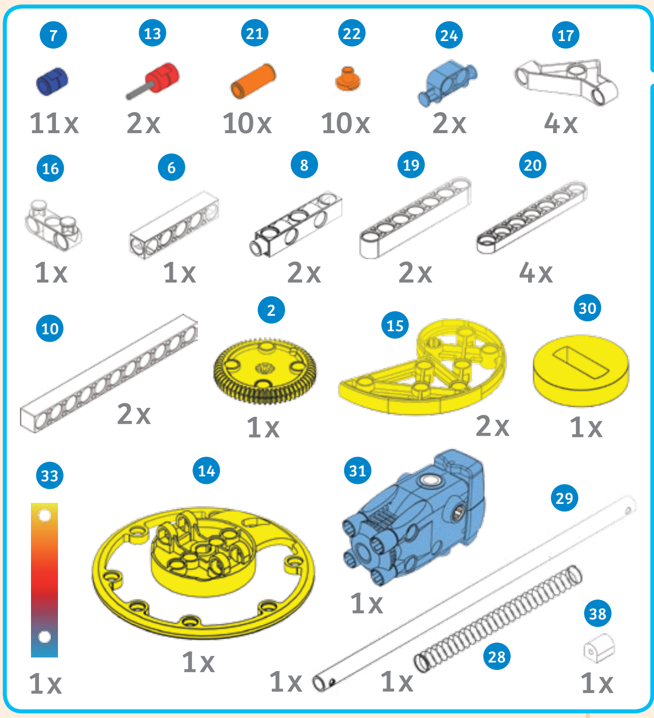
Any movable object is capable of transferring its momentum, either partially or completely, to other objects, or of receiving the momentum of other objects. In your experiment, the transfer of momentum occurs between your robot's foot and the ball.

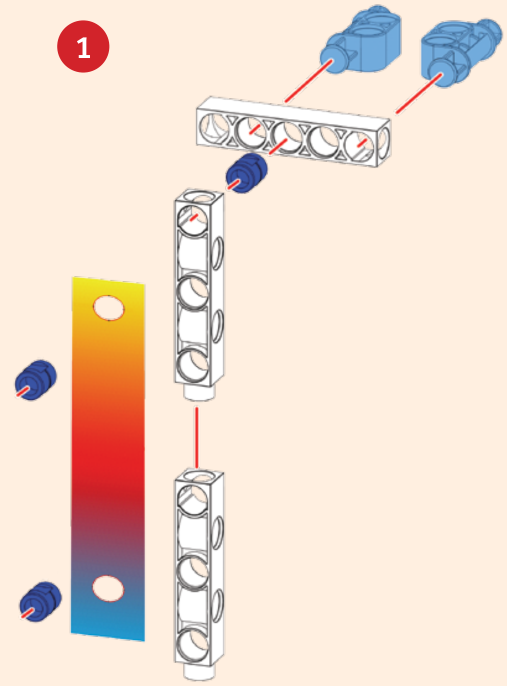
KEYWORD: ELASTICITY

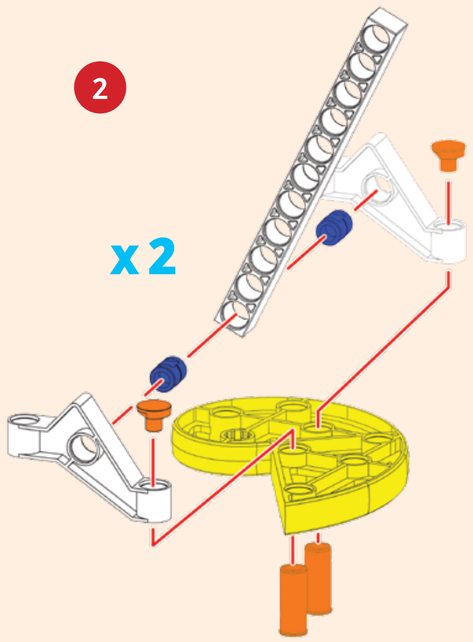
Elasticity refers to the property of an object that lets it change its shape when a force is applied to it and revert to its original shape when the applied force is removed. The best example of that is a spring.

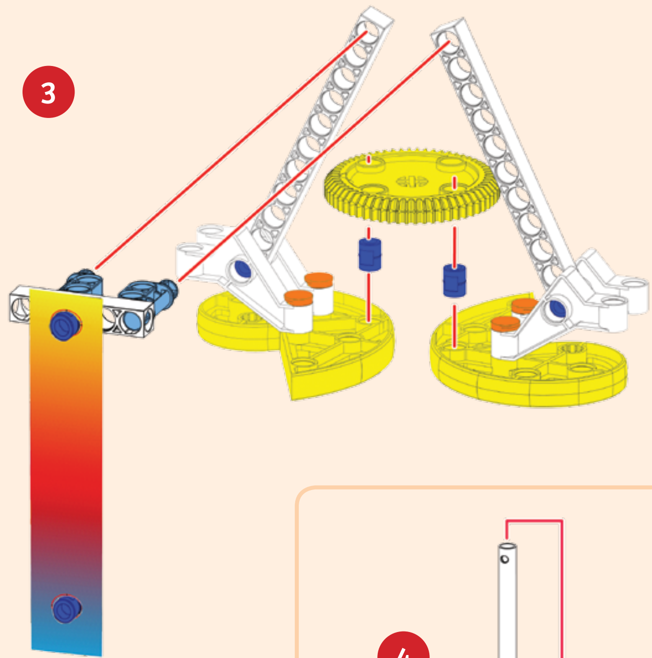
For any material, there is a limit to its range of elasticity, called its elastic limit. That means that if you overstretch a spring, it will lose all its tension. So handle it carefully!

