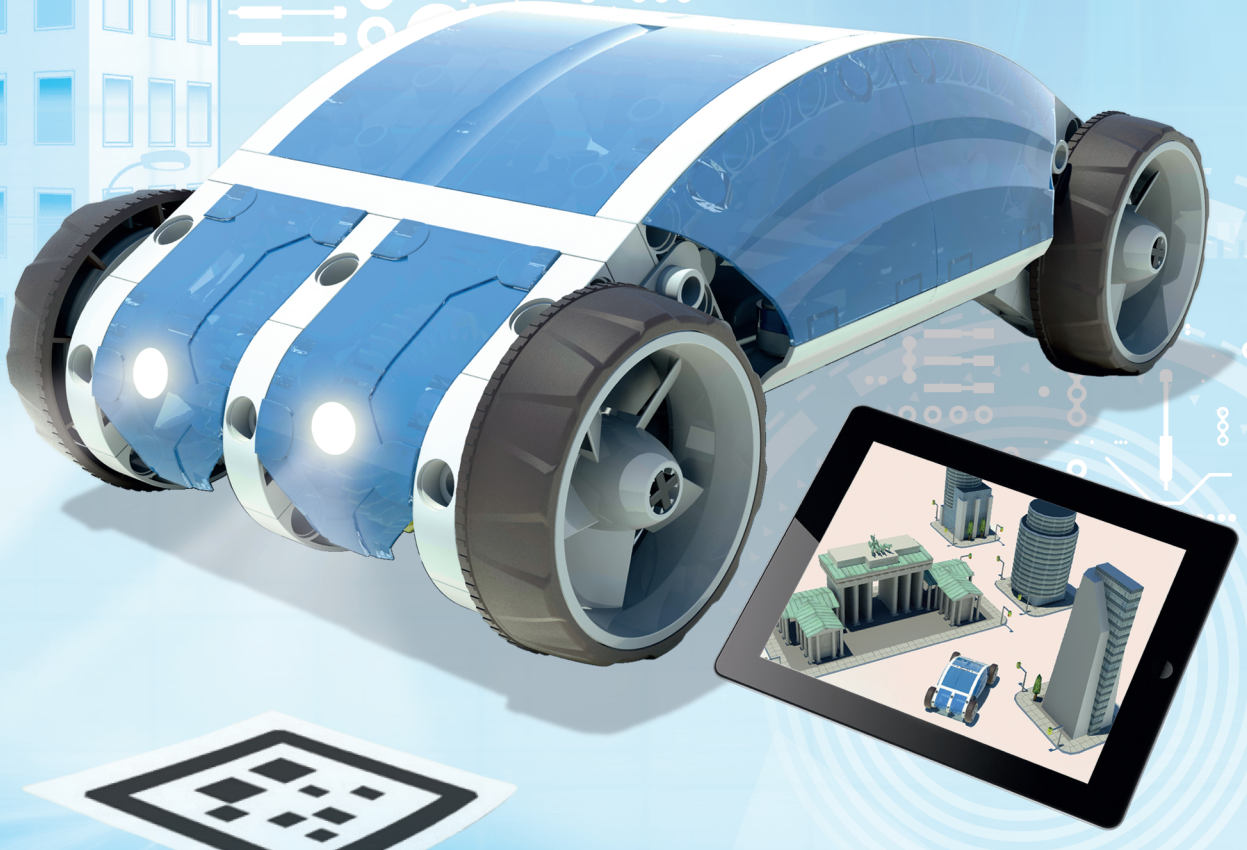
EXPERIMENT MANUAL

SMART CAR ROBOTICS



THAMES & KOSMOS

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Safety Information

WARNING! Not suitable for use by children under 3 years of age. There is a risk of choking if small parts are swallowed or inhaled. Store the experiment material and assembled models out of the reach of small children.

WARNING! Only for use by children aged 10 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.

Do not let any hair or other materials (such as string or carpet fibers) get into the model's drive mechanism.

Safety for Experiments with Batteries

›› Never experiment with wall outlets or the household power supply. Never insert wires or other parts into wall outlets! Household voltage can be deadly.

››› For operation, you will need four AA batteries (1.5-volt, type AA/LR6), 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 could lead to overheating of circuits and battery explosions.

››› 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.

››› Only install batteries in the correct polarity direction. Press 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.

››› Make absolutely sure that metallic objects such as coins or key chains are not left in contact with battery terminals.

››› Do not bend, warp, or otherwise deform batteries.

With all of the experiments that use batteries, have an adult check the experiment or model **before use** to make sure you have assembled it properly.

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. When your child is using a tablet or smart phone, make sure he or she understands that these devices are not toys.

We wish you and your child a lot of fun with the experiments!

FCC Part 15 Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, maybe cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different form that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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.

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An experiment to help you hit the ground running

Here are some preparations before you begin.
Get your tablet or smartphone ready to go!

Download the app and take off

YOU WILL NEED

› **QR code on this page**
› *Smartphone or tablet*
› *An app for scanning QR codes*

HERE'S HOW

1. Turn on your tablet or smartphone.
2. If you don't yet have a QR code reader app, download one from your app store and install it.
3. Start the QR code reader app.
4. Hold your tablet or smartphone over the QR code on this page so you see it on the screen.
5. As soon as the app has recognized (scanned) the QR code, you will be taken to a website from which you can click into the app store.
6. Install the smart car app.
7. Done. The app is the core element you will use to control all the models with your smartphone or tablet. Now start the app.
8. Follow the instructions and allow the app to switch on and use Bluetooth.
9. As soon as you see the start page, you can try practicing a few finger exercises — or, more precisely, "thumb exercises" — without the car.
10. Hold the tablet sideways as shown in the illustration and place your thumbs on the screen. You will immediately see a colored arc, which you will be using to control the smart car and other models.
11. The app also adjusts to you: Try placing your thumbs on some other part of the screen.

TIP!
You can get to the smart car website by using the QR code on this page. There you will find not only the link to the app, but further tips and information as well.

WANT TO LEARN MORE?
Use the app to control the models — to drive them (page 12) and program their motors (page 38). Welcome to the exciting world of the smart car!

QR Code

www.thamesandkosmos.com/apps/620349

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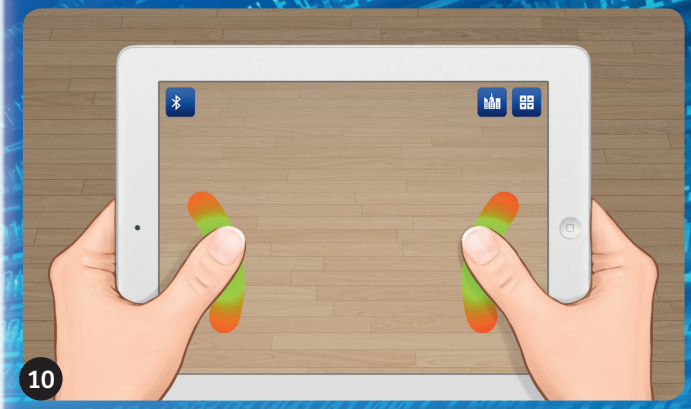

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WHAT'S HAPPENING?

The QR code (which stands for "quick response") was originally developed by the Toyota car company for unique identification of components in the assembly process. QR codes consist of a large square with small black and white squares inside it. This pattern can be used to encode information such as names or numbers. This is similar to the function of the bar codes that you see on food packages, or on your smart car box for that matter. The only difference is that little bars, rather than squares, are used to encode the data.

4 002051 620349

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:

35 FREE APP

See page 1 for instructions on downloading the app for controlling and programming the models. If you encounter any problems with the app, email: apps@thamesandkosmos.com

Checklist: Find – Inspect – Check off

✔	No.	Description	Count	Item No.
❍	1	Bluetooth battery box	1	714 270
❍	2	Motor with wire	4	714 271
❍	3	Wheel rim	4	714 272
❍	4	Tire	4	714 273
❍	5	Body part 1	4	714 274
❍	6	Body part 2	2	714 275
❍	7	Body part 3	2	714 276
❍	8	Body part 4	2	714 277
❍	9	Body part 5	4	714 278
❍	10	Curved frame	2	714 279
❍	11	3-hole dual rod	9	714 127
❍	12	Narrow 11-hole rod	2	714 280
❍	13	Narrow 7-hole rod	2	714 281
❍	14	3-hole rod	6	714 125
❍	15	5-hole rod	8	714 179
❍	16	11-hole rod	6	714 282

✔	No.	Description	Count	Item No.
❍	17	3-hole dual rod with pin	14	714 283
❍	18	5-hole dual rod	4	714 126
❍	19	Square frame	2	714 284
❍	20	Curved rod	12	714 285
❍	21	Small gear	8	710 062
❍	22	Medium gear	6	710 061
❍	23	Two-to-one converter	12	714 286
❍	24	Axle	4	713 490
❍	25	Motor shaft	6	702 801
❍	26	Axle lock	4	702 813
❍	27	Long tube	4	714 287
❍	28	Short tube	8	714 288
❍	29	Red anchor pin	24	702 527
❍	30	Blue anchor pin	44	714 129
❍	31	Die-cut sheet	1	714 289
❍	32	Button pin	2	714 329
❍	33	Set of AR code cards	1	714 334
❍	34	Anchor pin lever	1	702 590
❍	35	App (downloadable)	1	

You will also need:
4 AA batteries (1.5-volt, type AA/LR6), tablet/smartphone/iPod touch with camera/Bluetooth low-energy support/Internet connection, app for QR code scanning, stopwatch

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TIP!
You will find additional information here: "Check It Out" Pages 18 to 21, 37, and 61 to 64

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Now it's time to build even more models to drive. Test the motorcycle and zoom through the room with the car of the future. Do you think your forklift truck might even be able to hoist a load?

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... made easy. Learn how to control the motors in your models individually. The app's programming module makes it easy. Save the movement sequence and call it up again. That way, the models will move all by themselves!

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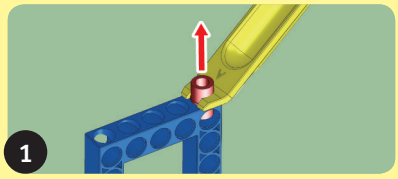
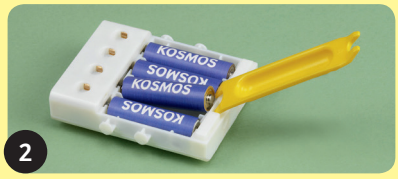
The anchor pin lever

In the box, you will find a little tool — the yellow anchor pin lever.

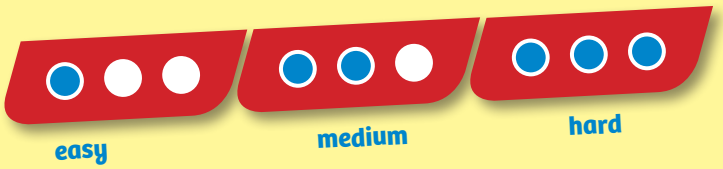
1. End A of the anchor pin lever makes it easy to remove anchor pins from the frames.
2. End B of the tool is used for removing batteries from the battery compartments.





TIP!
At the top of each model assembly page, you will find a red bar:

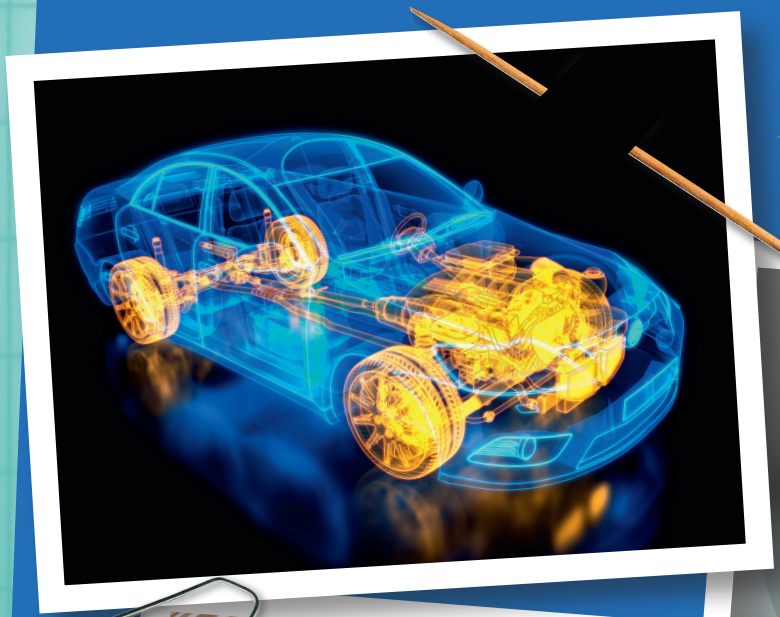
››› It shows how difficult the model's assembly will be:

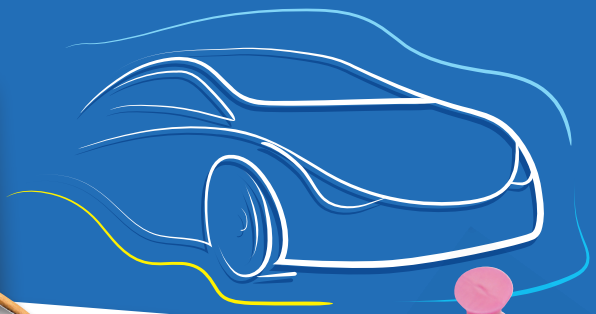


The Smart Car – The Future of the Automobile

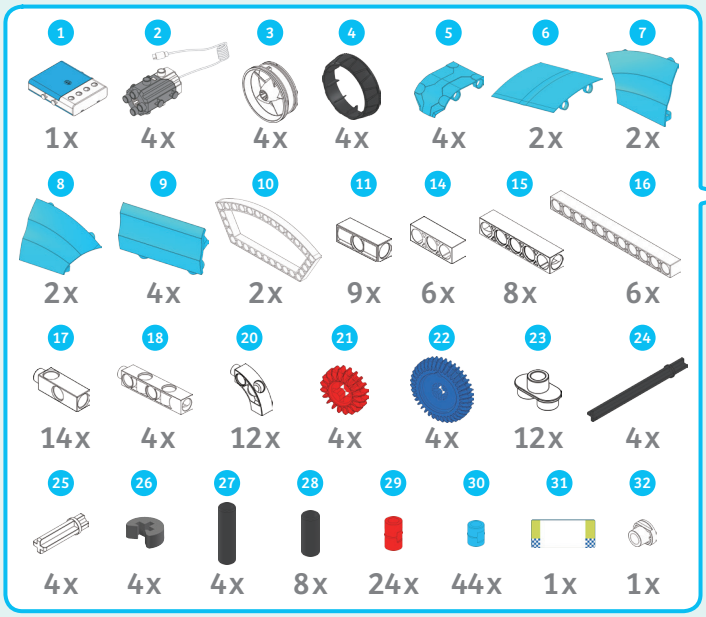
What does the car of the future look like? Your smart car will give you a clue or two. This smart car is a concept car, which is more or less synonymous with "prototype" or "first example," and is a way for engineers to try out their ideas.

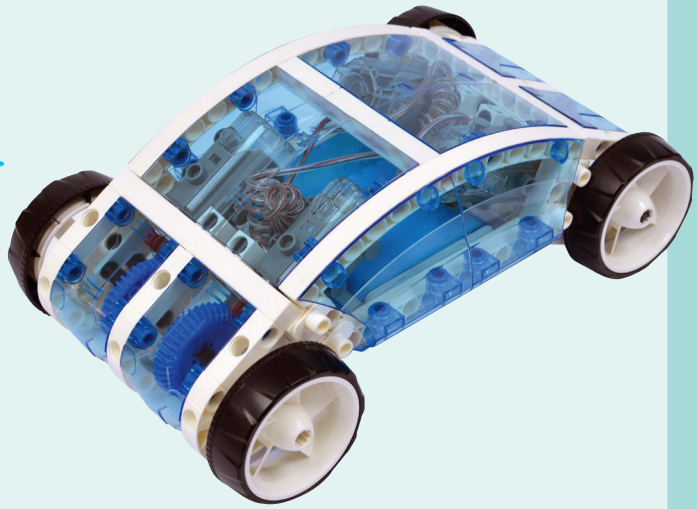
Now you can slip into their role. In the process, you will learn about some of the important features that the car of the future might hold. You will be able to try a few of them out yourself in the experiments. For example, your smart car will be able to drive autonomously, or all by itself!





SMART CAR





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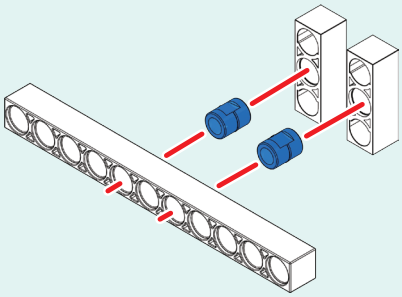

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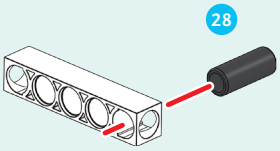

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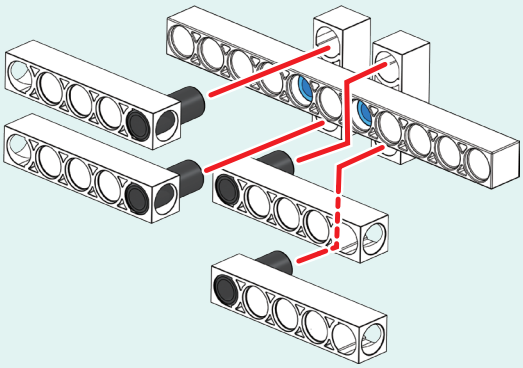

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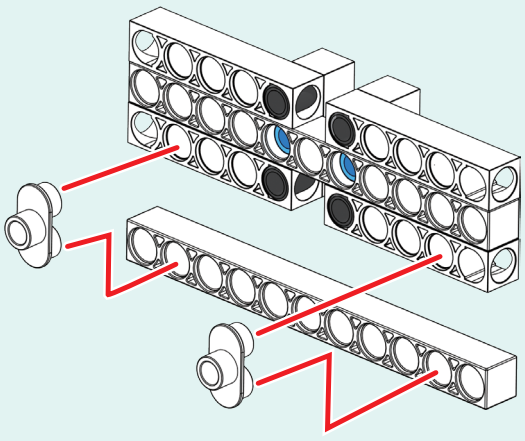

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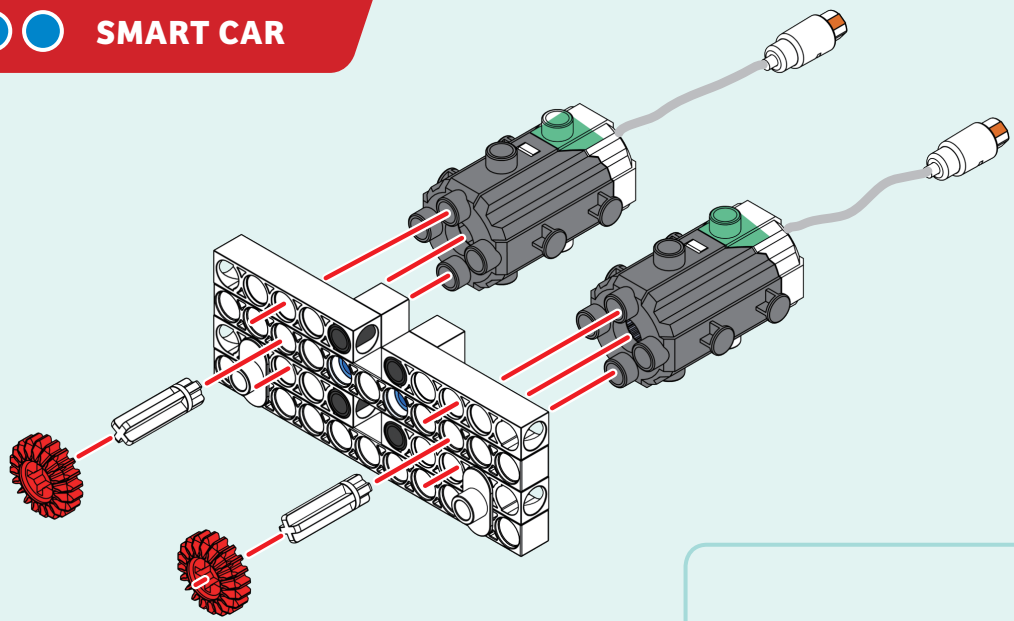

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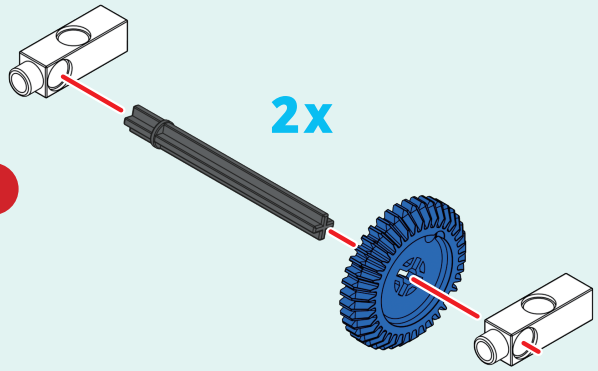

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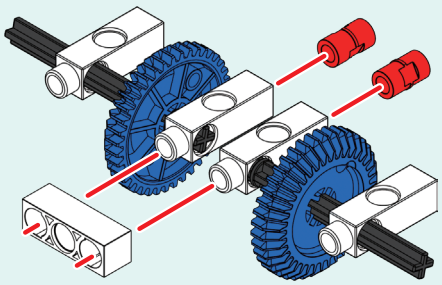