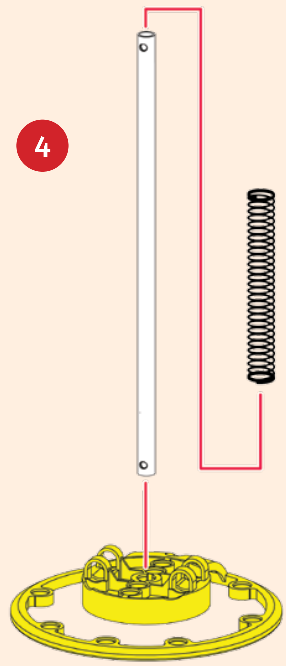
WEIGHING SCALE

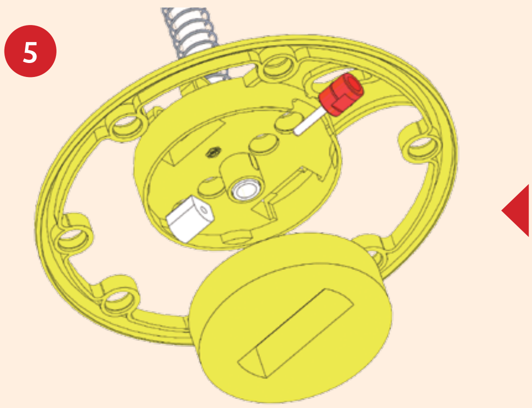




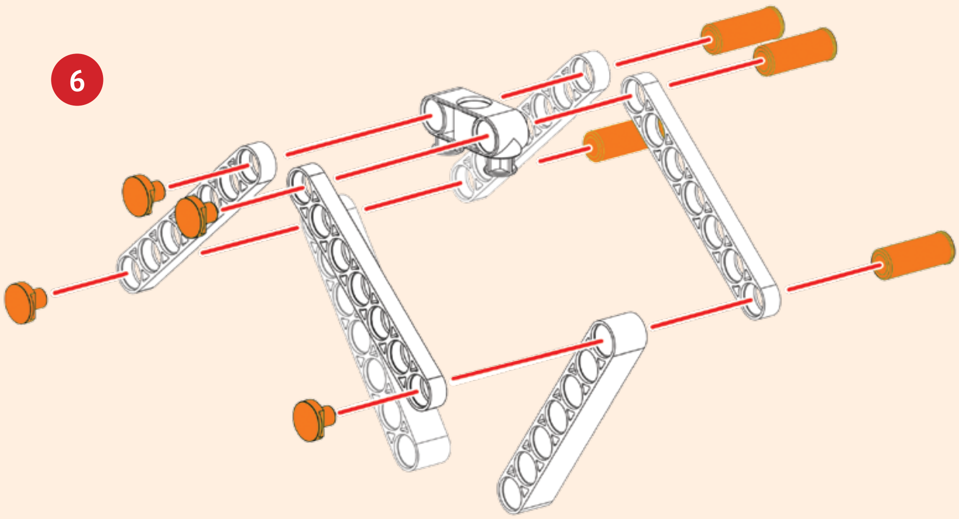




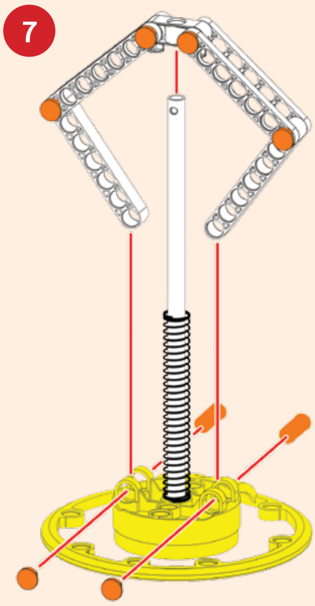




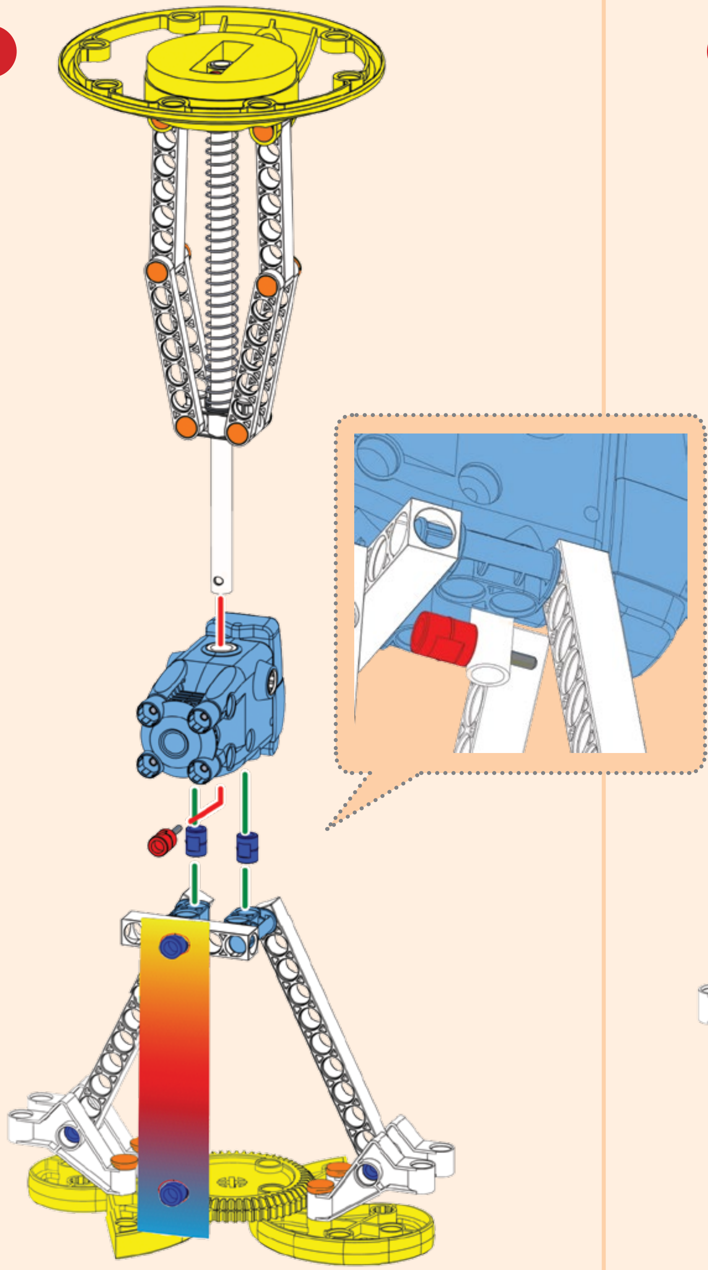
6



7

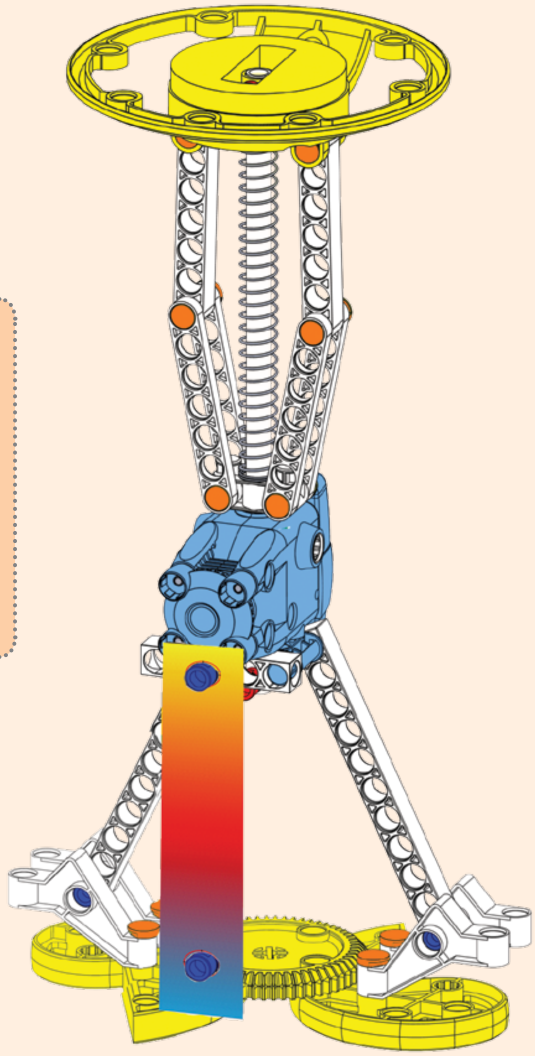


8



9

Done!



EXPERIMENT 5

Weighing with the scale

YOU WILL NEED

- **The assembled scale**
- *Pen and note pad*
- *Reference weights such as unopened food packages of powdered sugar, noodles, etc., weighing 125, 250, and 500 grams, or a kitchen scale*
- *Objects for weighing, such as paperbacks, batteries, etc. (they have to weigh between 200 and 800 grams)*
- *Pocket calculator*

HERE'S HOW

1. First, you will have to calibrate your scale — in other words, write gram amounts onto it.

2. To do that, you should find five objects having weights you already know. They should weigh between 200 and 800 grams. You have two options:

   • Ideally, use reference weights such as unopened packages of foodstuffs. Any package will have the weight of its contents written on it. Use packages weighing 125, 250 and 500 g. You can combine them into additional weights such as 375, 675 or 750 g.

   • If you happen to have a kitchen scale available, of course, you can use it to weigh objects and use the readings to calibrate your own scale. Just write down the weights of the objects as you weigh them.

3. Now, place one object after the other on your scale. The red anchor pin will move downward. Where it stops, use the pen to make a mark on the scale and enter the known weight total.

4. Then you can use your scale to determine the weights of other objects as well. Your scale markings will show you how heavy they are.

WHAT'S HAPPENING?

With a linear spring, the increase in the force needed to compress it together is constant, so your scale will be as well. That means that it is easy to divide the measuring points into finer increments by pure calculation. So, for example, if 250 g corresponds to 2.2 cm, you can easily calculate how many cm 300 g corresponds to. First, you have to figure out how many grams 1 cm corresponds to. To do that, divide 250 g by 2.2 cm: 250 / 2.2 = 113.64. So 1 cm on your scale corresponds to about 114 g. The mark for 300 g has to be at about 300 / 114 = 2.63 cm. Of course, that is only valid up to the elastic limit between 200 and 800 grams (see page 14).

DID YOU KNOW?

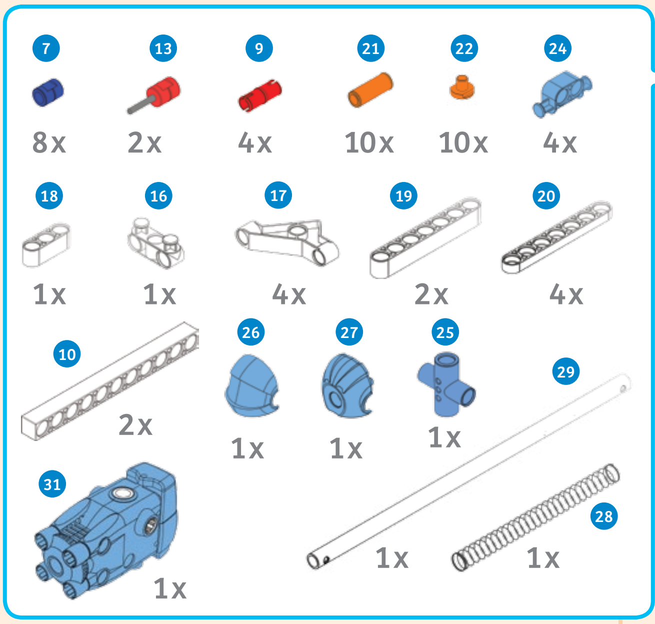
In everyday usage, people often talk about the weight of an object without specifying whether they really mean weight or mass. But it's important to distinguish the two. The mass of an object is always the same wherever it happens to be at that moment, whereas its weight depends on the force of gravity.

So, for example, an object having a mass of 100 kg will retain this same mass on Earth, in a weightless environment, on the Moon, or anywhere else. With weight, it's a different story: In a weightless environment, you won't feel any weight at all. On the Moon, its weight will be a lot less than on the Earth (about one sixth). The weight of an object on the Moon with a mass of 100 kg is therefore just one sixth — 16 kg — of its weight on Earth.

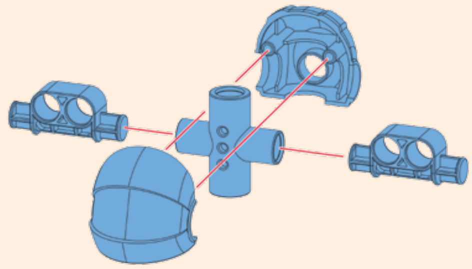
NOTE: G VS. OZ!

This experiment uses grams as the unit of measure instead of ounces. Food packages in the US are required to have quantities listed in both metric (grams, kilograms, milliliters, liters) and U.S. Customary System (ounces, pounds, fluid ounces) units. In science, metric is always used.