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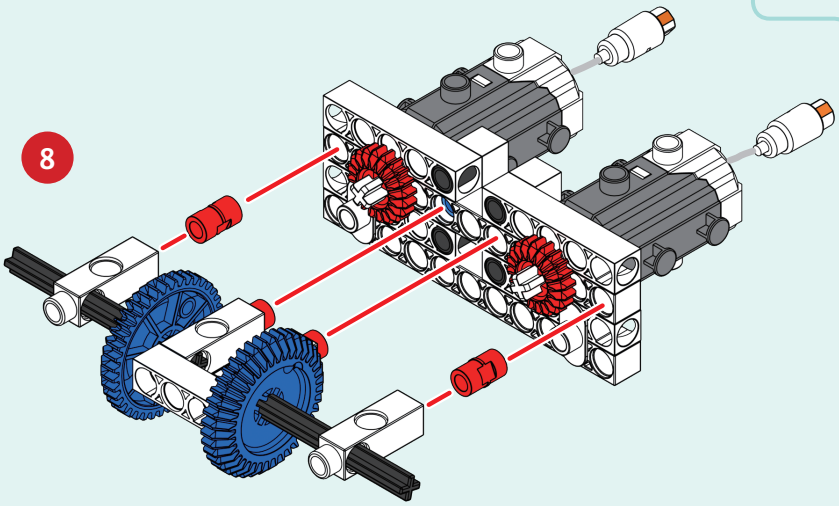

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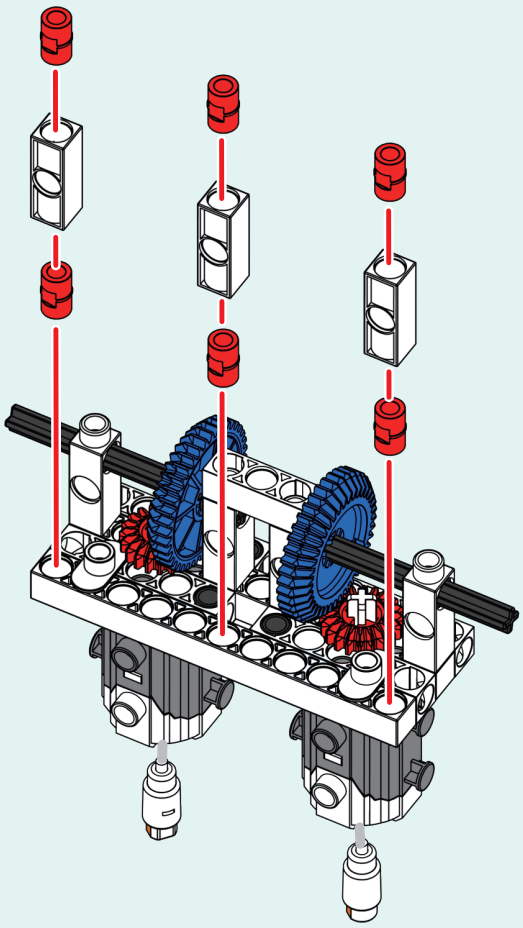

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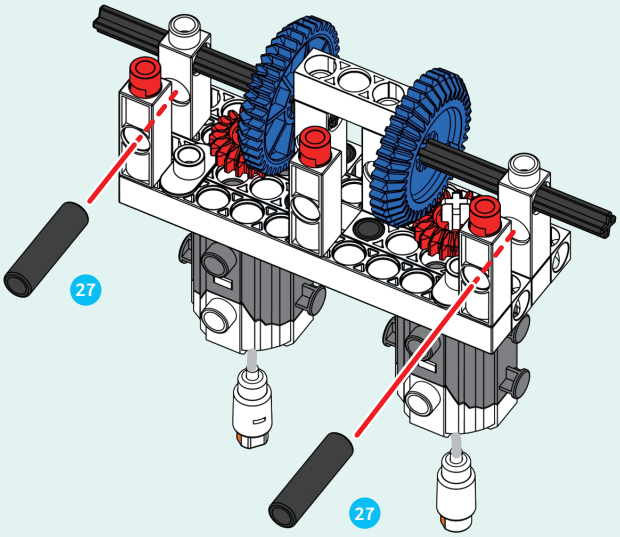

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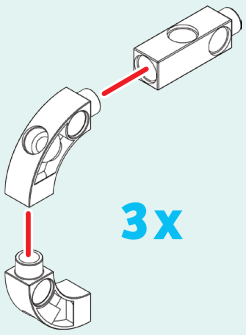

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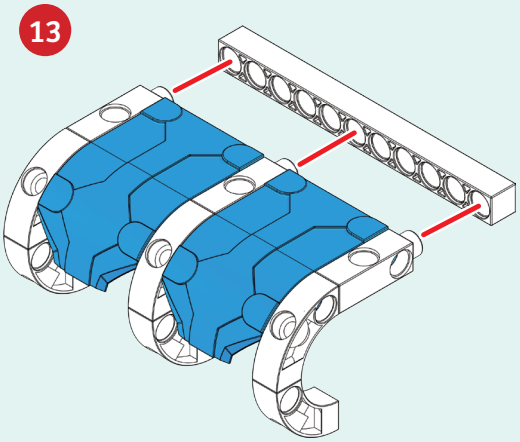

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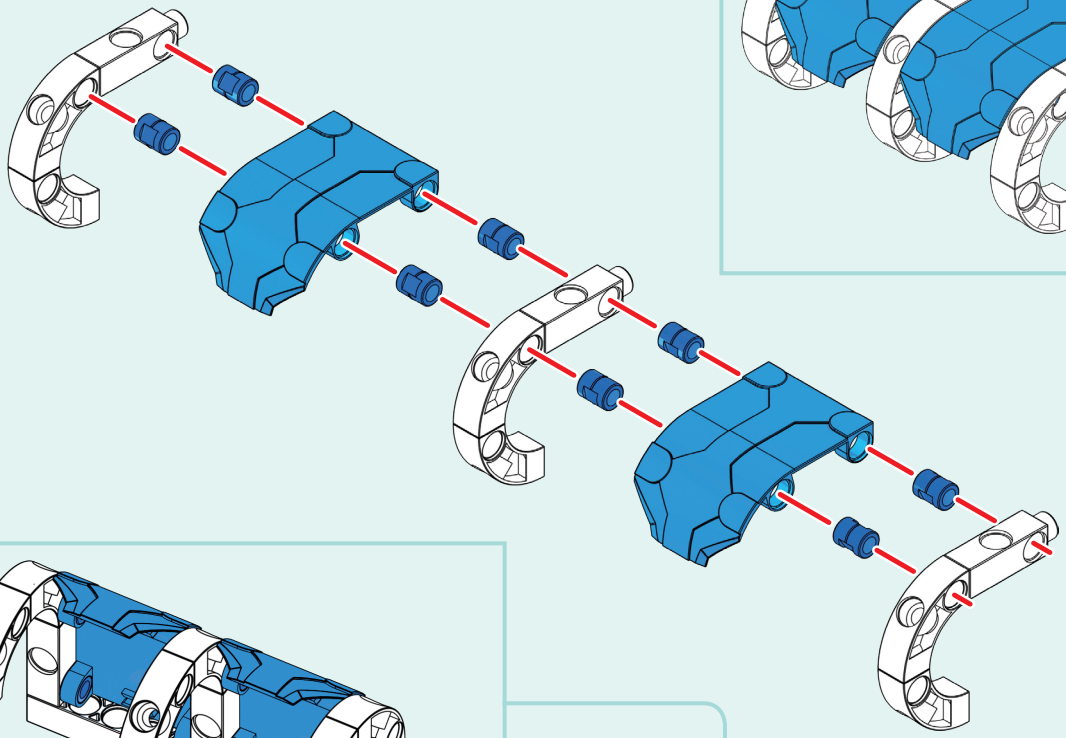

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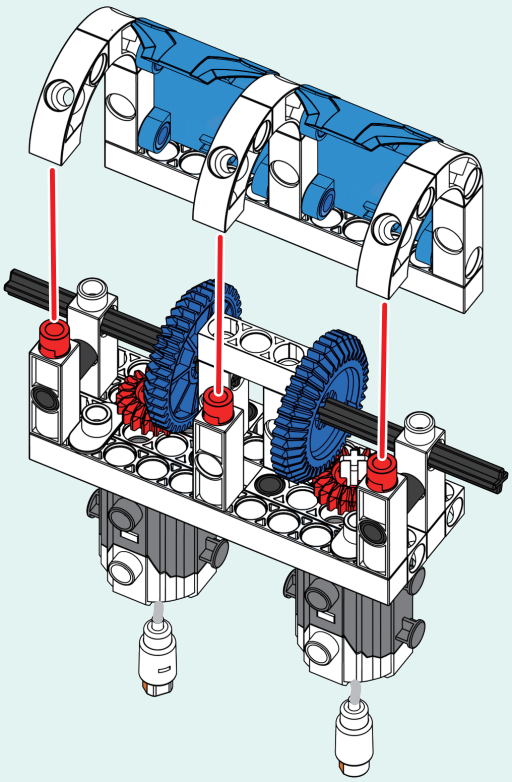

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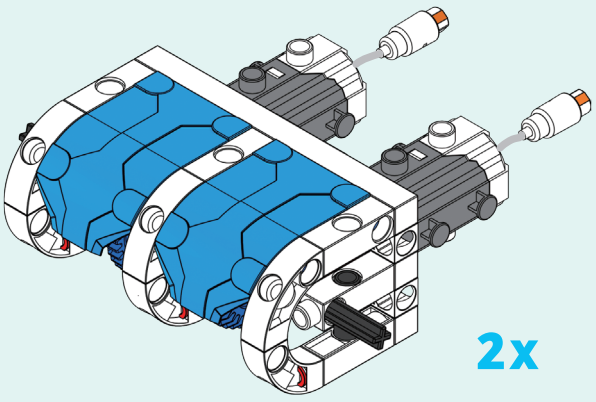

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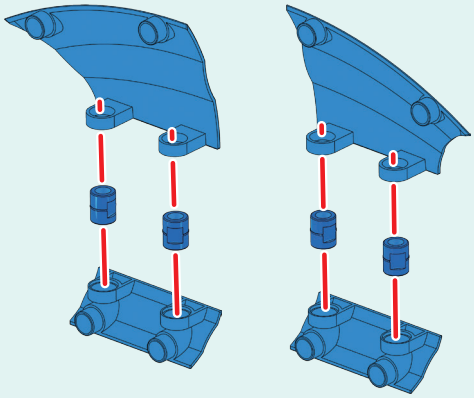

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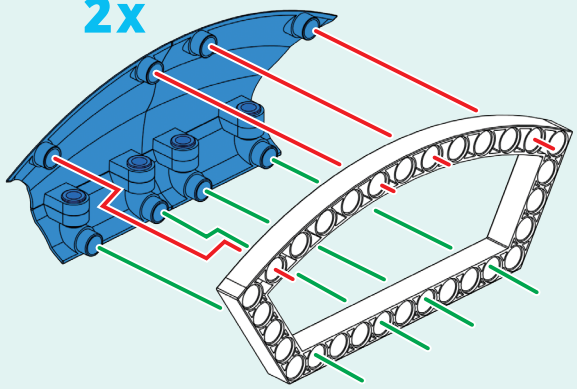

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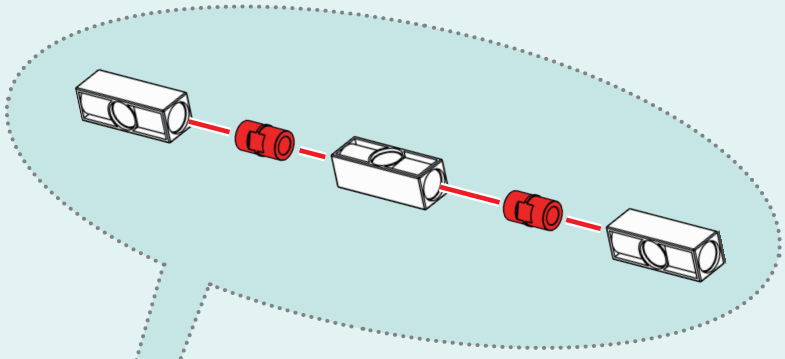

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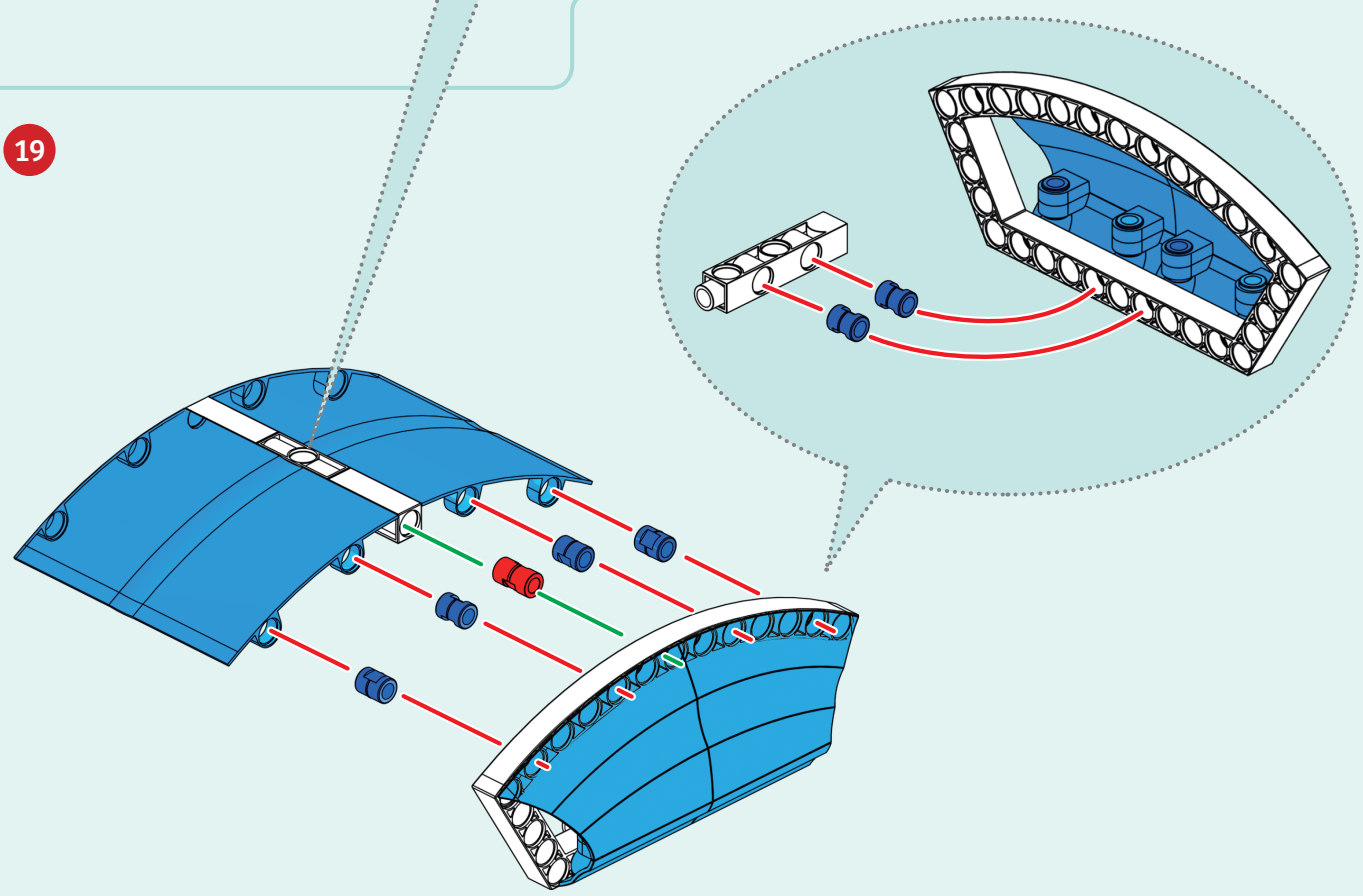

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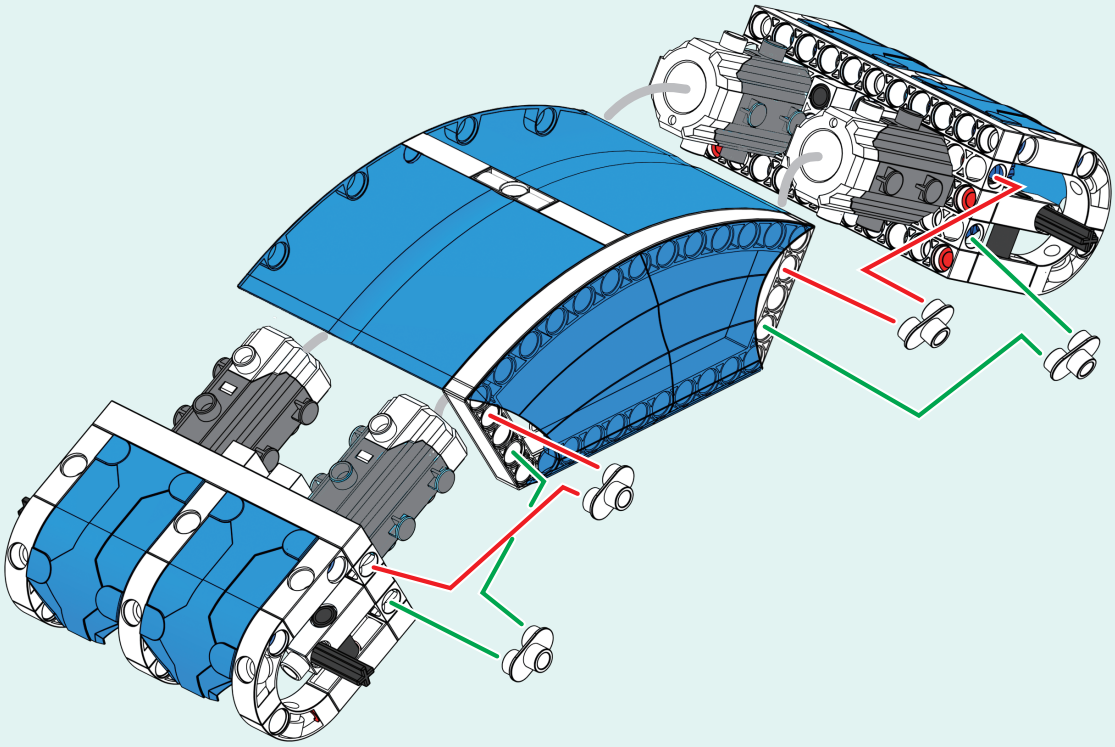

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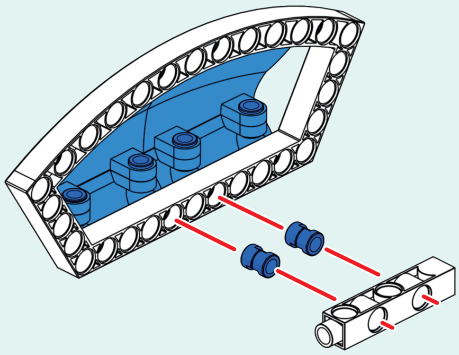

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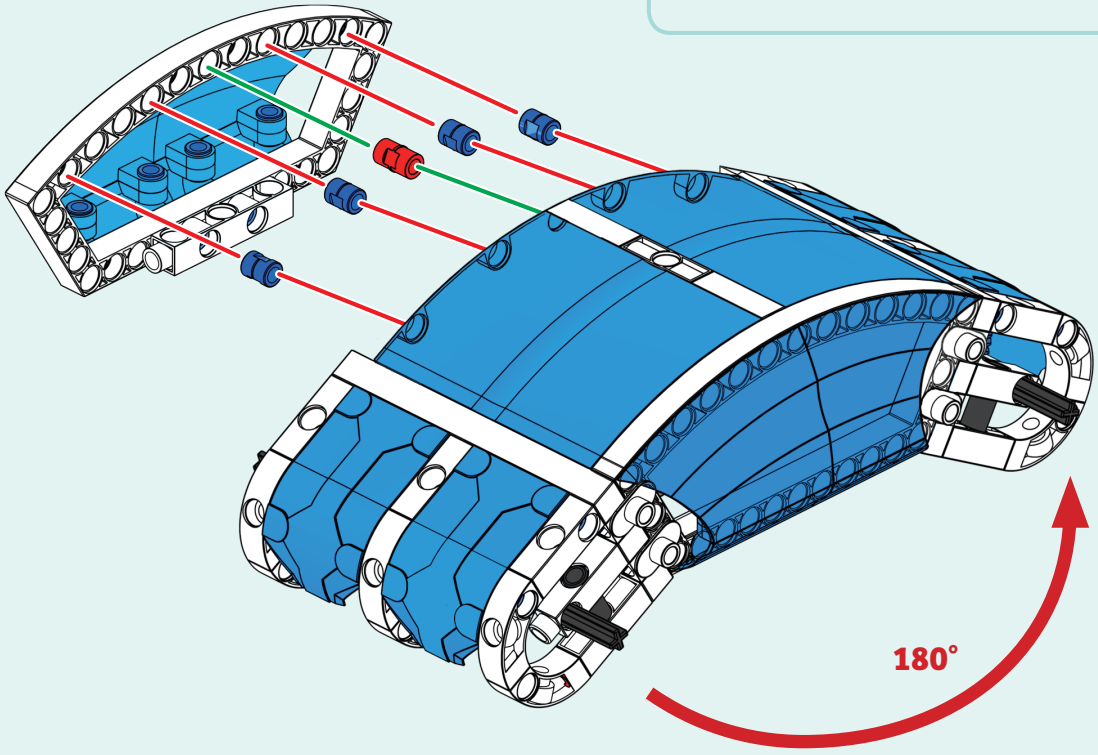