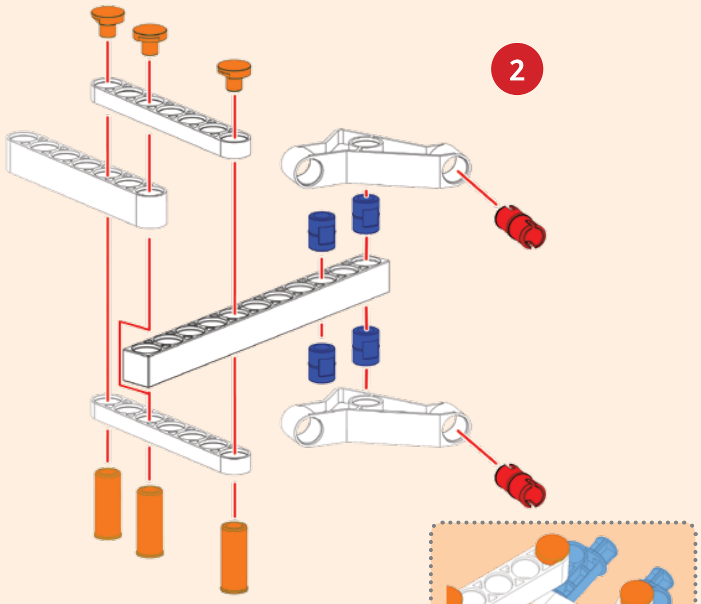
GRAPPLE CLAW



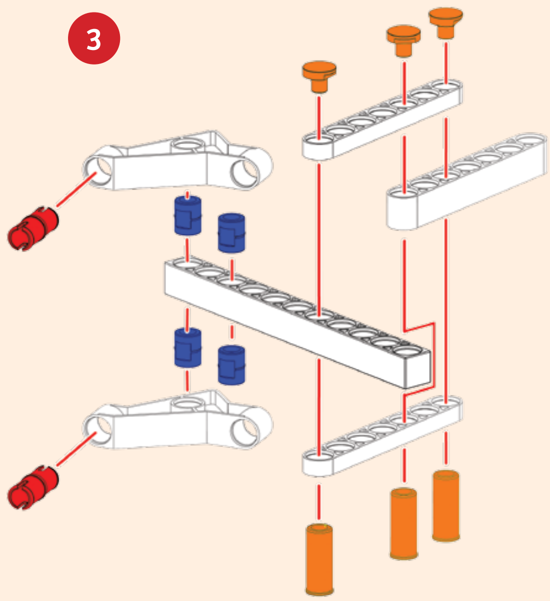
1



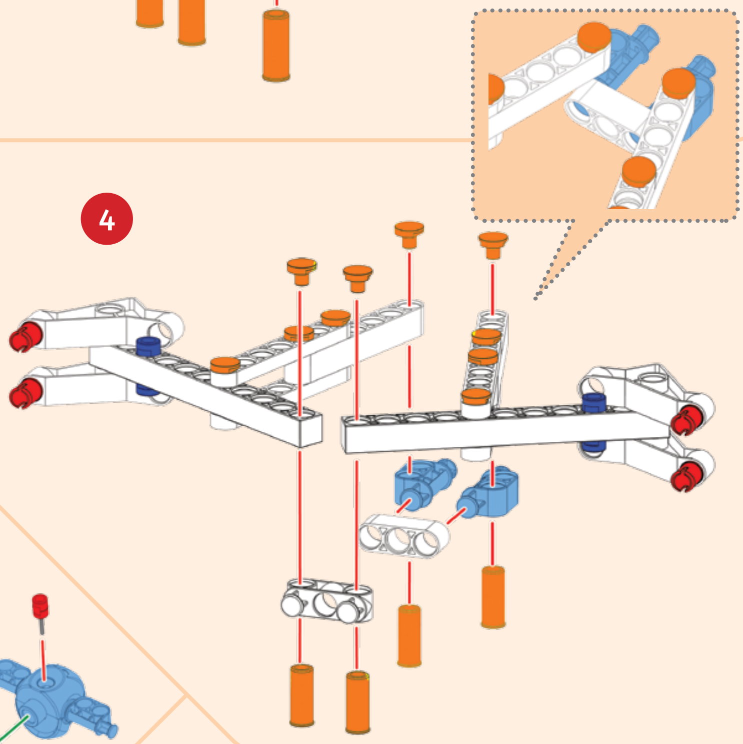
2



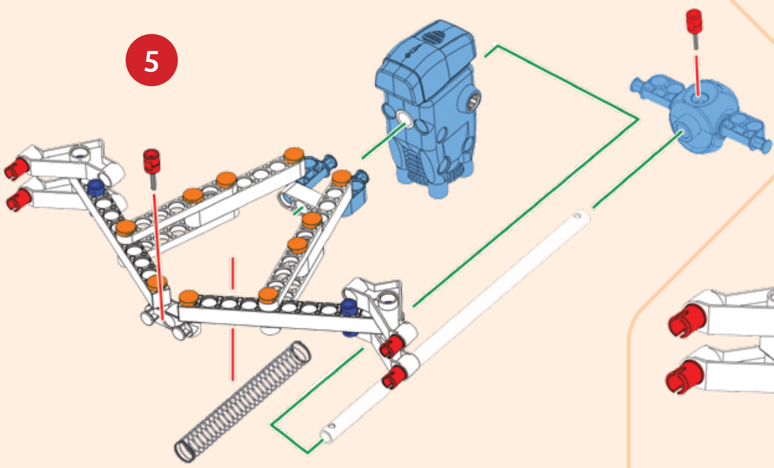
3



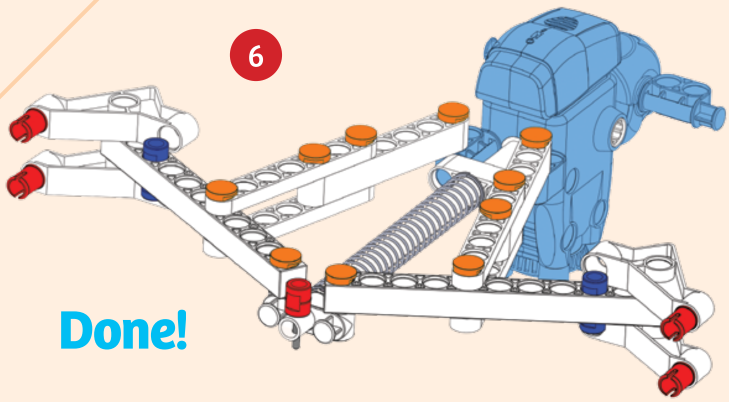
4



5

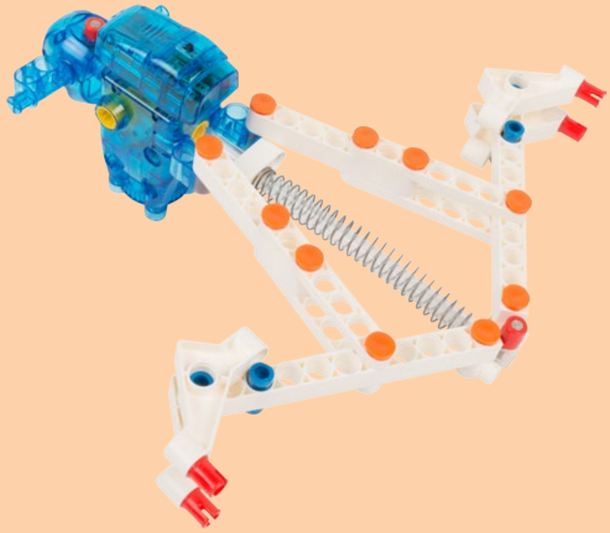


6



Done!

EXPERIMENT 6



Testing the grapple claw

YOU WILL NEED

- **The assembled grapple claw**
- *Various objects for gripping*
- *Building blocks*
- *Paper cup*
- *Water*
- *Stopwatch*

HERE'S HOW

1. Use the grapple claw to try to grab various objects, lift them into the air, and set them down gently again. To do that, hold the motor housing in one hand and the controller (the "head") in the other.
2. How heavy is the heaviest object that you can grab with it?
3. Now let's raise the level of difficulty. Use the grapple claw to build a tower of blocks. Set each block onto the ones beneath — as high as you can go.
4. You can also make a contest out of it. Take turns with one or more opponents placing the blocks on the tower. The loser is the one whose last block makes the tower collapse.

LET'S GO

How about a gripping race with friends? Try using the grapple claw to carry a full paper cup of water a certain distance in as short a time as possible. The winner is the one who spills the least amount of water and covers the distance in the shortest time. Measure the time with the stopwatch.

This competition is best performed outside. That way, it won't matter if anything spills.

WHAT'S HAPPENING?

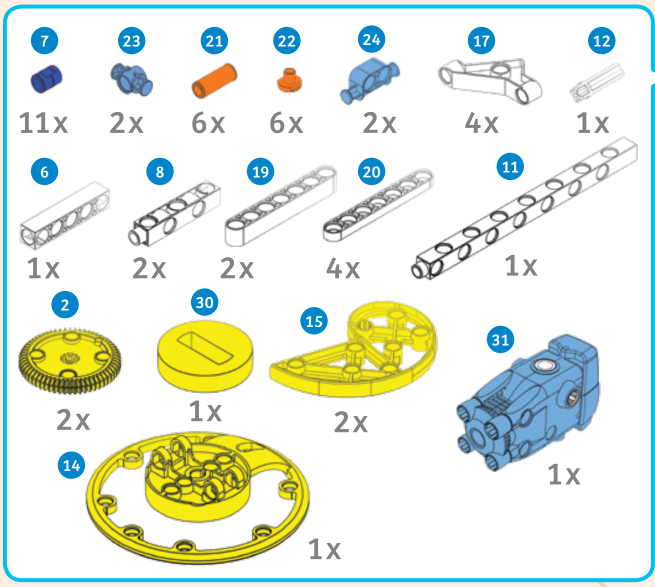
The grapple claw gives you a clear idea of the kinds of things that robots have to do. For them, this kind of arm is an essential working organ. It creates the connection between the robot and other objects when performing actions such as soldering, screwing, gluing, drilling, tying, or painting, for example. Those actions require just the right touch and sure control of many components in the proper sequence. You probably noticed that when building the tower.

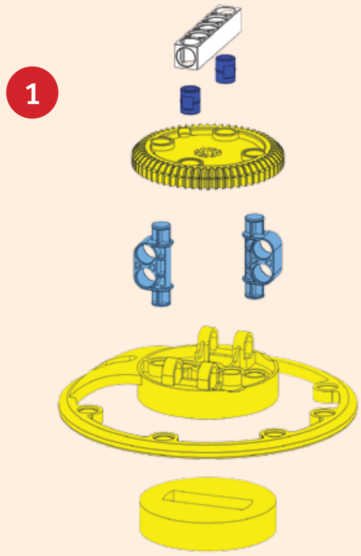
Since the human hand is useful for all sorts of things, it often serves as a model for robot grapple claws and robotic hands.

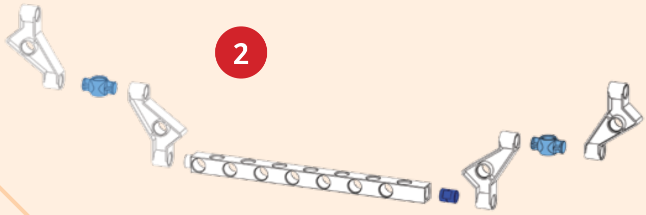
DID YOU KNOW?

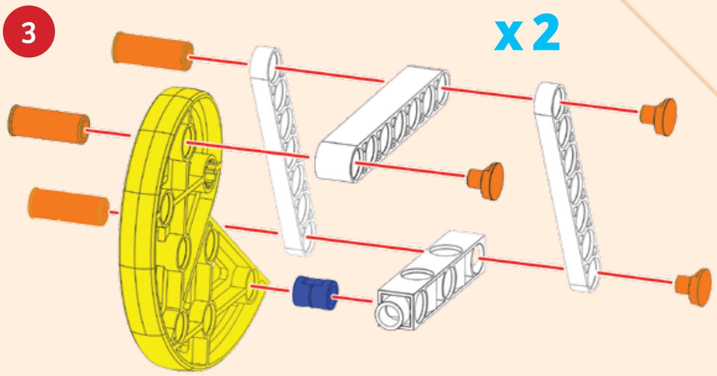
As early as 1676, the British physicist Robert Hooke discovered the principle behind spring technology: The force needed to extend or compress a spring is proportional to its length (see page 18). In his honor, this is known today as Hooke's Law.

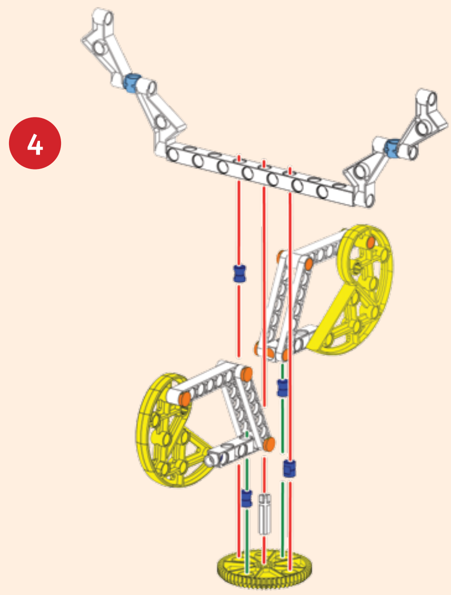
CAROUSEL

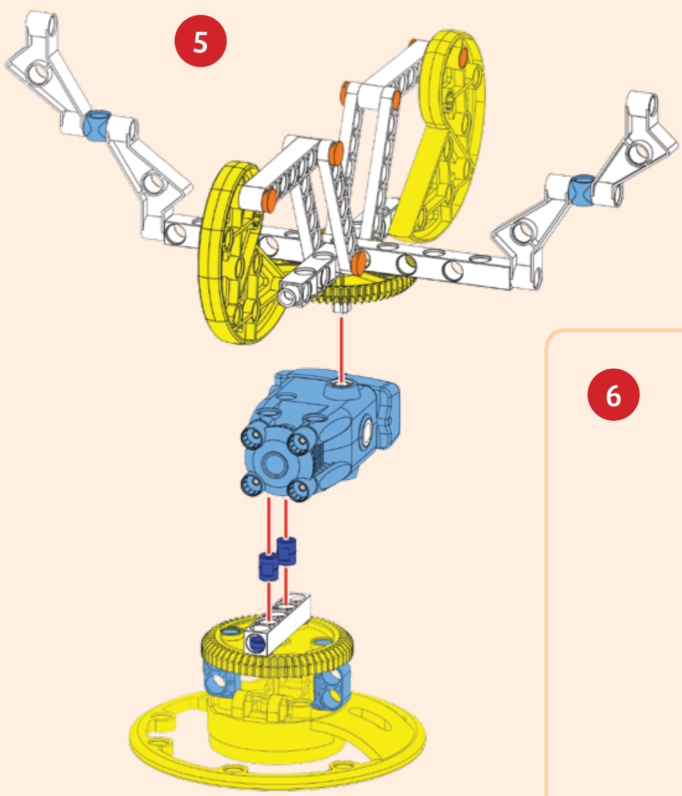

7 11x
23 2x
21 6x
22 6x
24 2x
17 4x
12 1x
6 1x
8 2x
19 2x
20 4x
11 1x
2 2x
30 1x
15 2x
31 1x
14 1x