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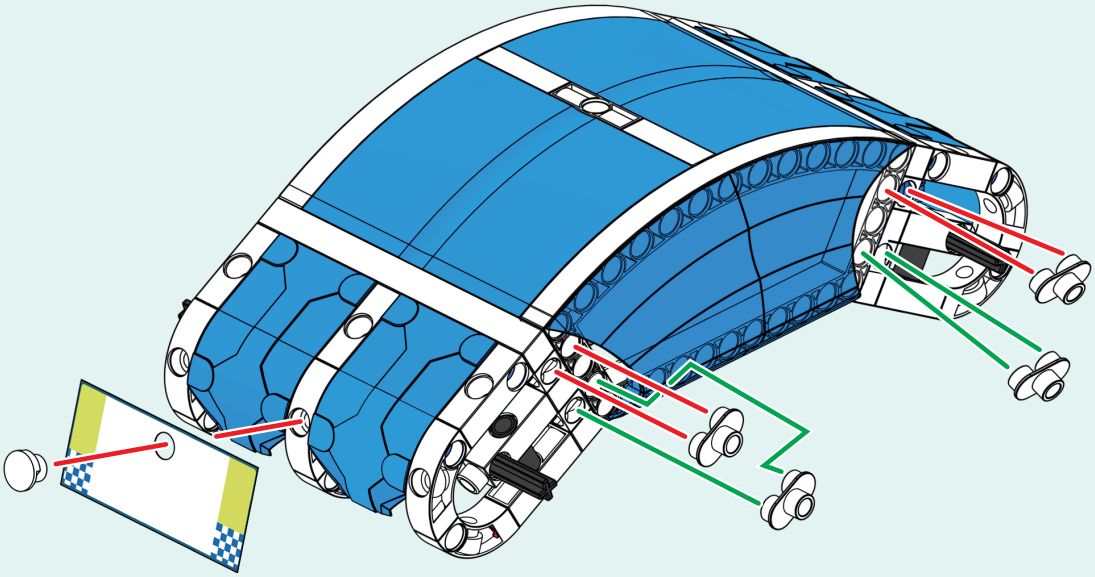

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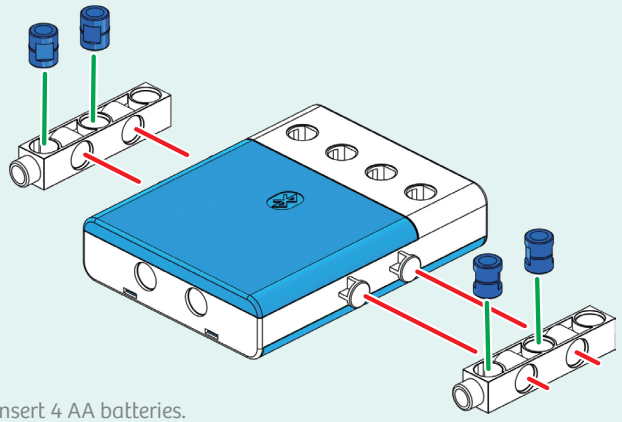
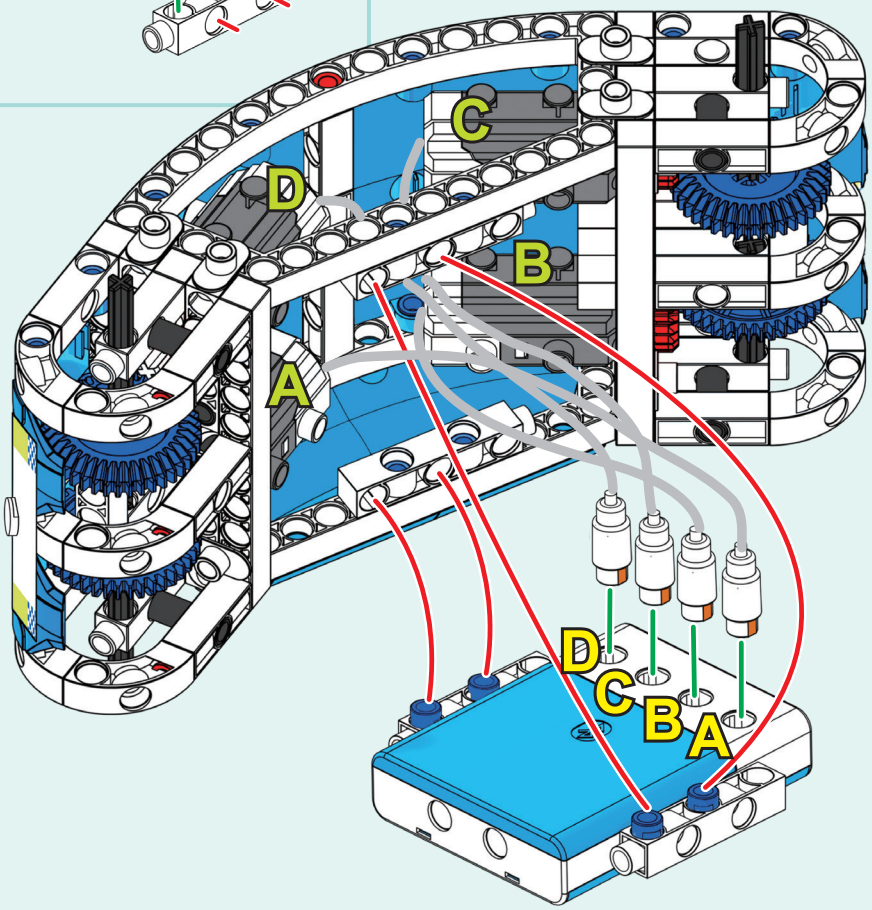


Now insert 4 AA batteries.

25



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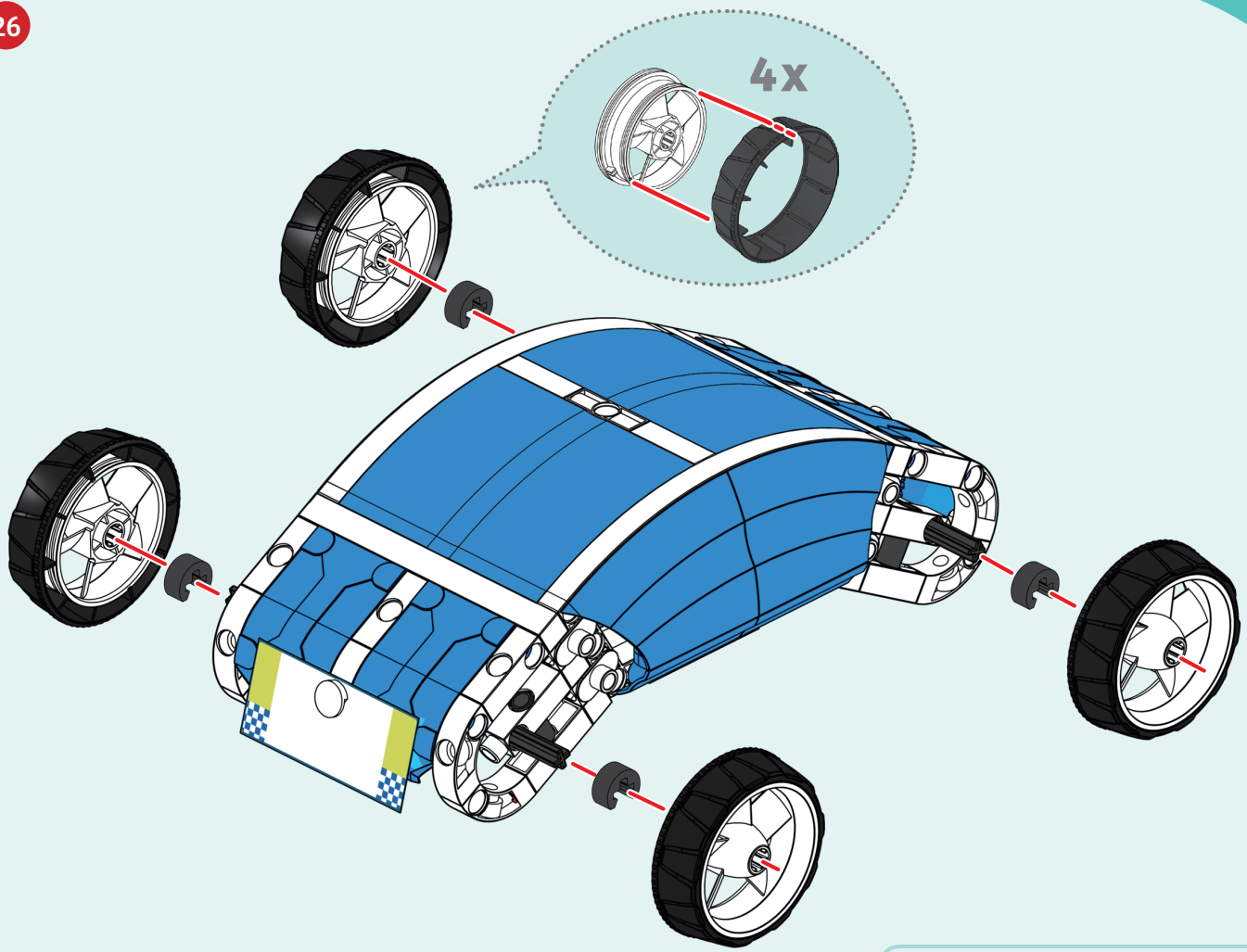
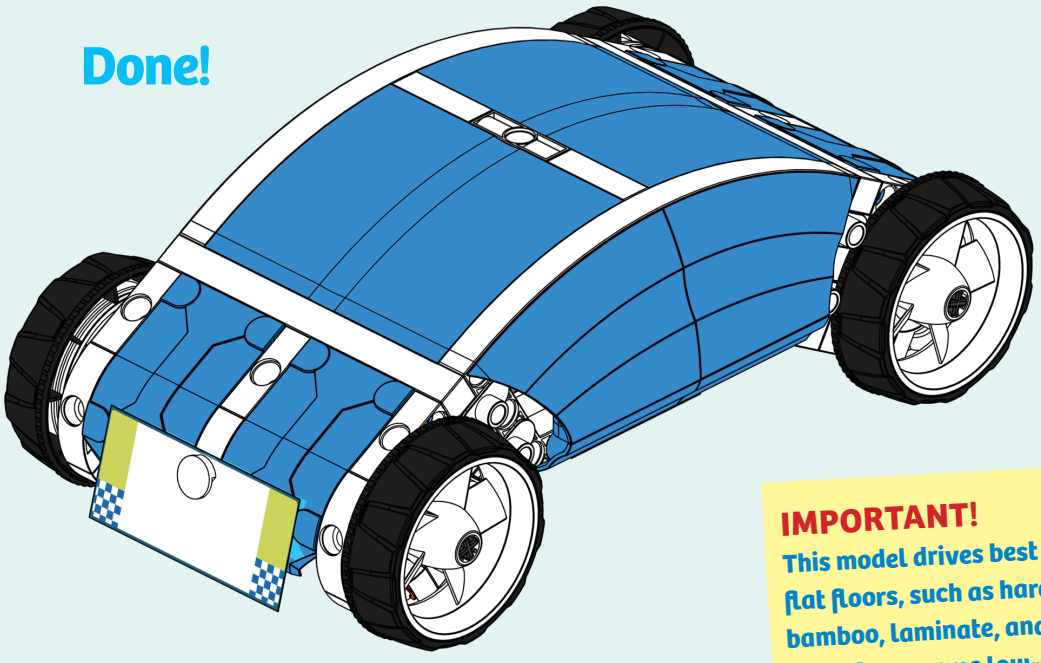


Done!



IMPORTANT!
This model drives best on smooth, flat floors, such as hardwood, bamboo, laminate, and smooth tile. It works on some low-pile carpeting, but it is not intended to drive on carpeting.

EXPERIMENT 1

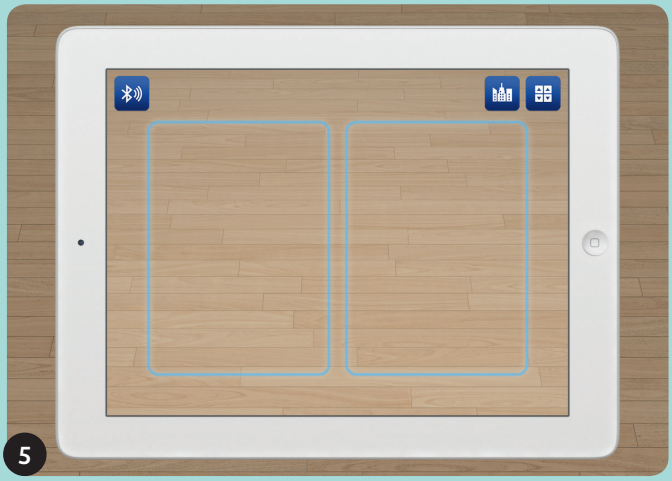
Controlling the smart car with the app

YOU WILL NEED

- **The assembled smart car**
- **Smart car app**
- *Smartphone or tablet*
- *4 Batteries*

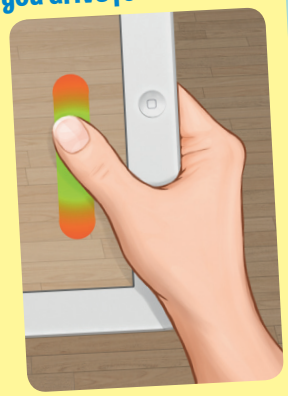
HERE'S HOW

1. Make sure that all of the batteries have been inserted correctly in the smart car's battery box.
2. Start your tablet or smartphone and the smart car app. Allow the app to switch on and use Bluetooth.
3. Hold the tablet or smartphone sideways.
4. Tap the Bluetooth button on the upper left. The name of your car will appear on the screen: smart car. Tap on it to establish the connection between tablet/smartphone.
5. The two lit areas will show you where to place your thumbs.
6. As soon as you press the screen with your thumbs, the two arcs will show up. You will use them to control your smart car. Push upward to turn the wheels forward. Move your thumbs down to make the car drive backward. The license plate shows you which end of the car is the front and which is the rear.
7. The middle of the arc means "stop." Slow down the smart car by pushing your thumbs to this middle position.
8. You can turn by pushing one thumb upward on one of the arcs and the other downward:
   a. The smart car will drive to the left if you move your left thumb down and simultaneously push your right thumb up.
   b. Conversely, the car will drive to the right if you move your right thumb down and simultaneously push your left thumb up.
9. Drive around a little to get the feel for it. Have a nice trip!



TIP!

You can also drive the smart car with just one thumb, but only if you want to drive straight. To do that, tap twice quickly on the screen and hold your thumb (or finger) on the "straight ahead" controller that appears. It will let you drive forward and backward easily. As soon as you lift your thumb or finger off the screen, the controller will disappear again.

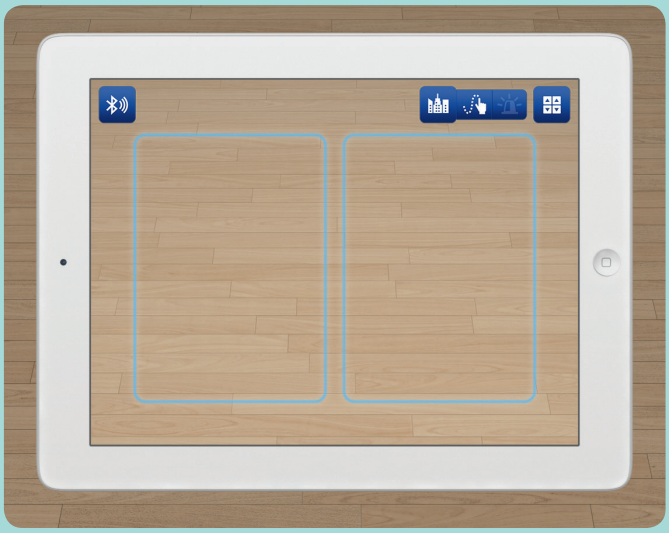


DID YOU KNOW?

The smart car isn't the only thing you can steer by moving its two sides' controls in opposite directions. You also do that with tracked vehicles such as bulldozers and caterpillar earthmovers.

HERE'S HOW (CONTINUED)

1. After making your first few trial runs, it's time to take a look at the app.
2. At the top left, you will see the Bluetooth button. It shows whether the tablet/smartphone is connected to the smart car.
3. At the top right, depending on the mode, you will see several other buttons. Tap once on the button with the high-rise buildings. The default display will show:
   a. the AR button (page 14)
   b. the Draw & Drive button (page 16)
   c. the button for the police siren (page 14)
   d. the programming button (page 44).



WANT TO LEARN MORE?

You will find more information about all the functions right in the app. Try even more experiments: How fast can your car go, and can it drive uphill?

WHAT'S HAPPENING?

Bluetooth is a kind of radio technology used for data transmission. The technology has become widely used in small devices people use while driving. For example, with a Bluetooth headset, you can leave your smartphone in your pocket while receiving a call and hear the call directly through the headset. To use Bluetooth technology, the devices have a tiny microchip with a transmitter and receiver unit. In addition, they will need the appropriate software to control the data transfer.

Bluetooth®

KEYWORD: BLUETOOTH

The name Bluetooth refers to the Viking King Harald Blaatand (literally translated as "Bluetooth"). Just as King Bluetooth united large areas of Denmark and Norway in his time, today's Bluetooth technology is intended to connect together tablets, smartphones, headsets and more.

TIP!

The wheels of your smart car should always maintain good contact with the ground. Try your car on a variety of surfaces! It's also important to be sure that the gears always mesh well.

EXPERIMENT 2

Driving your smart car through virtual streets

YOU WILL NEED

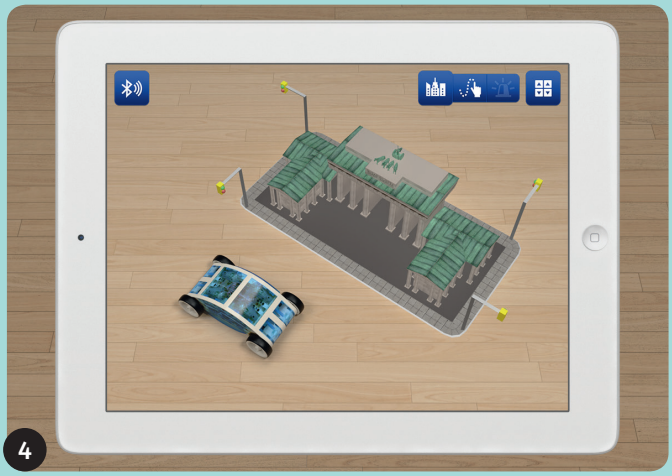
- **The assembled smart car**
- **AR code cards**
- **Smart car app**
- *Smartphone or tablet*
- *4 Batteries*

HERE'S HOW

1. Arrange the AR code cards on the floor and get your smart car ready to go.
2. Launch the app to connect the tablet/smartphone with the car via Bluetooth. Tap on the AR button. Now you're in the AR mode.
3. Hold your tablet or smartphone over the AR codes lying on the floor so its camera can "see" them.
4. Wow! All of a sudden, skyscrapers and other buildings will appear on the screen.
5. The display has changed, too: At the top right, you will now see two more buttons:
   a. You will learn about the Draw & Drive function in the next experiment on page 16.
   b. The other is for a police siren (see the "Want to Know More?" box).
6. Have you noticed the traffic lights around the buildings? They switch periodically between red and green.
7. Try to find out the optimal distance between the AR codes — and, therefore, the virtual buildings — that will let you steer your smart car through the concrete canyons most easily.
8. Off you go! But be careful! Not only do you have to pay attention to the traffic lights, you also have to be sure not to drive into the virtual buildings!

TIP!
Ideally, place the AR code cards at least one meter apart, with some right at the edge of your driving route.


3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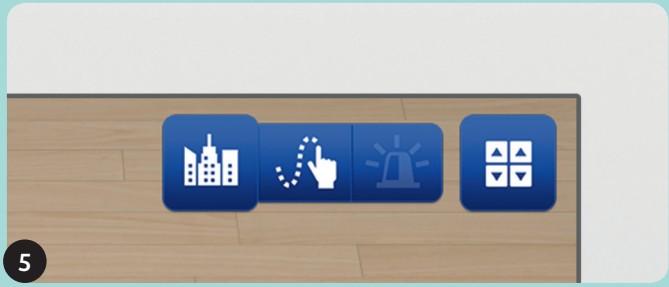
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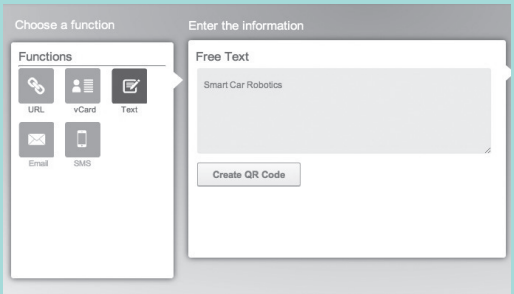
WANT TO KNOW MORE?

Look out, a cop! Use the police function to activate a siren. It will go off if you run a red light!

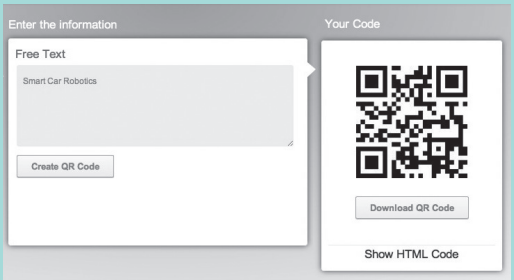
DID YOU KNOW?