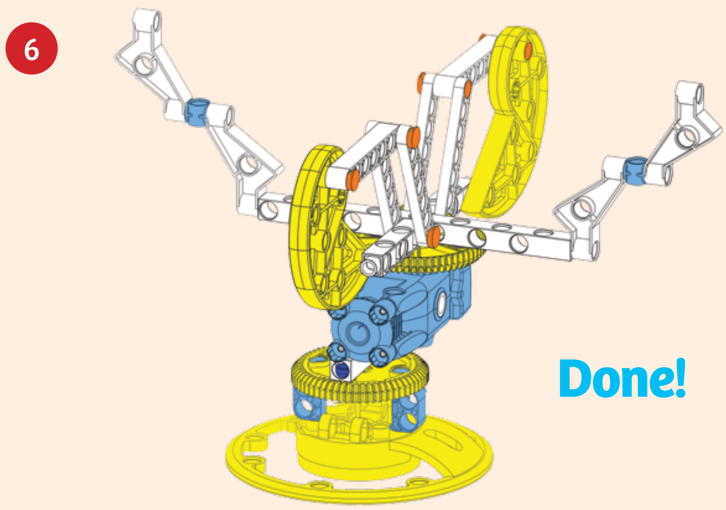

1


2


3
x2


4


5


6
Done!

EXPERIMENT 7

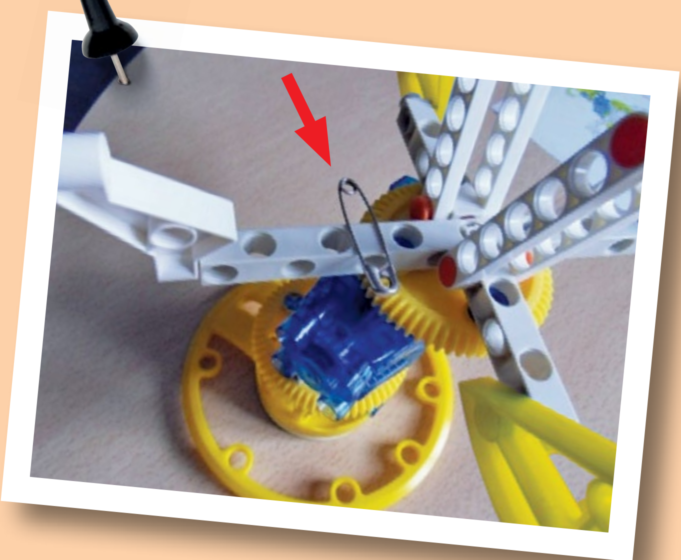
The forces of spinning

YOU WILL NEED

- **The assembled carousel**
- *Small screwdriver*
- *Two AAA batteries or two AAA rechargeable batteries*
- *Safety pin*

HERE'S HOW

1. Open the battery compartment of the motor by unscrewing the little screw. Insert two AAA batteries oriented according to the polarity indicator markings. Replace the cover and tighten the screw.
2. Place the closed safety pin on one of the carousel's arms as close to the center of the carousel as possible. What happens when you start the motor?
3. Shut off the motor and move the safety pin a little closer to the outside. Start the motor again. What happens now?



WHAT'S HAPPENING ?

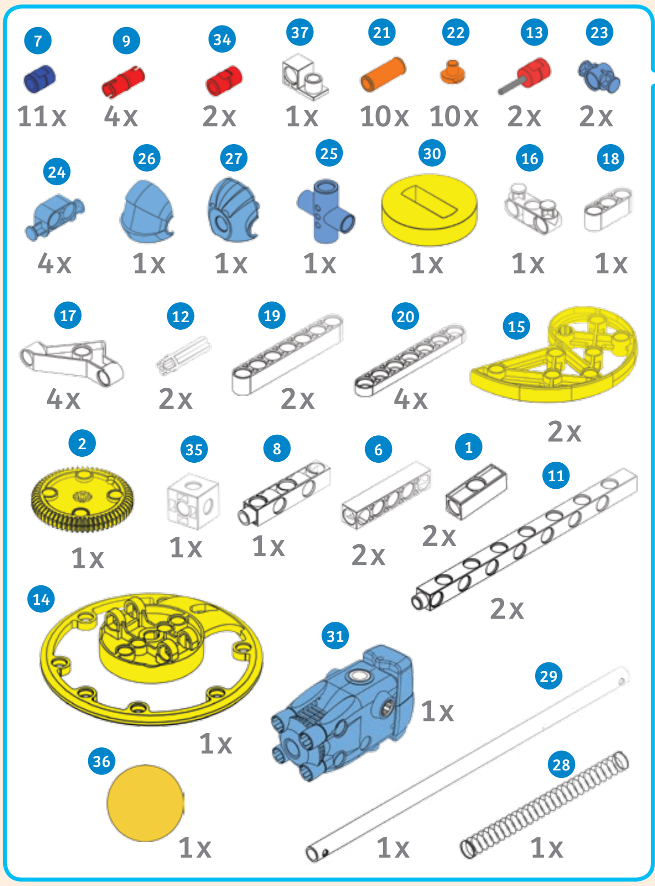
If an object is rotated around an axis, it is acted upon by centrifugal force. This force is directed outward and causes the object to "fly away" from the axis. This has real-life applications, such as in carousels with seats that fly outward as the carousel spins. The same phenomenon is used in washing machines. In their case, the wet clothes are spun so rapidly in a drum with holes in it that they are pressed against its walls and water is pushed through the holes to the outside.

With your carousel, centrifugal force makes the safety pin fly away as soon as the spinning gets fast enough. Close to the axis, the centrifugal force is not strong enough to do that, but as you move the safety pin farther away from the center it is.

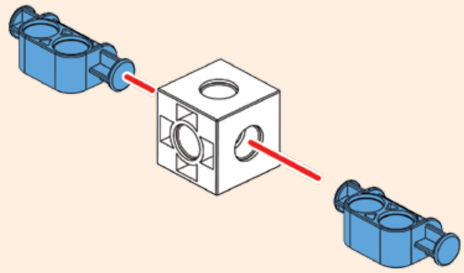
DID YOU KNOW ?

Take a closer look at the safety pin. It's a spring, too — more specifically, a torsion spring (see page 24).

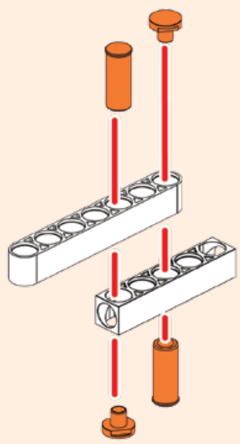
PITCHING MACHINE



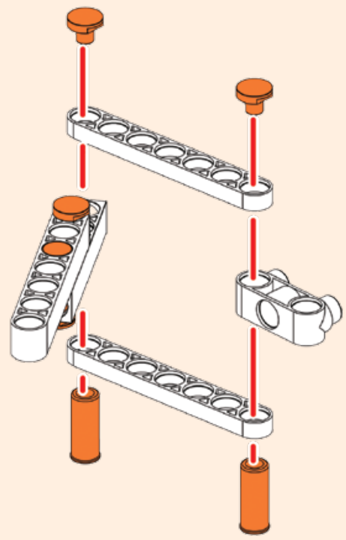
1



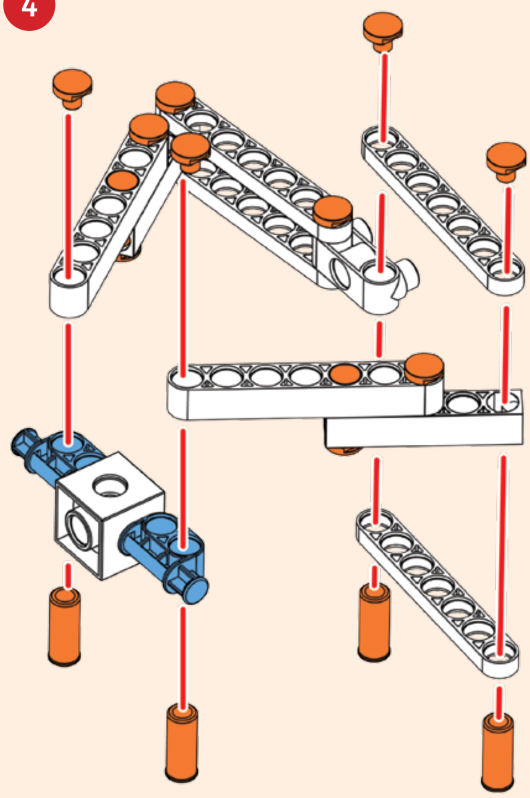
2 x2

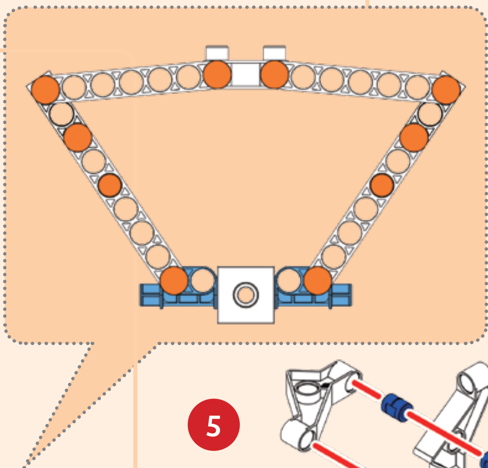


3

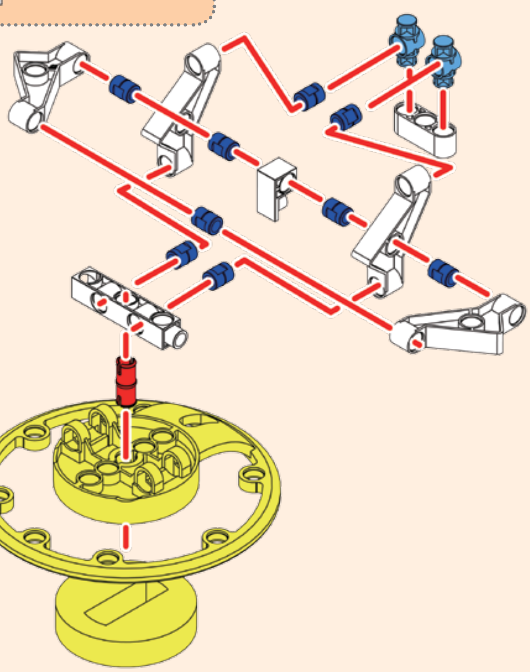


4

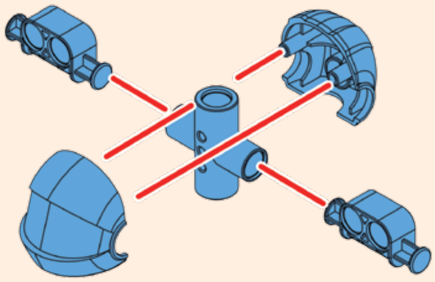




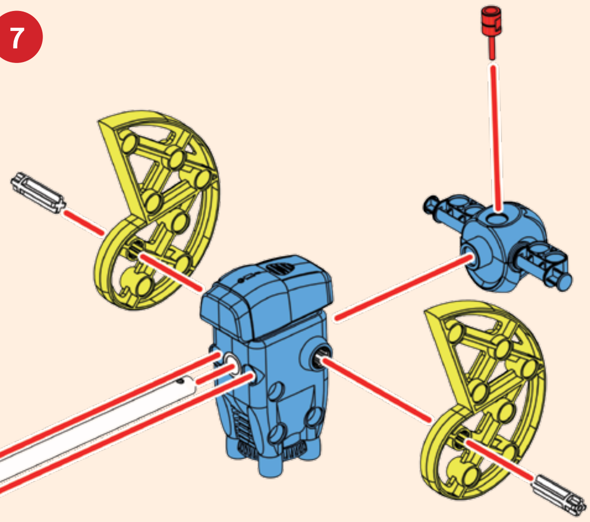
5

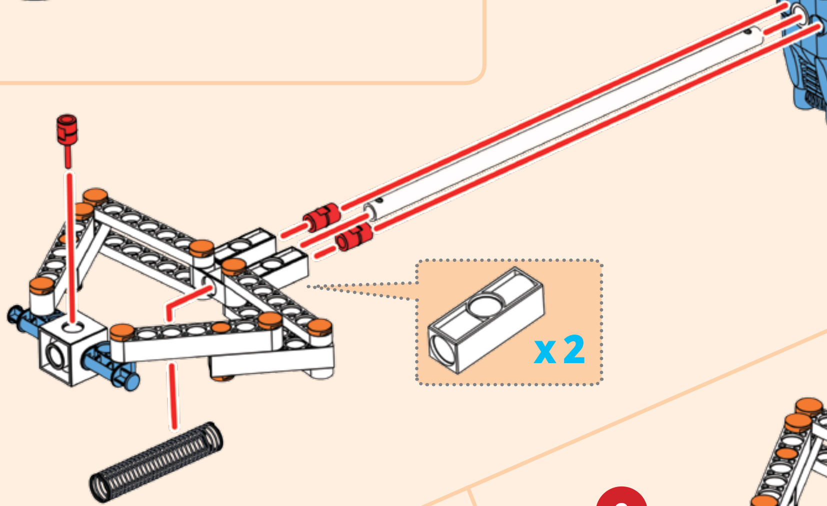


6

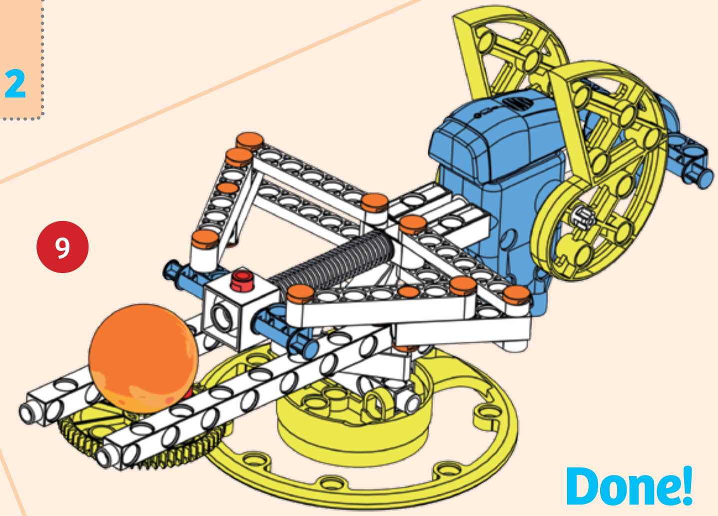


7



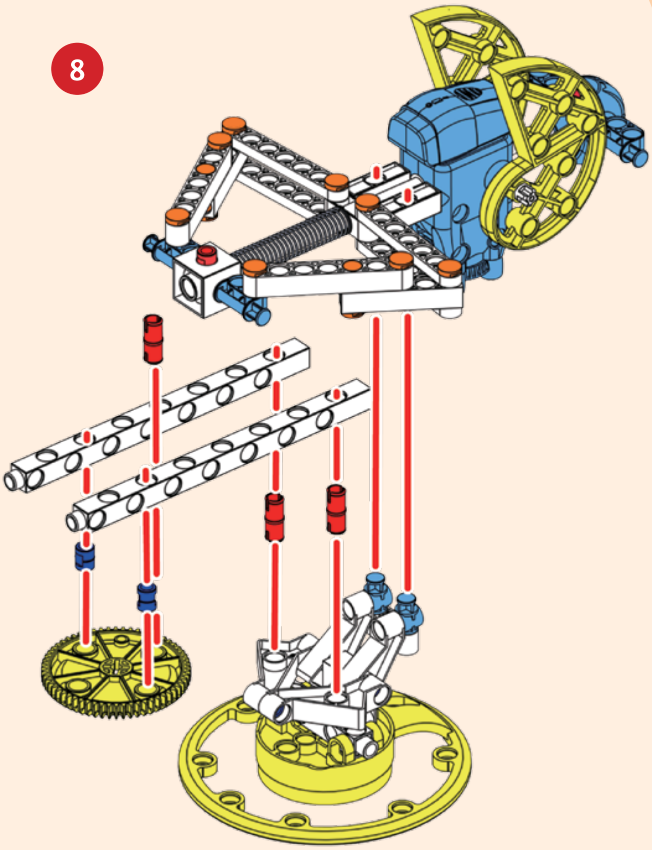


9



Done!

8



EXPERIMENT 8

Let's play ball!

YOU WILL NEED

› **The assembled pitching machine**
› *Small screwdriver*
› *Two AAA batteries or two AAA rechargeable batteries*

HERE'S HOW

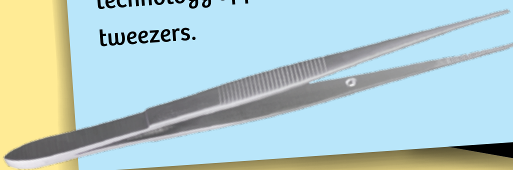
1. Insert the batteries.
2. Place the orange ball on the launch platform (the yellow gear).
3. Start the motor. The pitching machine will wind up, release, and hit the ball forward over and over again, as long as you keep replacing the ball!

CHECK IT OUT

Spring Technology in Everyday Life

Here are a few of the many different types of springs and how they are used.

Simple springs, such as bows for shooting arrows, were already being used by humans thousands of years ago. In the Bronze Age, around 2,200 to 800 BC, additional kinds of spring technology appeared, such as tweezers.



HELICAL SPRINGS

Indispensable for ballpoint pens and jumperbots

The best-known type of spring is the helical spring. You know it from your jumperbot, and it can also be found inside any ballpoint pen. Helical springs are also built into poles and walking sticks used for Nordic walking and hiking, in order to absorb the force of the body's weight and lighten the load on joints and muscles.

COIL SPRINGS

Sleep more comfortably and walk better

A special variant of the helical spring is the conical spring, which is wound in the shape of a cone. Conical springs are used in sofas and armchairs, and are also known as coil springs. Scientists have even come up with the idea of hiding them inside the soles of walking shoes. They are claimed to prevent injuries and ensure that the foot lifts better off the ground while walking. They are not allowed in the Olympics, however.

TORSION SPRINGS

At home everywhere

Torsion springs such as those in safety pins also belong to the general class of helical springs. In them, the spring wire ends in lever-like arms. Another example is a clothespin.

SPIRAL SPRINGS

Making mechanical watches tick right

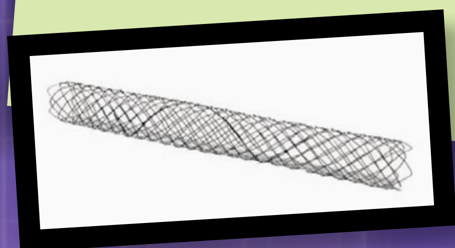
Spiral springs consist of a metal band wrapped in the shape of a spiral. They are used in wind-up toys, serving as a kind of mechanical energy store or clockwork motor. They have also been used for centuries to power mechanical watches.

THE FUTURE OF SPRING TECHNOLOGY

Ever smaller and lighter

There are record-breaking springs even today. And researchers are always pushing the boundaries of what can be achieved.