...that you can make your own QR codes? Maybe not with a built-in AR function, but you can still "embed" your name or an Internet address (URL) in a QR code.

To do it, log onto the Internet and point your browser to www.qr-code-generator.com.



For the "function," you can try selecting the "Text" option. Enter some words into the entry field, such as "Smart Car Robotics," and then select "Create QR Code."



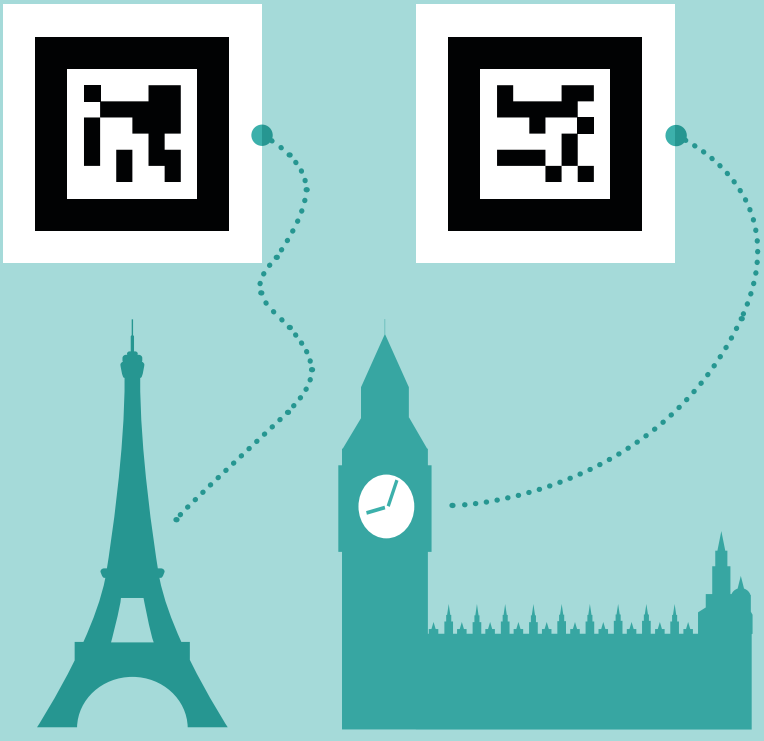
Click on "Download QR Code" on the right. Follow the instructions for saving it. Then, you will find a QR code in the selected download folder. You can print it out, for example, or send it to a friend by email.

WHAT'S HAPPENING?

You have already learned what a QR code is. But what does "AR" mean? This abbreviation stands for "augmented reality." It refers to a virtual augmentation or extension of your environment or reality through computers. "Virtual" means "not actual" or "not real," but "appearing to be real."

For example, the buildings that you see on your screen are not actual buildings. "Augmented reality," in other words, provides computer-generated additional information or virtual objects in the form of images, videos, or animations (such as the traffic lights) that appear on your screen.

You can sometimes see examples of this kind of augmented reality in television sports broadcasts. For example, an imaginary line might be indicated on the television screen to show how much farther a football team has to move the ball to get a first down.



Eiffel Tower, Paris

Big Ben, London

EXPERIMENT 3

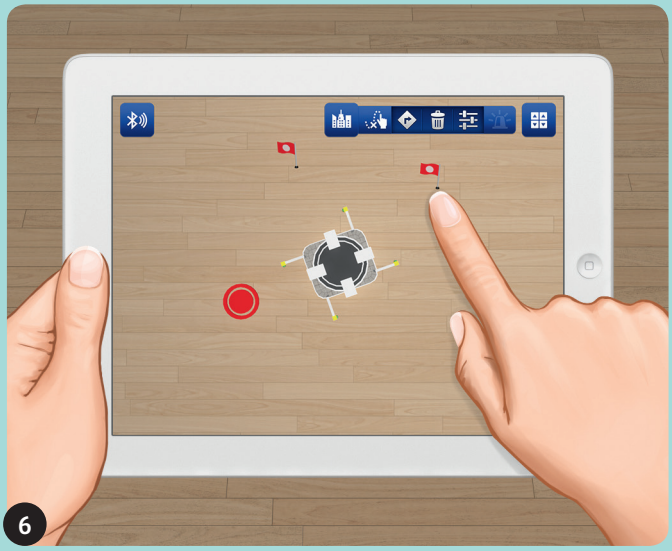
Self-driving car using Draw & Drive

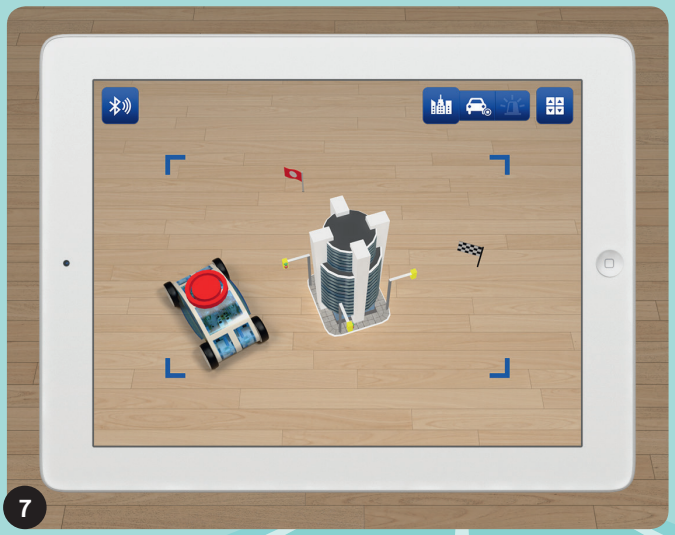
YOU WILL NEED

- **The assembled smart car**
- **Draw & Drive code (the smart car is shown on the back)**
- **Button**
- **AR code cards and smart car app**
- *Smartphone or tablet*
- *4 Batteries*

HERE'S HOW

1. Check to make sure that the batteries are installed properly.
2. Take the button pin from the kit and attach the Draw & Drive code, with the code facing up, on the roof of the car by inserting the button pin through the hole.
3. Spread out the AR code cards on the floor. Now start your smartphone or tablet and the app, and connect the tablet/smartphone to the car via Bluetooth.
4. Activate the AR mode by tapping on the AR button. Now you will see the buildings and the red dot on the car.
5. Try a brief test drive. Orient the car so that it drives forward when you push your thumbs upward. Then rotate the Draw & Drive code so that the little arrow is pointing in the driving direction.
6. Then tap on the Draw & Drive button. The view will change from normal mode to a bird's-eye perspective.
7. Now you can draw, up to six dots on the screen by tapping on it. Your car will drive towards these dots in sequence.
8. As soon as that's done, press the icon with the arrow. The perspective will change back to normal mode. The car, building, and route should always be visible on the screen.
9. Now tap "Let's go."
10. And now things really do get going: Your smart car drives like a robotic car, all by itself, along the pre-programmed route!





KEYWORD: AUTOMOBILE

The word "automobile" is actually a little misleading. It comes from Greek, and means something like "self-driving." But that's exactly what our cars can't do, since someone always has to be sitting at the steering wheel. When the word was coined, what people understood by it was that an automobile didn't need a horse or ox to pull it, since it had a motor. Truly self-driving, though, they were not, and still aren't. But things are changing. It isn't just your smart car that can drive all by itself — there are real ones that can do that too. You can read more about them starting on page 18.

WHAT'S HAPPENING?

As soon as you press the Draw & Drive button, other buttons will appear:

› This one takes you back to the normal view and deletes the current route.

› You press this button when you want your car to start driving the pre-programmed route. You have to make sure that the (virtual) building, smart car, and the route are all showing up on the screen.

› This is how to delete the pre-programmed route.

› Use this to adjust the power and precision of your car. A high power setting means the motors have a lot of power. That way, your car will get to its goal quickly. But it can also happen that the wheels turn too fast, making the car skid. A lower power setting lets your car drive more slowly, but also more steadily. Test different power settings on different surfaces. Use the precision setting to determine how often the car calculates its route. High precision means that it will follow the route exactly, but it will drive more slowly in the process.

› This is the button for the siren.

EXTRA EXPERIMENT

Decide on a starting and finishing point in the virtual city along with your opponents. Each player draws a route from start to finish (as described in Experiment 3) and then has the smart car drive that route. Time the different routes with a stopwatch. Who can find the fastest route for the car to take?

The Future of the Car, Part I: Achieving a Self-driving Automobile

Your smart car is a self-driving robotic automobile. Can you imagine your parents watching a DVD with you while they drive around town? Or texting their friends while driving — completely safely? Or all of you playing a board game together while traveling down the highway?

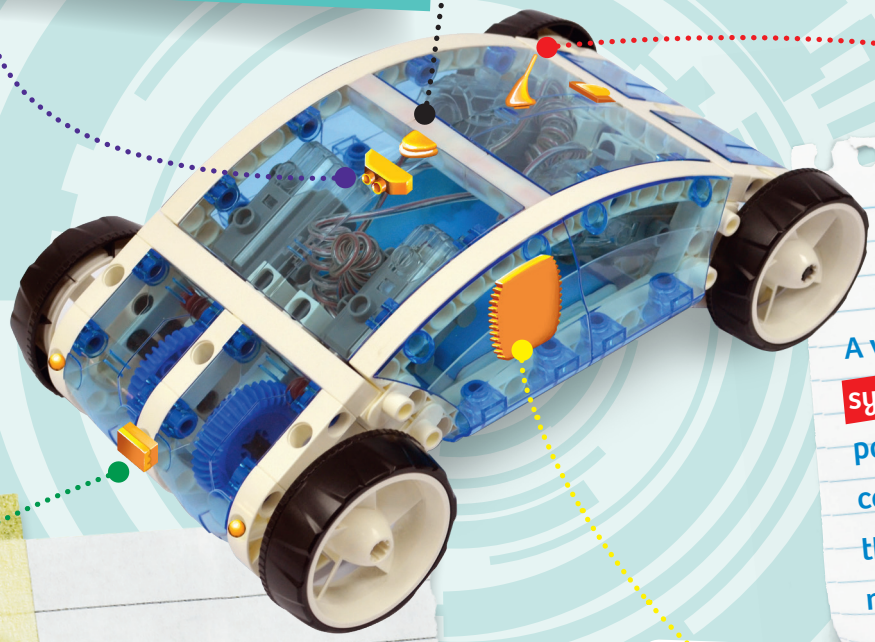
Well, your family's car can't do that. Not yet.

But automotive engineers expect that by around 2020 it will be completely normal for some cars to drive at least partly on their own. Car companies such as Audi and Mercedes, not to mention the search engine company Google, are already working on their own version of the self-driving car of the future. What will these "smart cars" be able to do?

Let's take a test drive with one of these futuristic cars:

Let's go! A 3D camera pointed toward the front detects driving lanes and the traffic ahead. This information is then compared to data from the vehicle-interval radar.

A laser scans the car's surroundings and detects every street sign and traffic signal along with other cars and pedestrians.



A very precise GPS navigation system determines the car's position down to just a few centimeters, more precisely than any of today's GPS navigators.

In addition, the car of the future will feature radar systems on the front, back, and sides of the car that will prevent the car from running into other vehicles or anything else for that matter.

From all this information, the on-board computer will decide what to do: brake or accelerate, make an evasive turn, overtake, or maybe just park.

In this way, the robotic car will be able to keep a safe distance from the vehicles in front of it no matter what the situation, and it will always be able to stay safely in its lane. It will even be able to overtake other vehicles and pass them. It will turn on its blinker, accelerate, and leave the slow old truck in its dust. Then, it will safely merge back into the driving lane after completing the passing procedure.

CHECK IT OUT

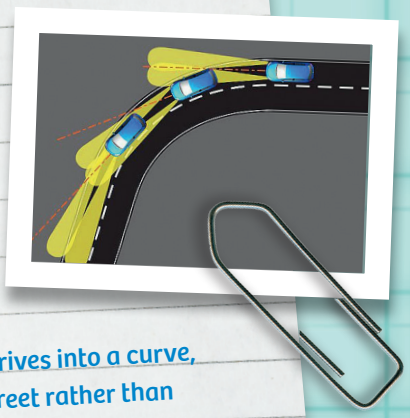
Learn about other driver assistance systems

PARKING ASSISTANCE

This makes parking easier, especially in tight spaces. The system provides either just auditory or auditory plus visual display information about the distance to another car. The purely auditory version indicates decreasing distance with increasingly rapid warning tones. Auditory-visual systems show the approach to an obstacle on an LED or some other graphic display as well as using warning tones when the distance is very small. In addition, there are systems that do all the necessary steering maneuvers all by themselves.

ADAPTIVE LIGHTING

Headlights that use this technology can shine around a corner: They alter their lighting direction when the vehicle drives into a curve, so the driver still sees the street rather than just the bushes planted alongside it.



AUTOMATIC LIGHTING

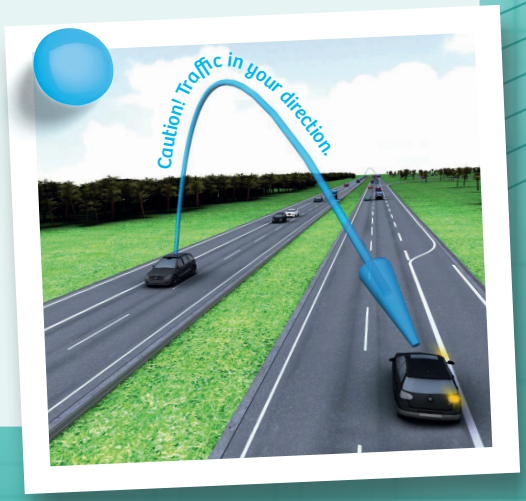
An automatic lighting system recognizes when it gets darker and switches on the headlights all by itself. The sensors are usually mounted behind the top of the windshield.

ANTI-LOCK BRAKING

An anti-lock braking system (ABS) helps to make driving safer by preventing the wheels from locking up when you start to brake. They do it by delivering rapid "pulses" of braking pressure, resulting in better control of the car.

Car-to-car communication

This refers to a system for letting cars "talk" to each other. The technology will be used in the future to allow cars to work out traffic issues among themselves. For example, let's say you barely manage to stop your car before hitting a fallen tree on a country road. Seconds later, a car approaching from behind is automatically warned about the danger with a buzzing sound and a breakdown symbol that appears in the windshield. That way, the driver knows to reduce speed in order to avoid an accident.



Collision avoidance

This uses sensors to detect the distance of the car from other cars or bicyclists, for example. If the car threatens to get too close to one of these, the system applies the brakes to avoid an accident.

LANE DEPARTURE WARNING SYSTEM

The lane departure warning system warns the driver when the vehicle begins to move out of its lane. It issues a warning when the distance from the lane markers is too small.

WINDSHIELD WIPER SENSOR

This technology uses a rain sensor mounted on the windshield to determine whether, and how heavily, it is raining, and then controls the windshield wipers accordingly.

ADAPTIVE CRUISE CONTROL

This adjusts the car's speed in congested traffic. In the future, it will let the driver assign all the work of "stop-and-go driving," or the tedious process of repeatedly moving forward and then quickly applying the brakes, to the car itself.

CRUISE CONTROL

A speed control system, sometimes called "speed control" or "cruise control," adjusts the engine's RPM in order to keep the car at a speed specified by the driver.

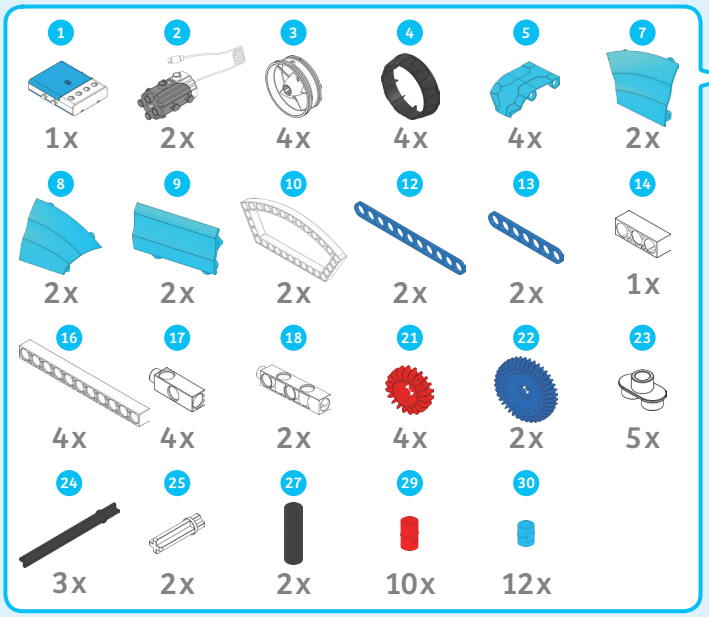
TRAFFIC SIGN RECOGNITION

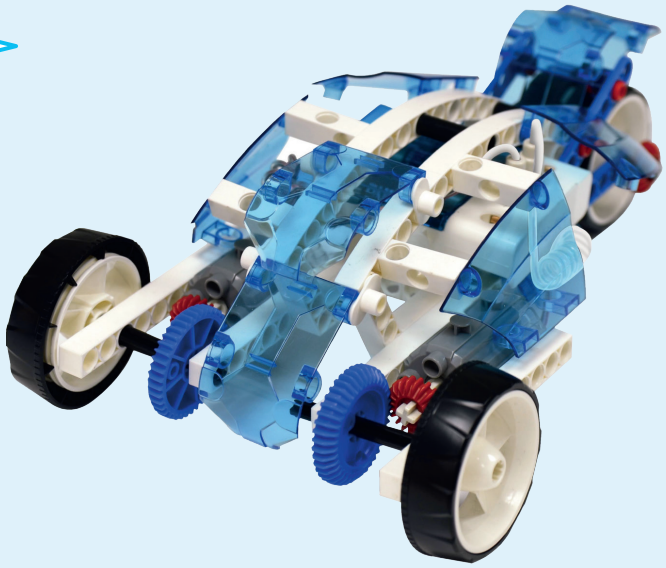
This will use forward-facing cameras to record traffic signs along the edge of the road. The computer processes these signals with an image recognition program and displays them on a screen. Or, it can warn the driver when he or she is about to exceed the speed limit or has just entered a one-way street in the wrong direction.

More Driving Fun

Have you tested all of your smart car's abilities? And won every race? Then it's time for some new experiments, and high time to build another model. How about a "trike" — a motorcycle with three wheels? Or a forklift truck? Or another car of the future? You can build and drive all of them! Let's get going!