For example, there are springs used in medicine that are so small that they can be implanted directly in patients in order to widen their arteries. These springs often have to be no bigger than 0.03 mm!



PNEUMATIC SPRINGS

Engineering for demanding drivers

You can also use air to absorb shocks. Pneumatic (or "air") springs are often used in cars, for example. A compressor creates compressed air and the suspension is achieved by an air bellows. A complicated electronic system automatically adjusts the energy absorption to each wheel in accordance with actual needs. That creates an almost perfectly equal clearance under the chassis, even when the vehicle is loaded.

Kosmos Quality and Safety

More than one hundred years of expertise in publishing science experiment kits stand behind every product that bears the Kosmos name. Kosmos experiment kits are designed by an experienced team of specialists and tested with the utmost care during development and production. With regard to product safety, these experiment kits follow European and US safety standards, as well as our own refined proprietary safety guidelines. By working closely with our manufacturing partners and safety testing labs, we are able to control all stages of production. While the majority of our products are made in Germany, all of our products, regardless of origin, follow the same rigid quality standards.

Project management and German text: Stefanie Bernhart
Technical product development: Genius Toy Taiwan Co., Ltd., Dr. Petra Müller
Additional text, editing, and layout: Ted McGuire
Additional graphics and layout: Dan Freitas
Manual style guide: Atelier Bea Klenk, Berlin
Manual illustrations: Genius Toy Taiwan Co., Ltd.

Manual photos: askaja (all paper clips); Jamie Duplass (all tape strips); picsfive (all push pins); iStock p. 3 all, p. 6 bottom, p. 9 middle and bottom, p. 11 bottom, p. 14 middle and bottom, p. 17 bottom, p. 19 middle, p. 21 bottom, p. 24 tweezers, walking stick, bow, pen, clock; Franckh-Kosmos Verlags-GmbH & Co. KG, p. 6 top, p. 9 top, p. 11 top, p. 17 top, p. 19 top, p. 21 top and middle, p. 24 clothespin and shocks; Ben Britton, p. 14 top; Chan Bliss (CC BY SA 2.0 Flickr), p. 24 shoe; jill570641 (CC BY SA 2.0 Flickr), p. 24 stent.

Packaging style guide: Peter Schmidt Group GmbH, Hamburg
Packaging design: Dan Freitas
Packaging photos: Franckh-Kosmos Verlags-GmbH & Co. KG, Ben Britton (Thames & Kosmos)

The publisher has made every effort to identify the owners of the rights to all photos used. If there is any instance in which the owners of the rights to any pictures have not been acknowledged, they are asked to inform the publisher about their copyright ownership so that they may receive the customary image fee.

Distributed in North America by Thames & Kosmos, LLC. Providence, RI 02903
Phone: 800-587-2872; Email: support@thamesandkosmos.com

We reserve the right to make technical changes. Printed in Taiwan / Imprimé en Taïwan