MOTORCYCLE





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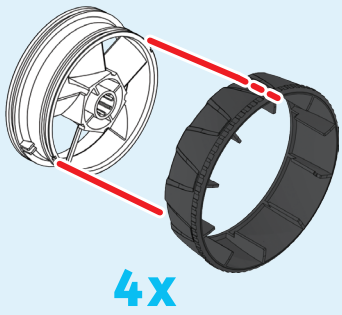

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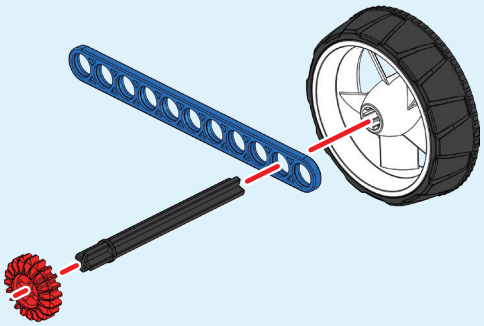

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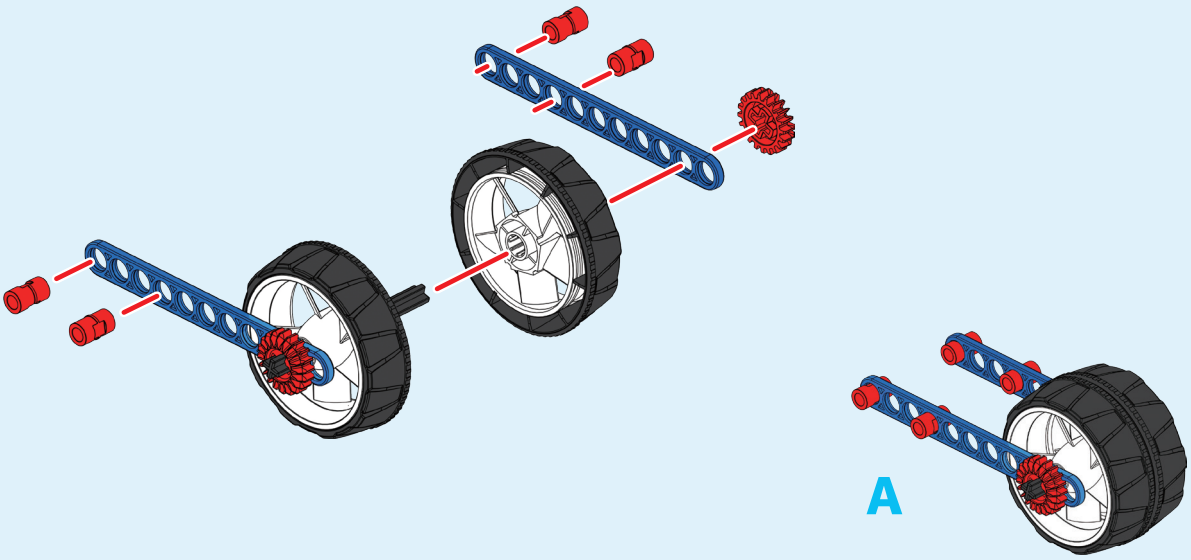

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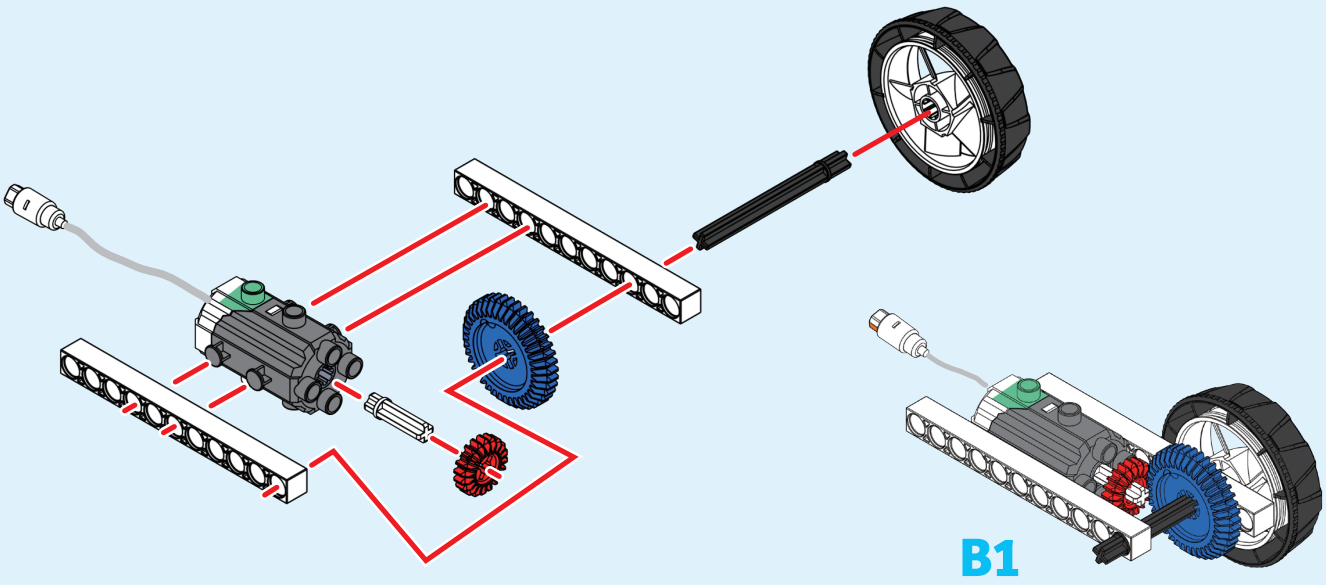

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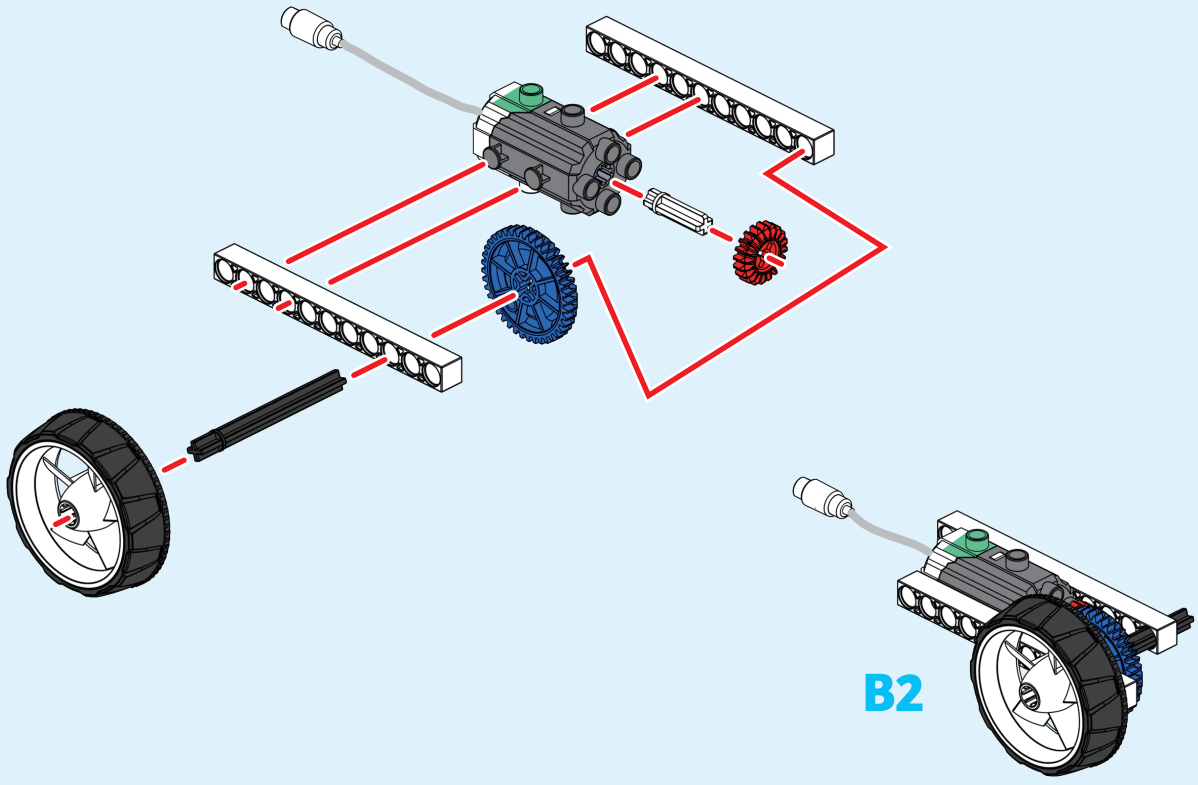

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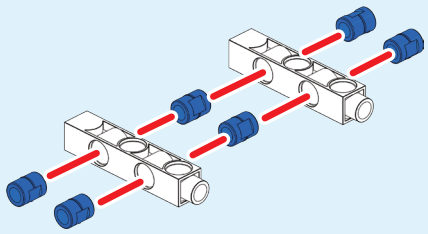

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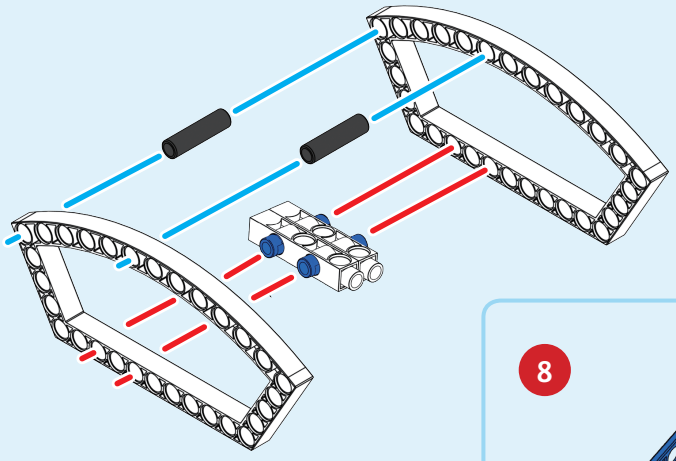

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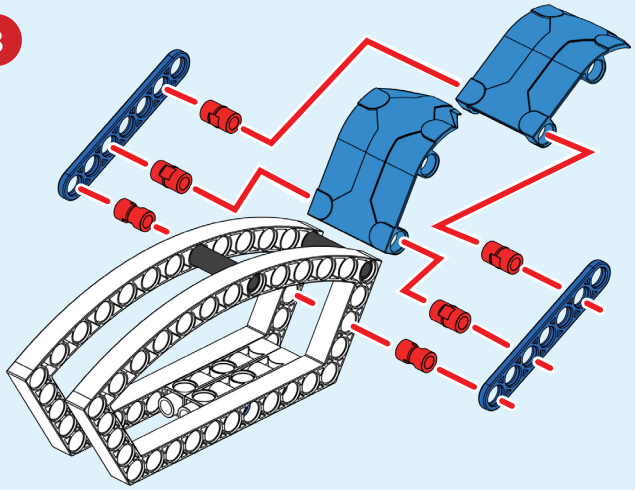
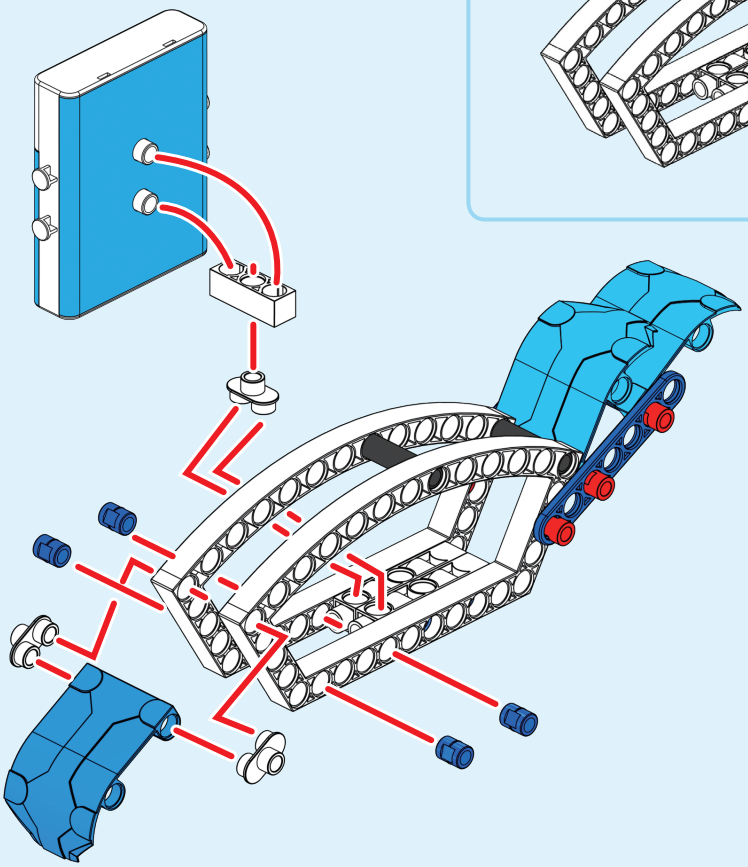


Now insert 4 batteries.

9



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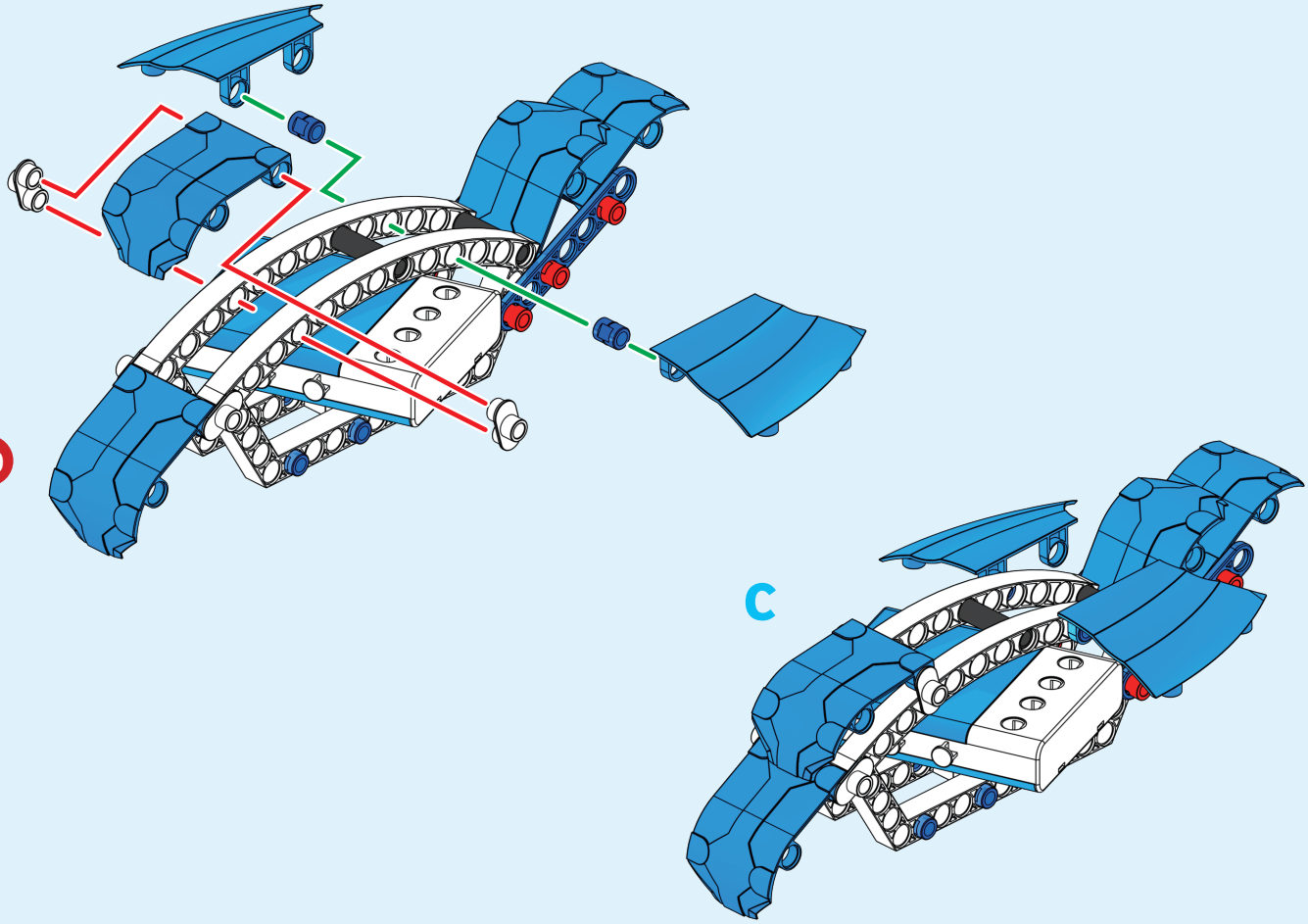

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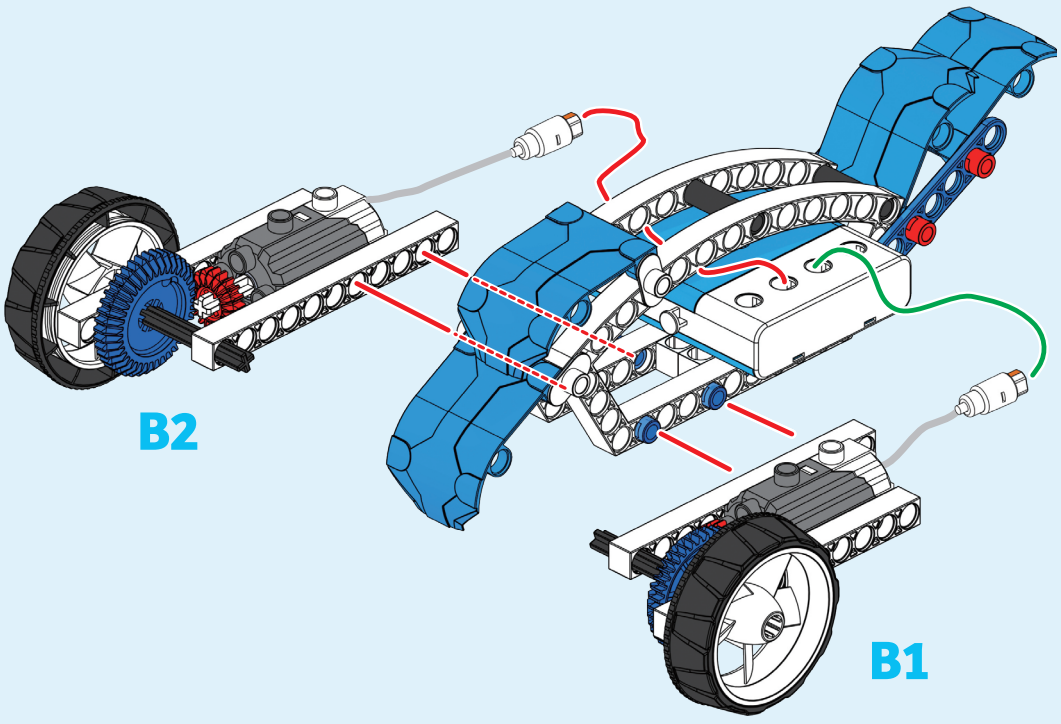

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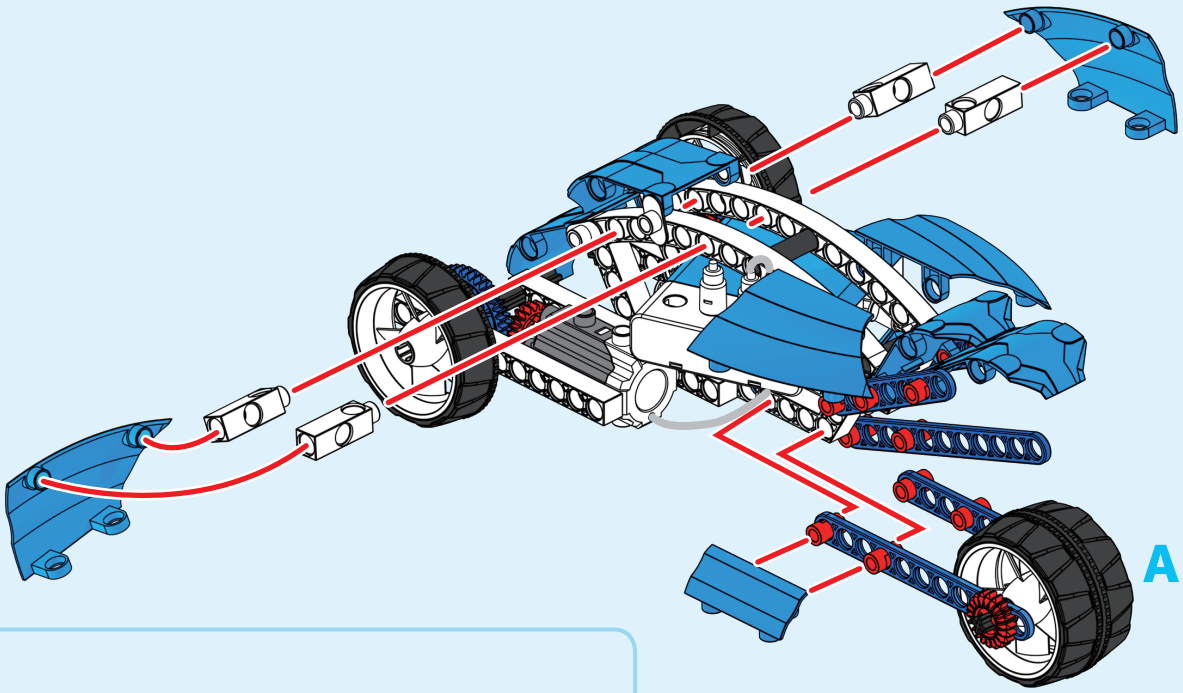

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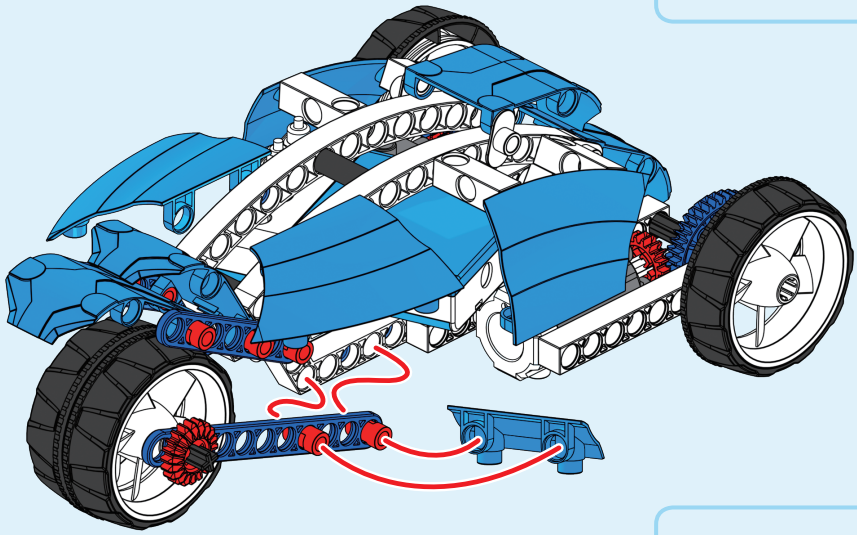

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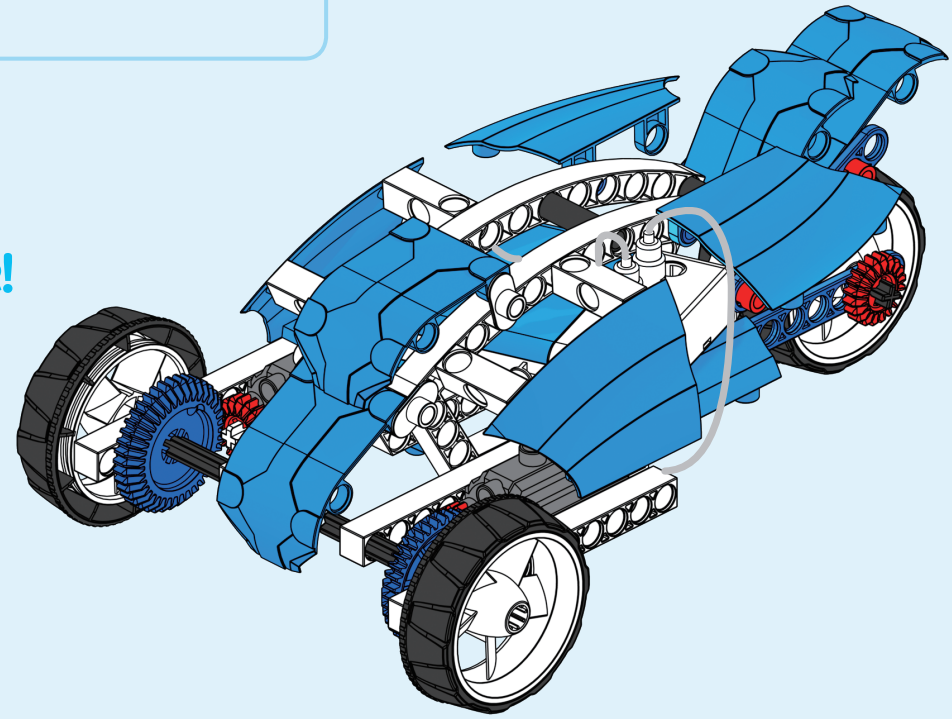
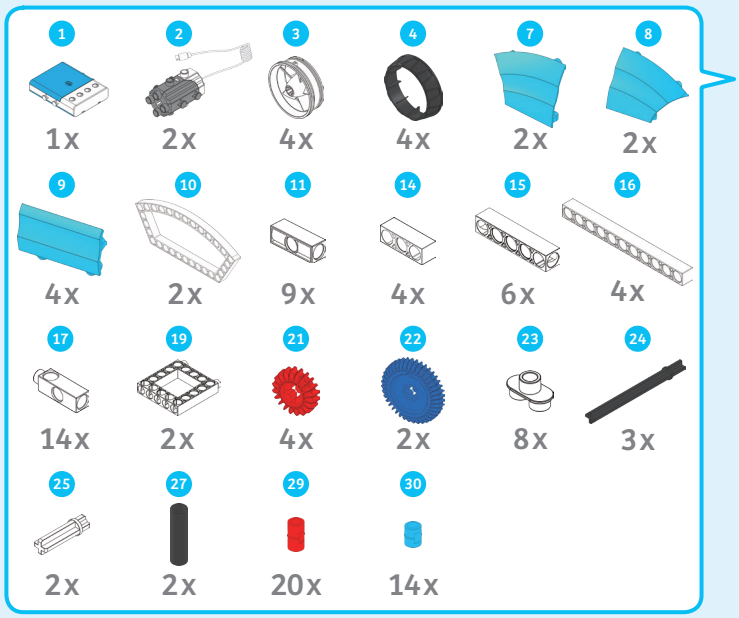


FORKLIFT



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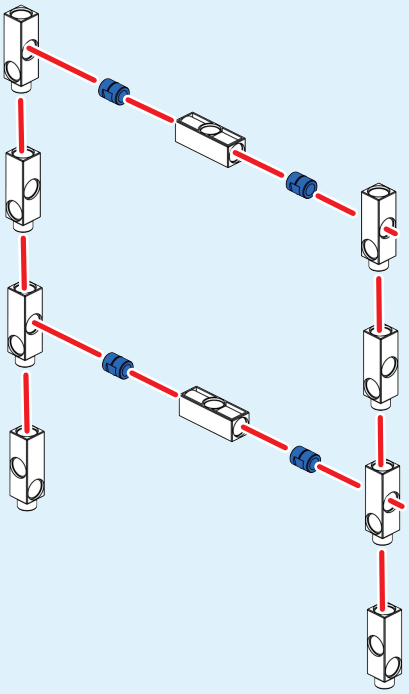

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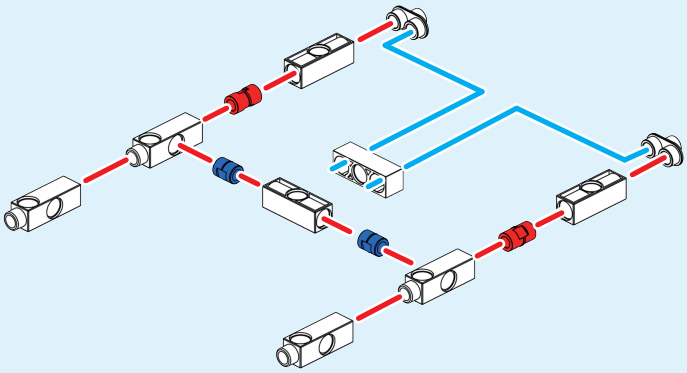

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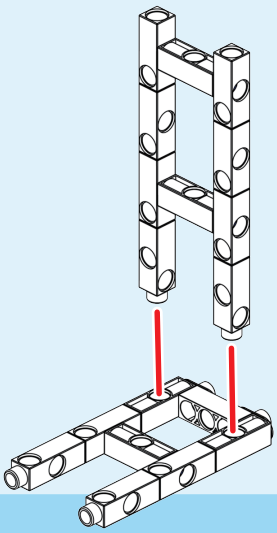

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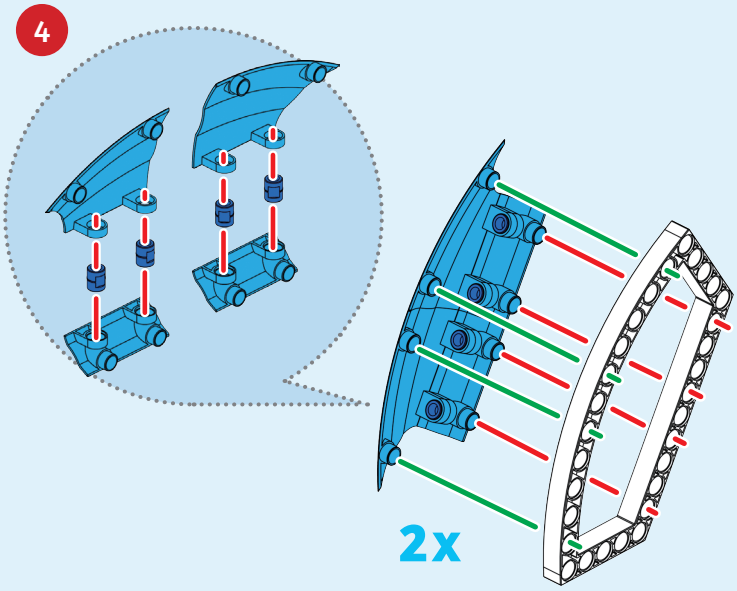

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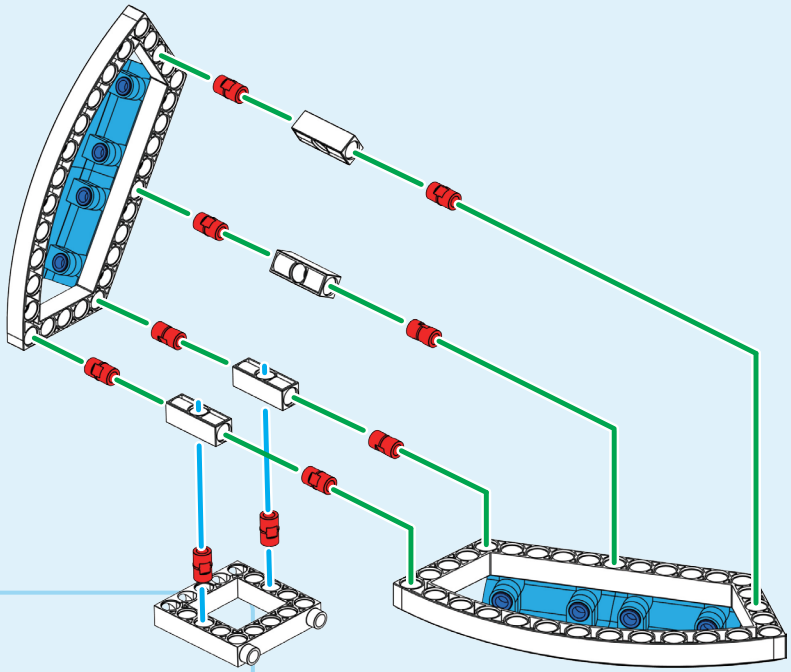

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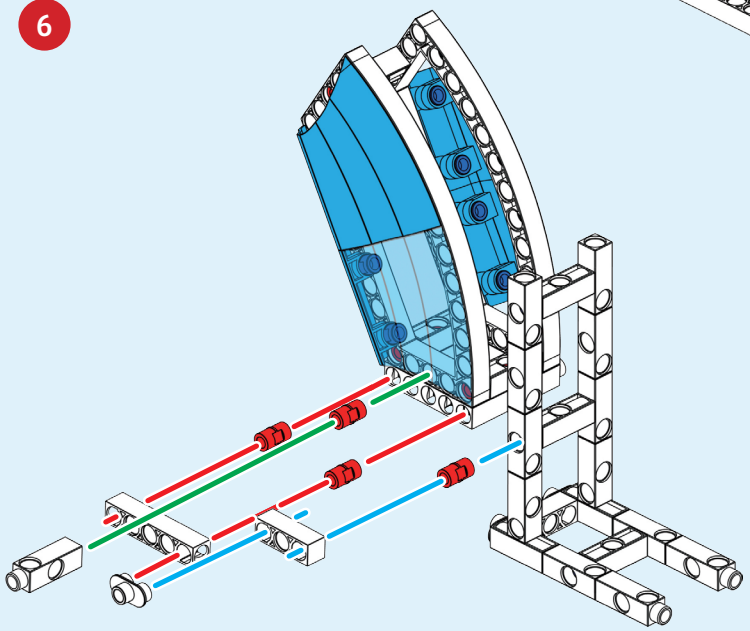

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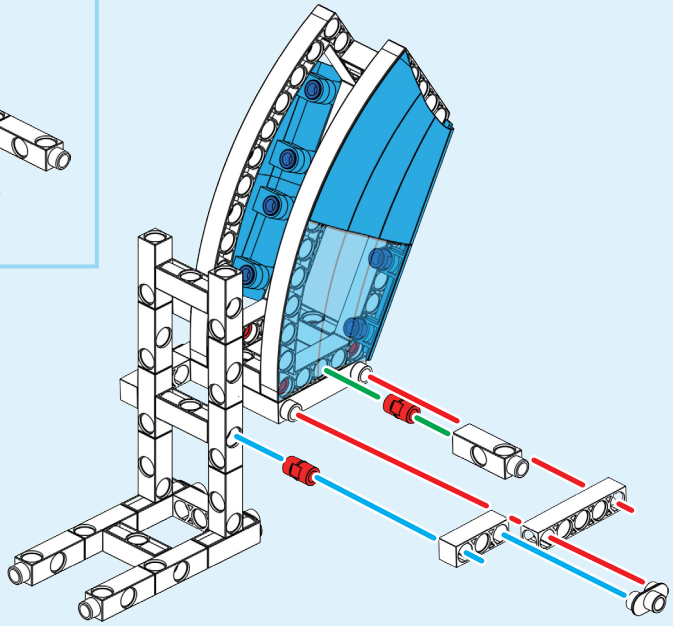

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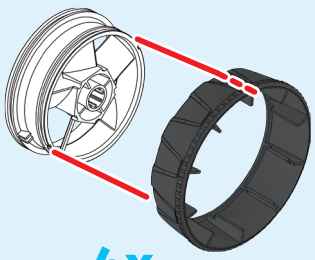

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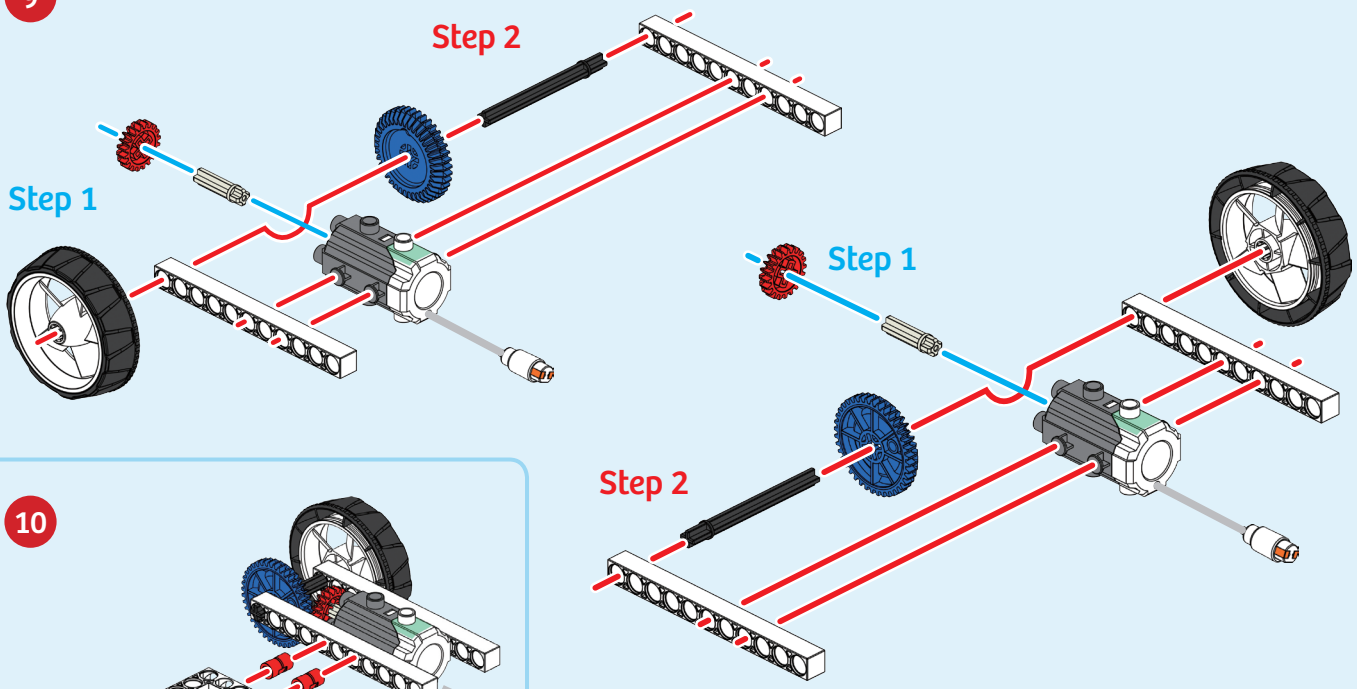

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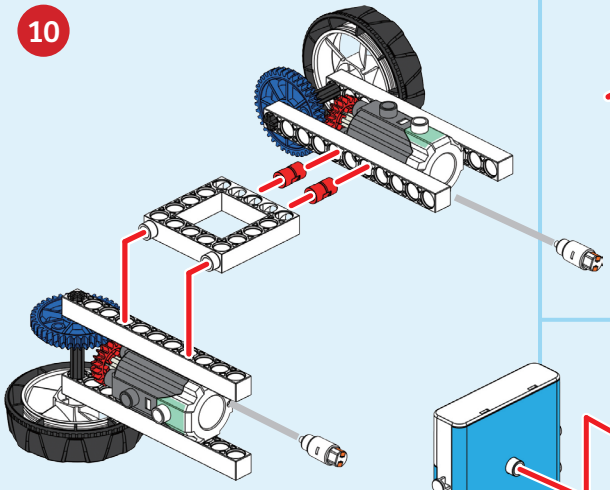

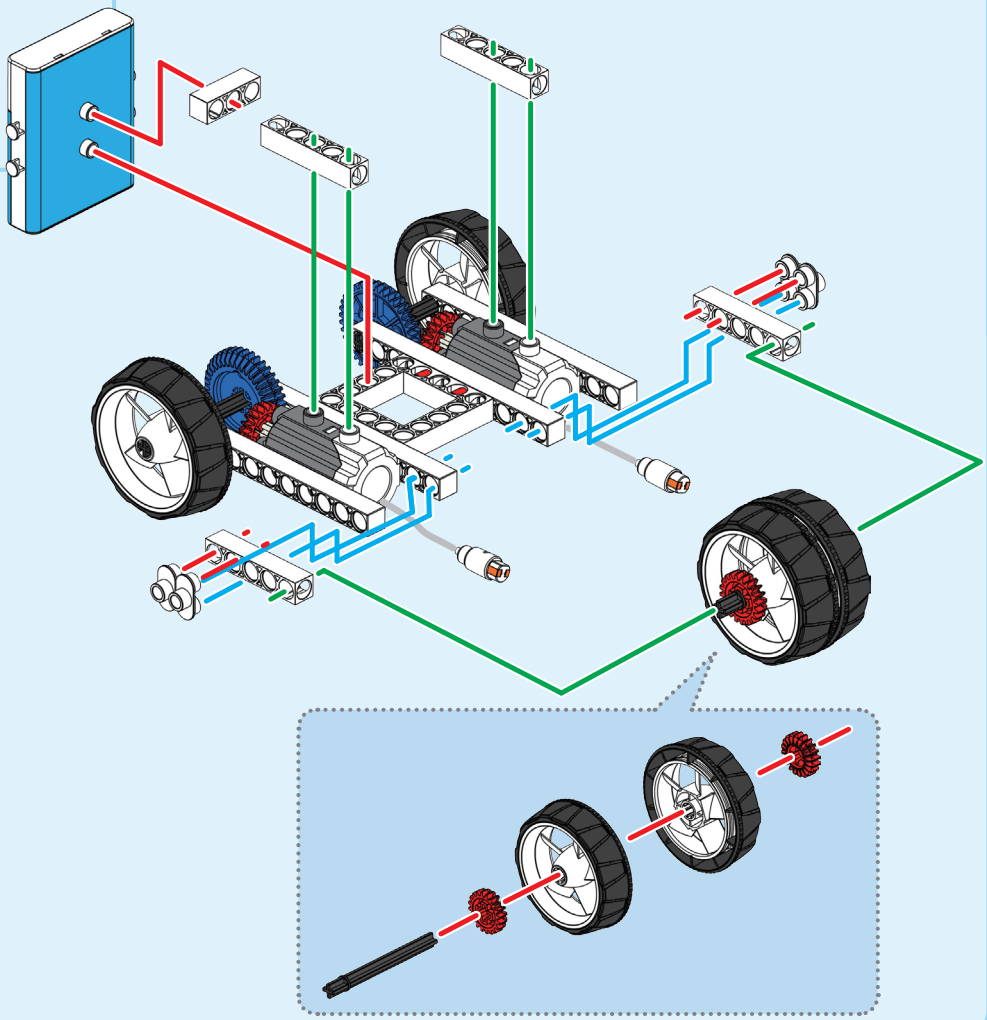

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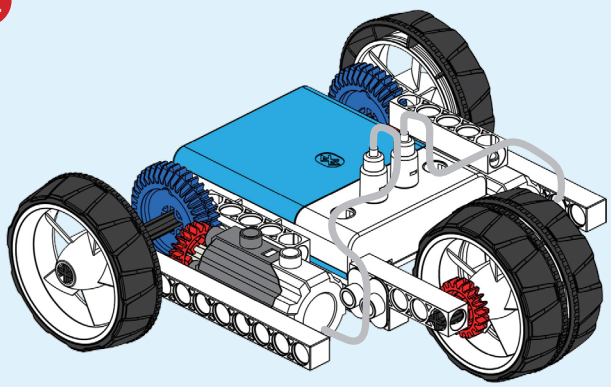

Now insert 4 batteries.

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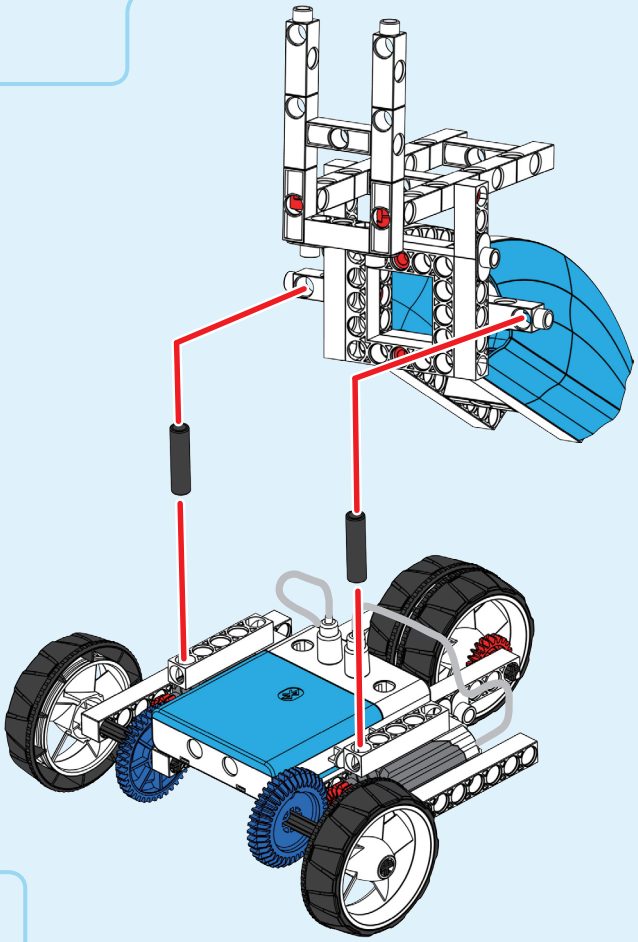
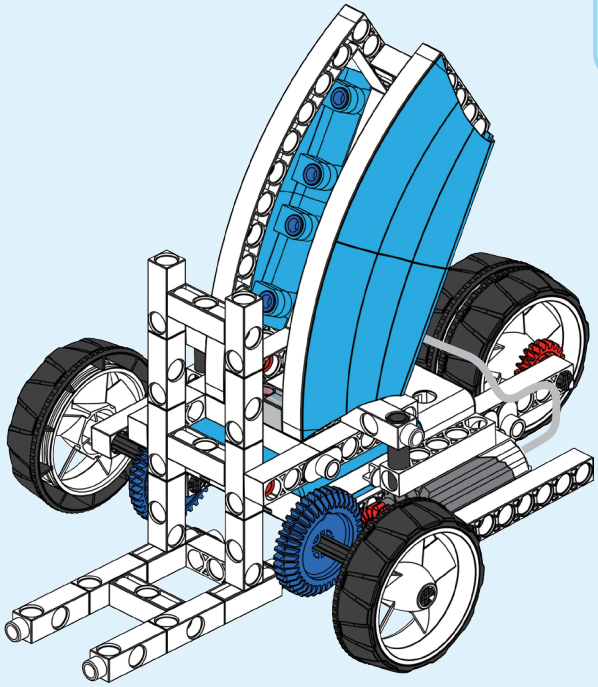
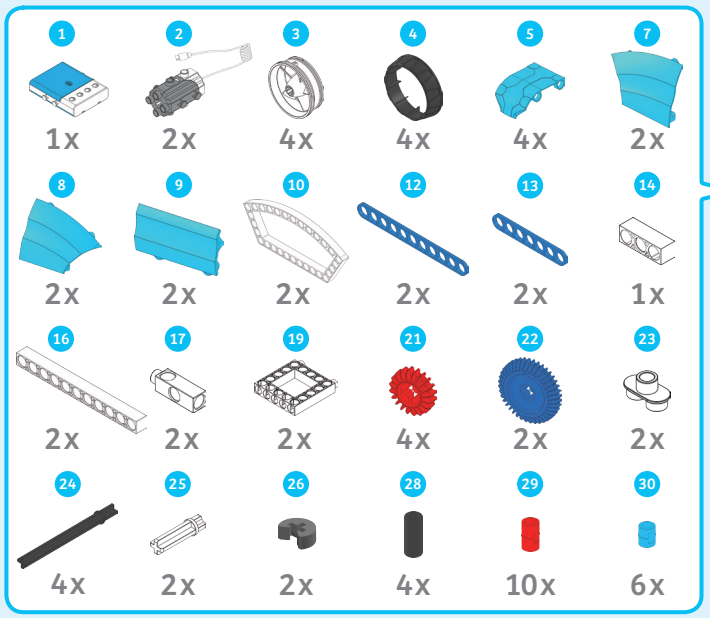
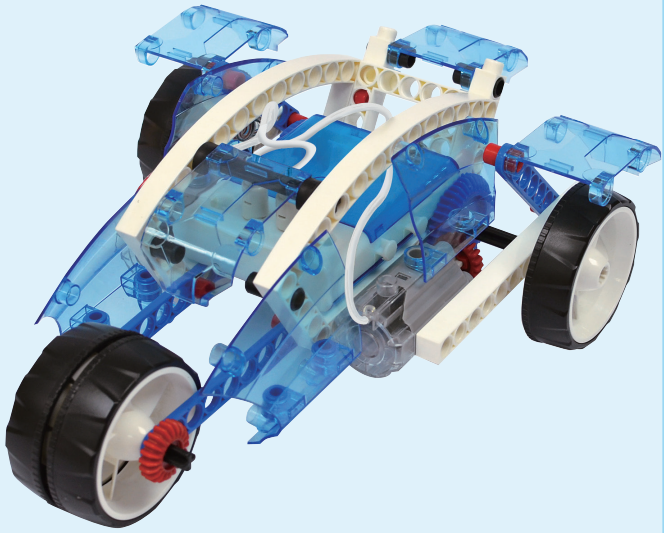




Done!

CAR OF THE FUTURE





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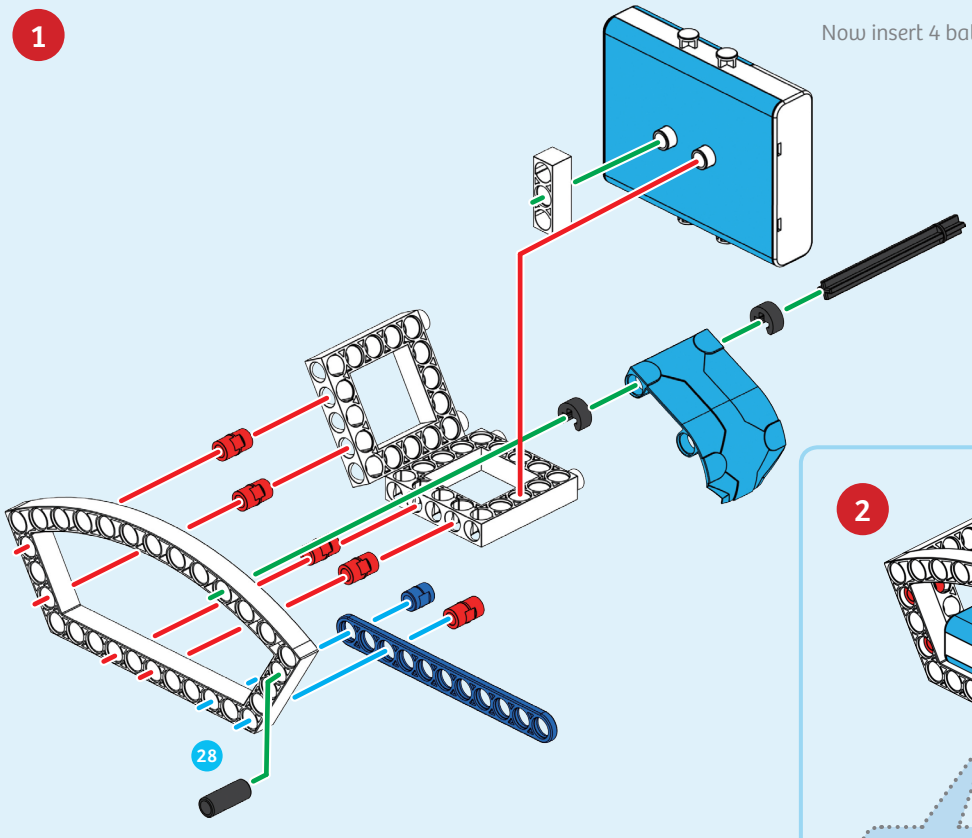
Now insert 4 batteries.



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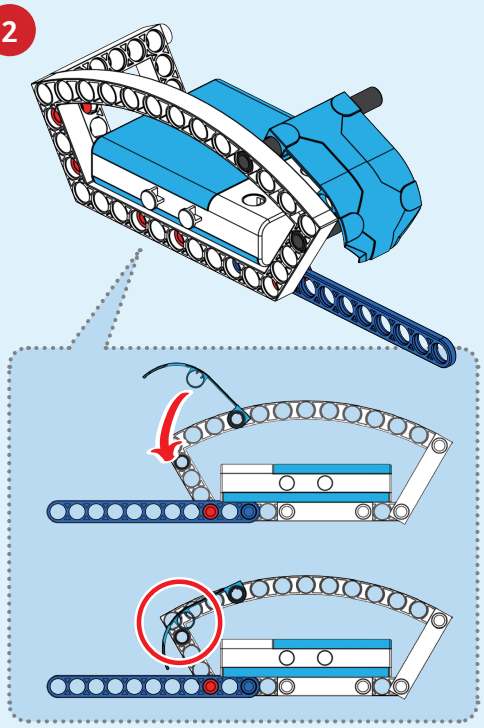

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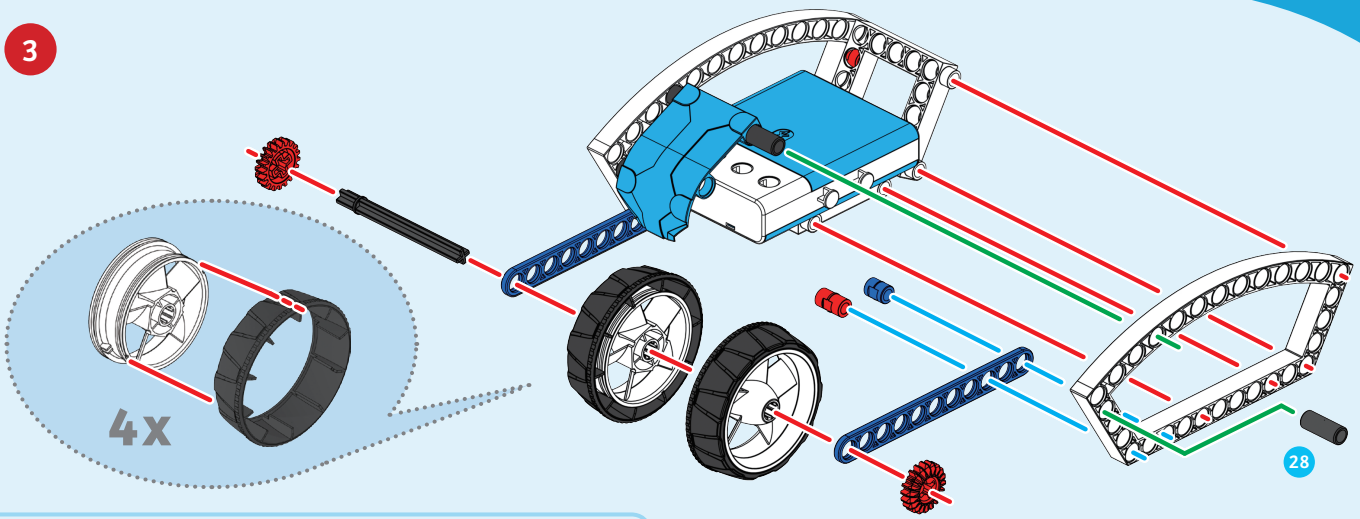

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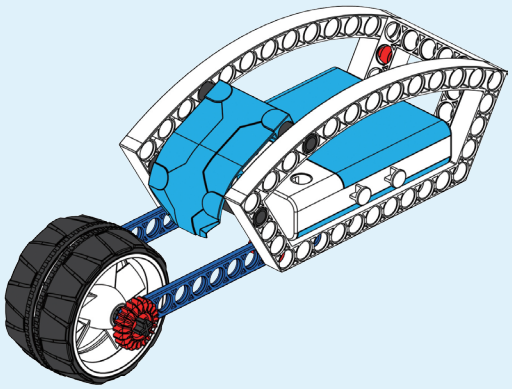

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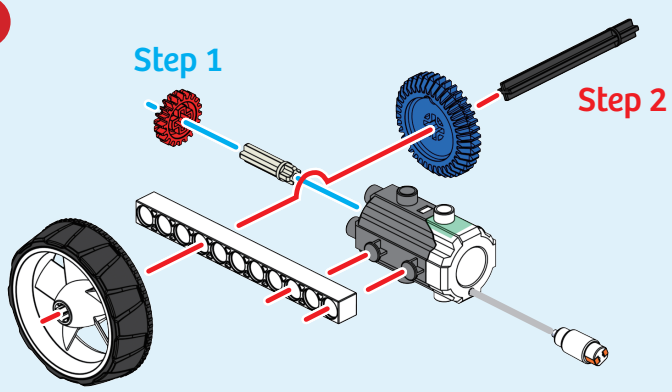

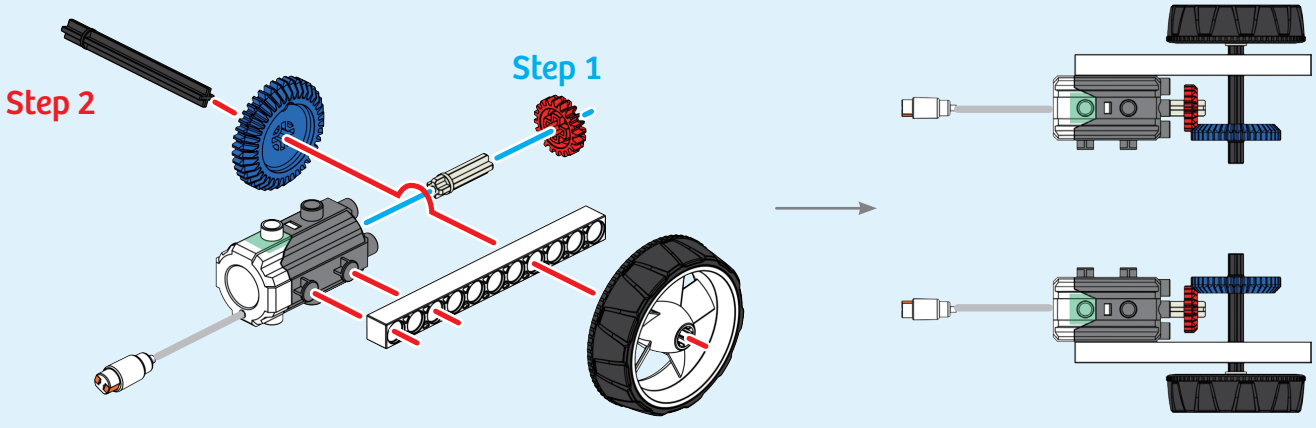

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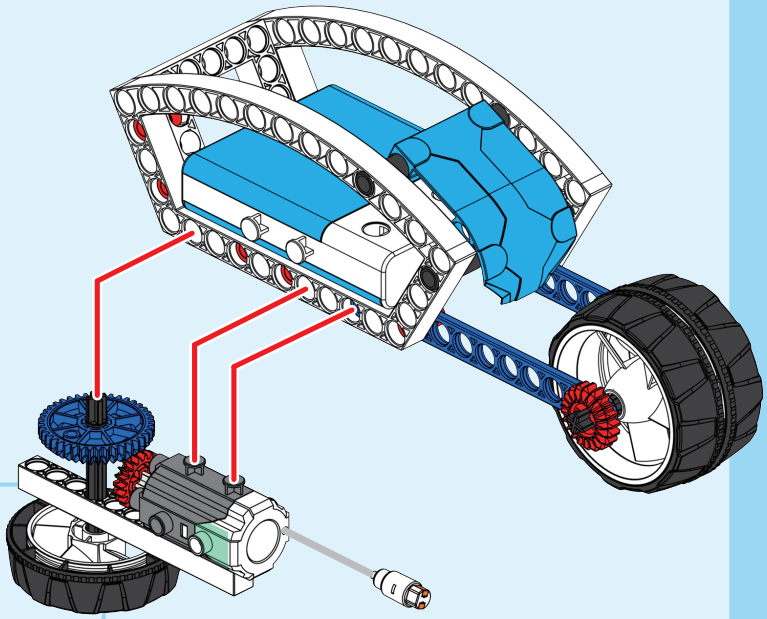

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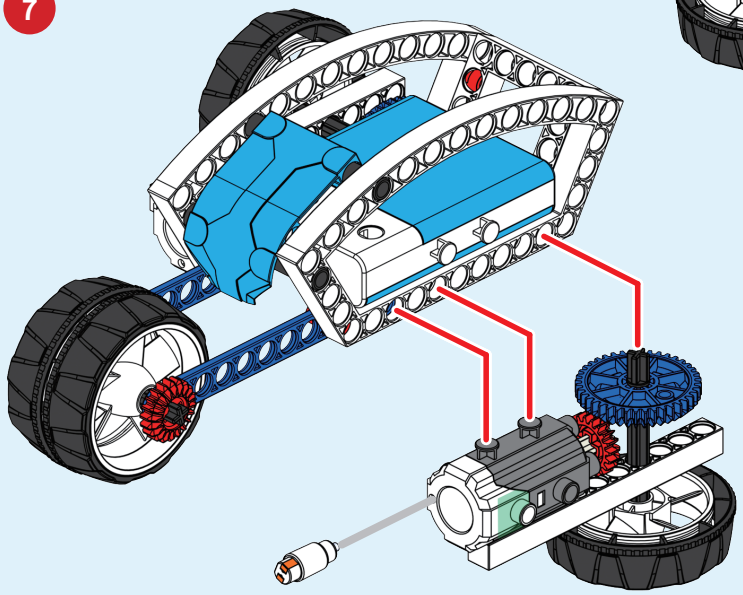

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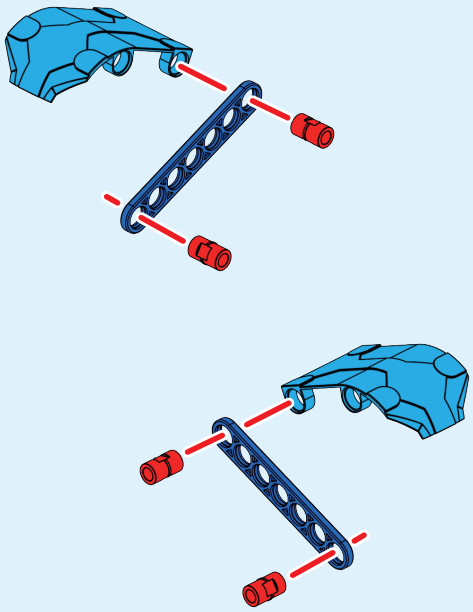

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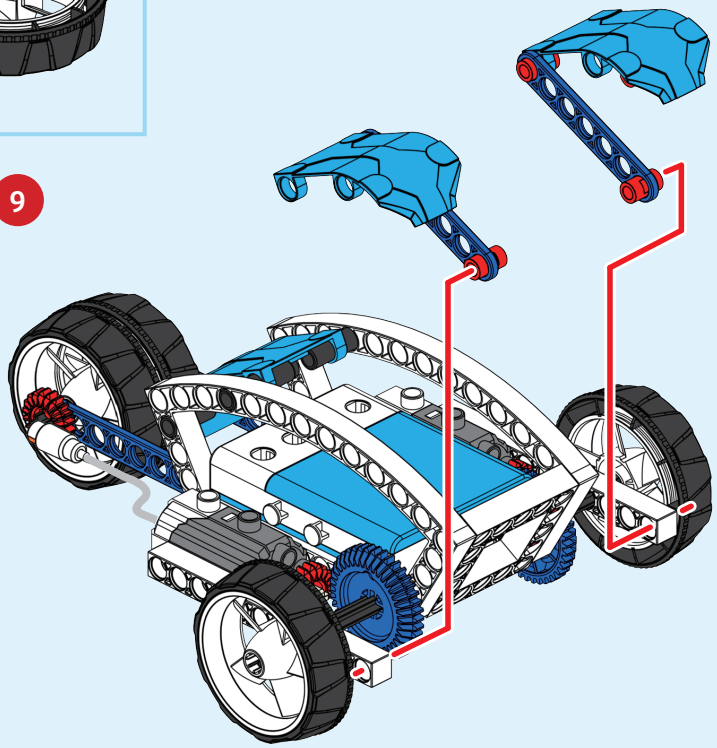

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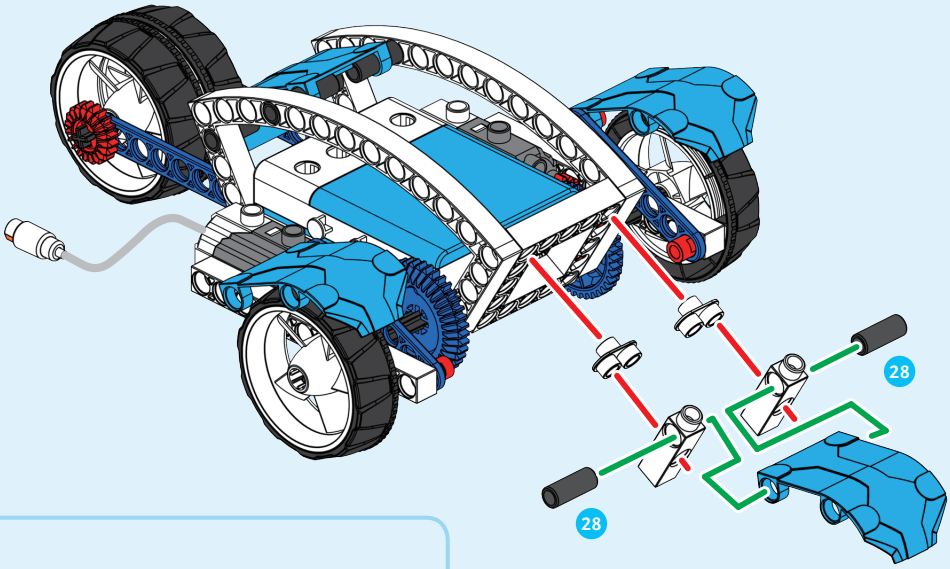

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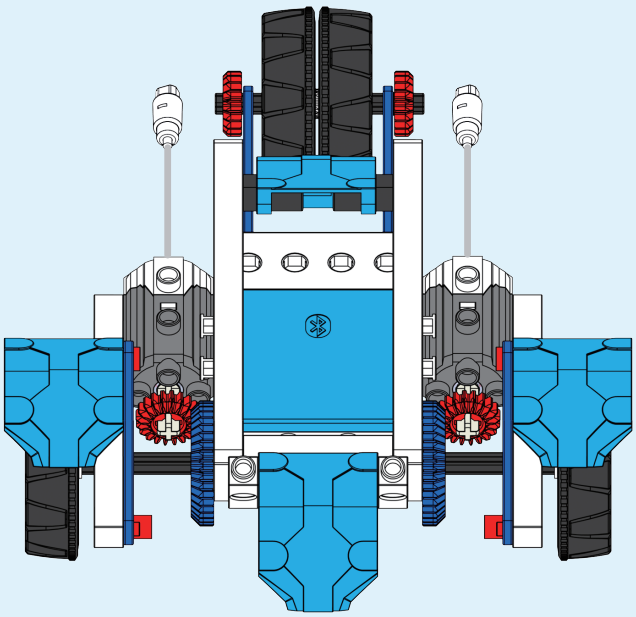

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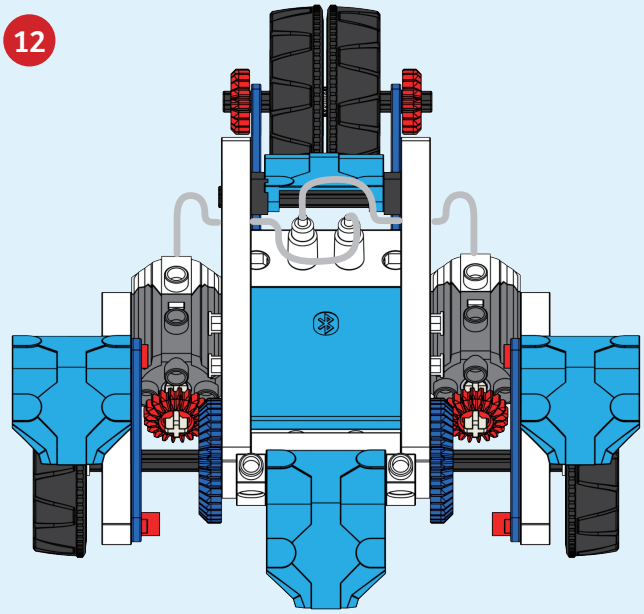

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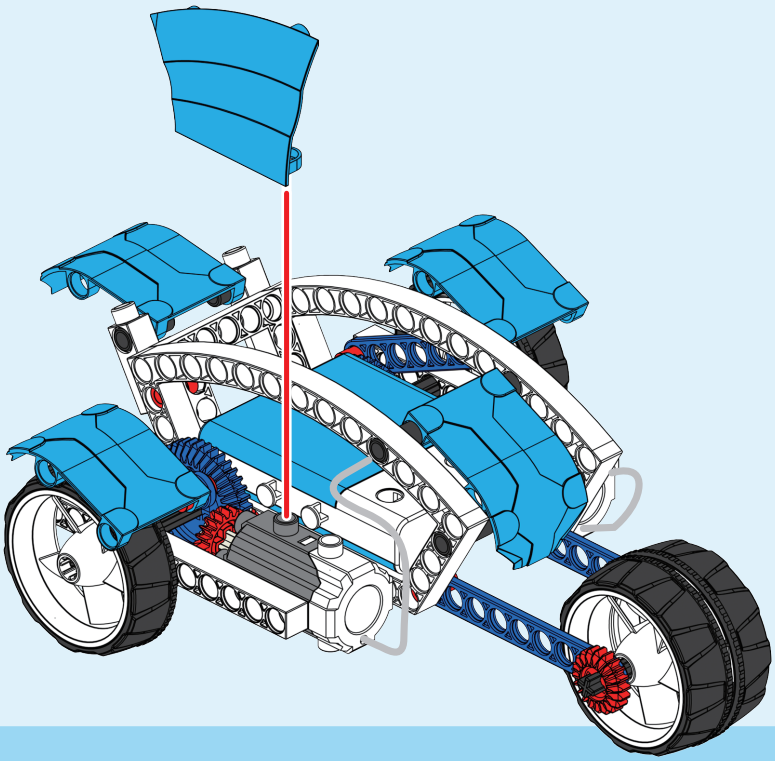

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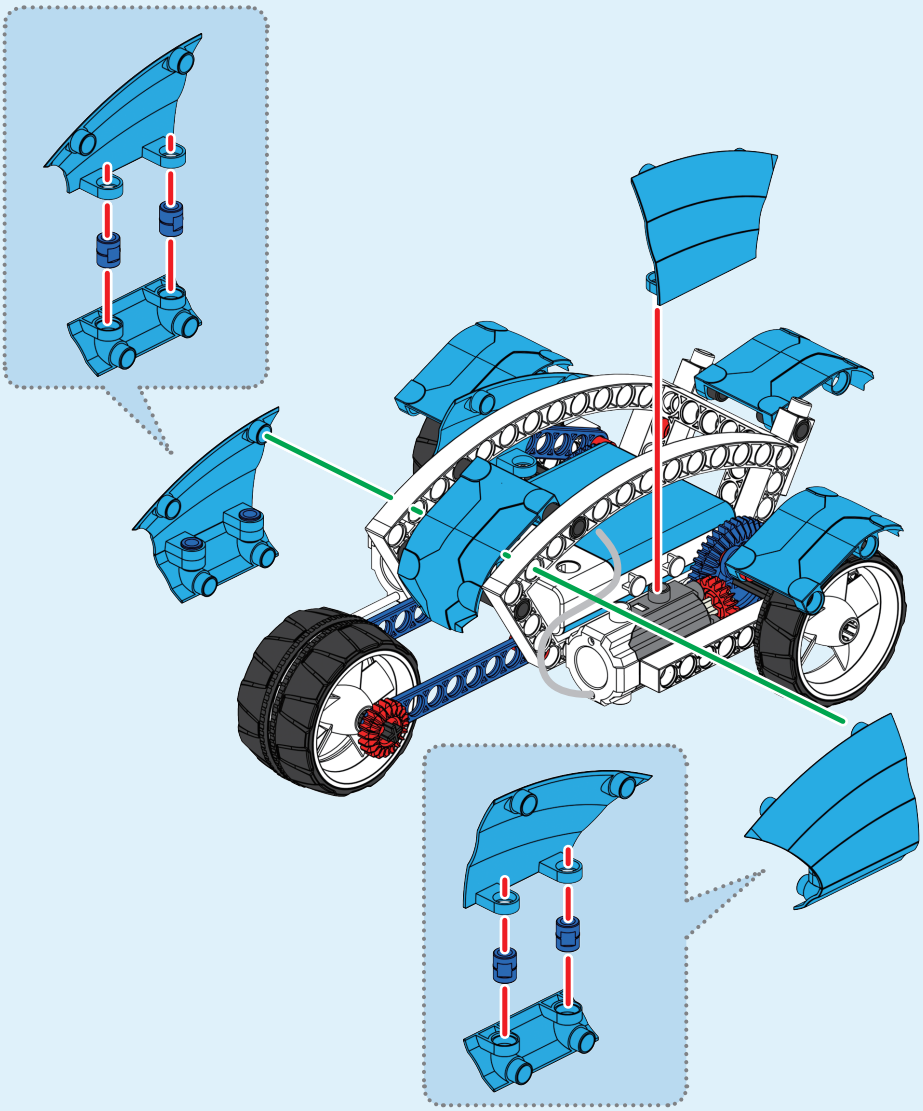
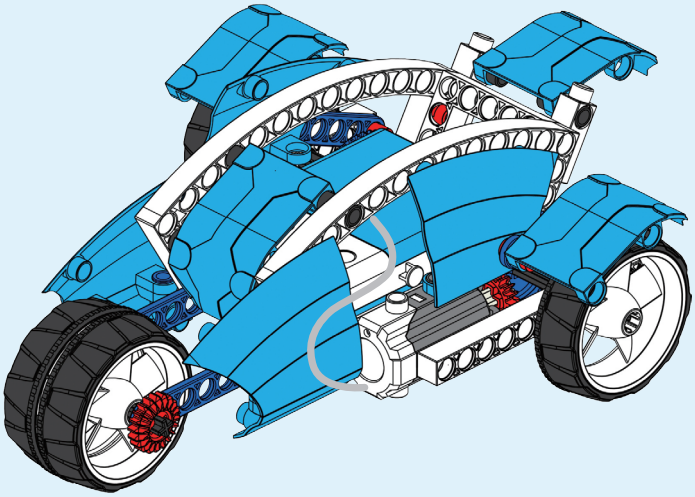


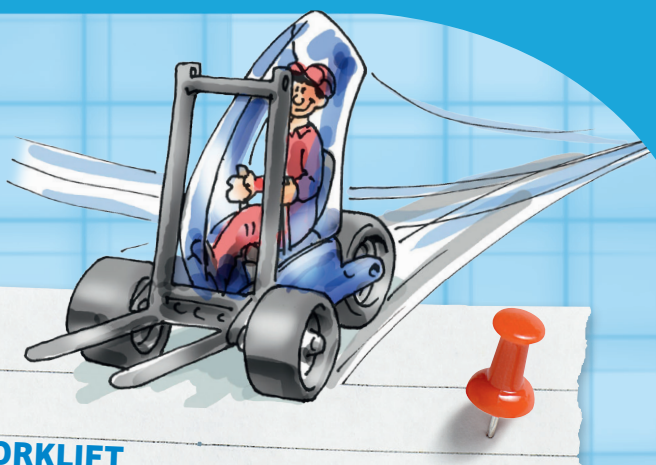


Done!

CHECK IT OUT

A three-wheeled motorcycle?

Does such a thing actually exist? Yes, and it has for a long time. The French inventor Gustave Trouvé built a motorcycle with three wheels all the way back in 1881. And that wasn't the only amazing thing — it was also the first officially recognized electric vehicle. His electric three-wheeler had a rechargeable battery, just like cars that use the most modern drive technology today (see page 63).



FORKLIFT

Two impressive facts will prove to you the astonishing things that forklifts can do.

A lot of models can lift between 1 and 8 tons up to 6 meters in the air. That would be the equivalent of between 1,500 and 12,500 of your smart cars!

The second record has to do with speed. You wouldn't think by looking at a forklift that it could mix it up with a purebred sports car, but it can. You just have to convert it a little, or — more precisely — you have to install its engine in a cart. A model like that can accelerate from 0 to 100 km/h in under three and a half seconds. That's a world record!

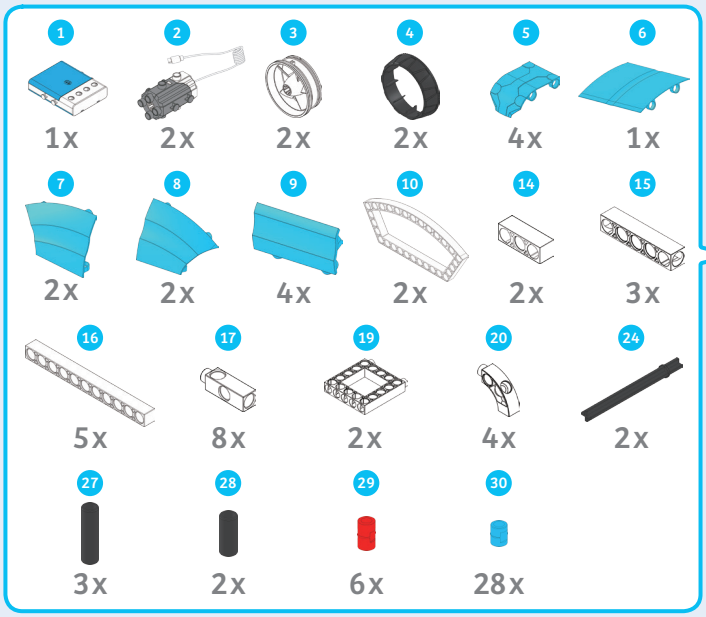
AND A CAR WITH THREE WHEELS?

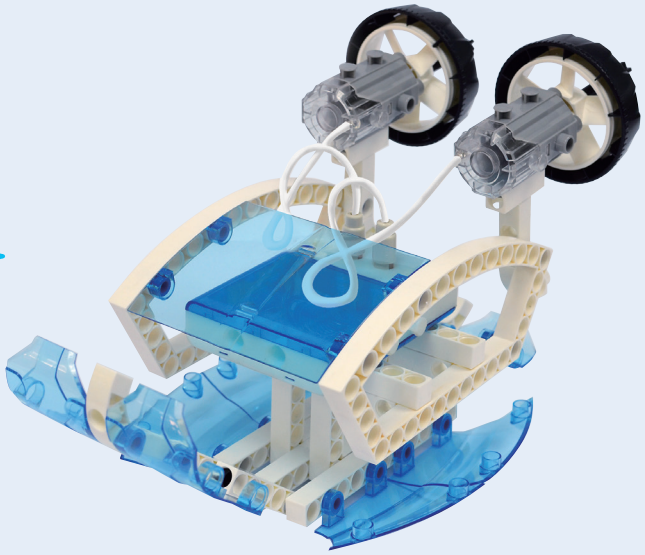
That's been done, too: The Reliant Regal was a small three-wheeled car from England, produced from 1952 to 1971. It was even legal to drive one with a motorcycle license. It also became famous as a sort of film star: In the "Mr. Bean" television comedy, the title character often clashes with a Regal Supervan III — tipping it over, driving into it, and pushing it out of parking spaces.

Programming

There are even more things to be discovered in your experiment kit box: a boat and three "flying models." They can't exactly float or fly, but they are true programmable "concept" models. You will be able to control each individual motor with the app. In a few years, we may also be able to program cars, boats, or airplanes to guide them on their way to their destinations. Let's get building!

AIRBOAT





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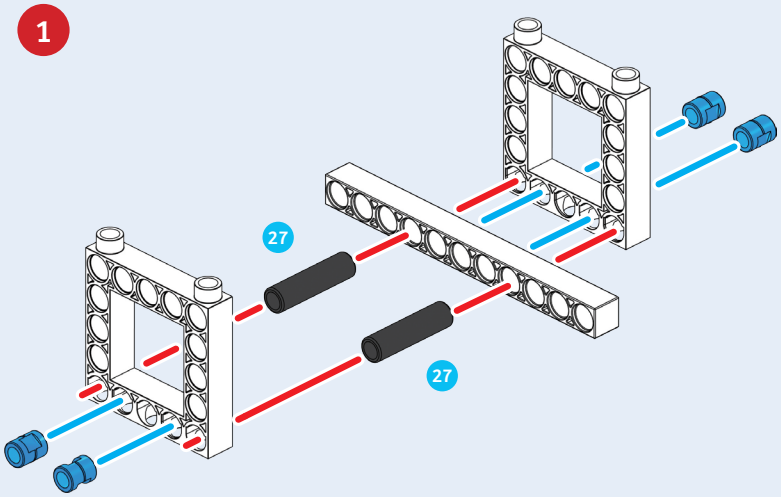

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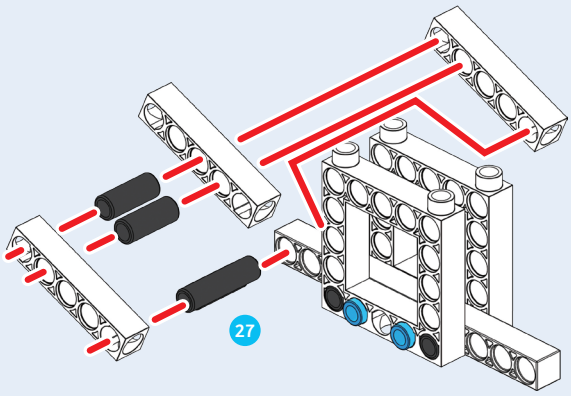

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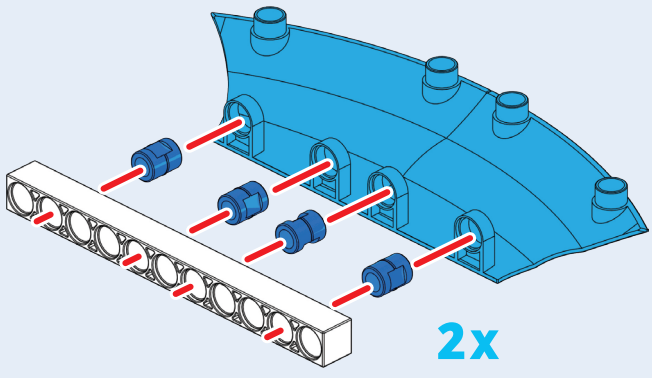

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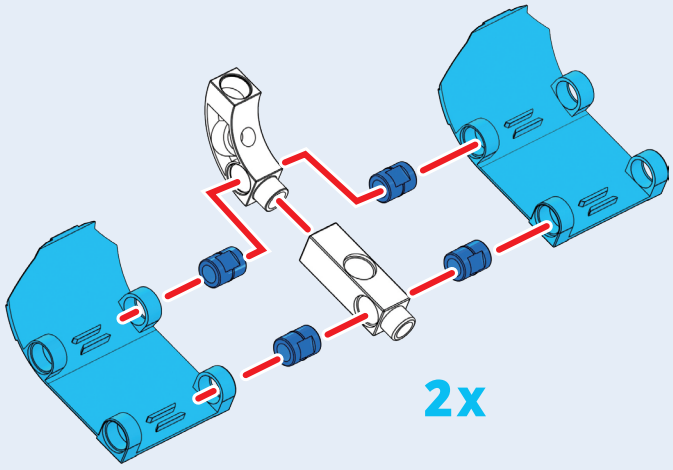

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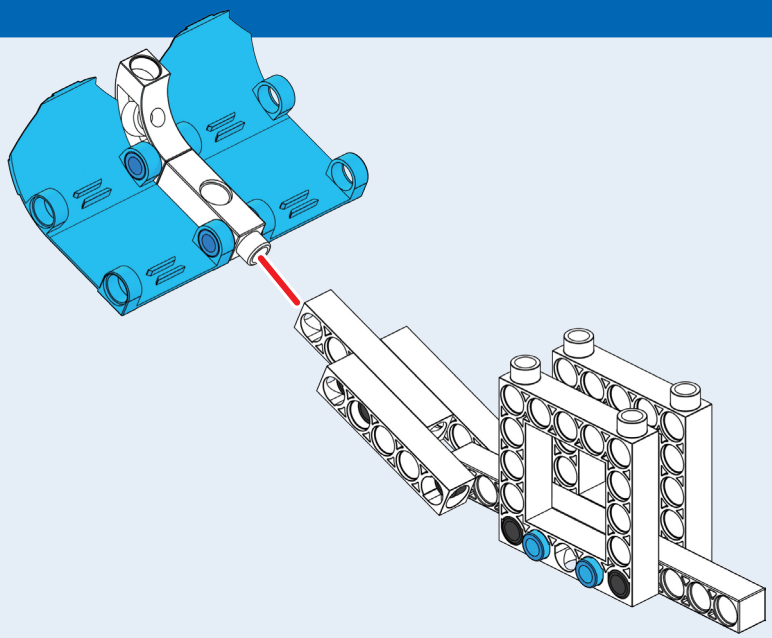

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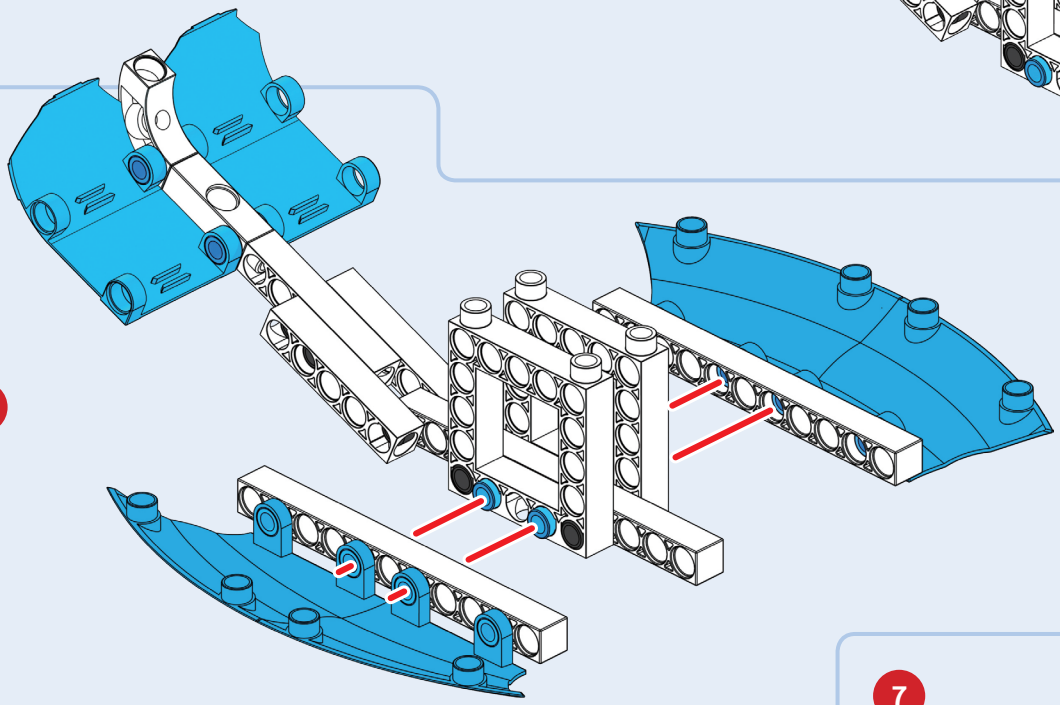

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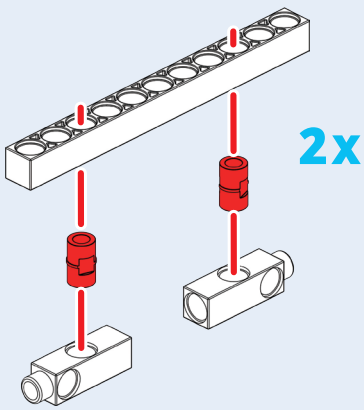

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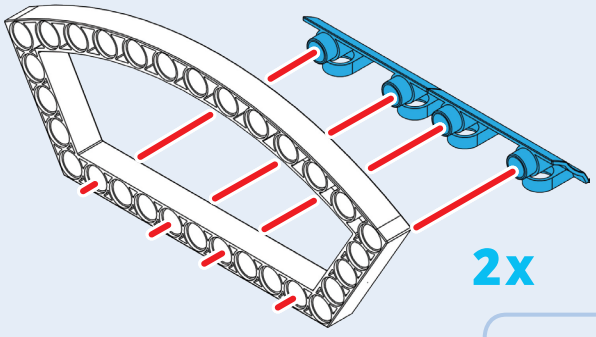

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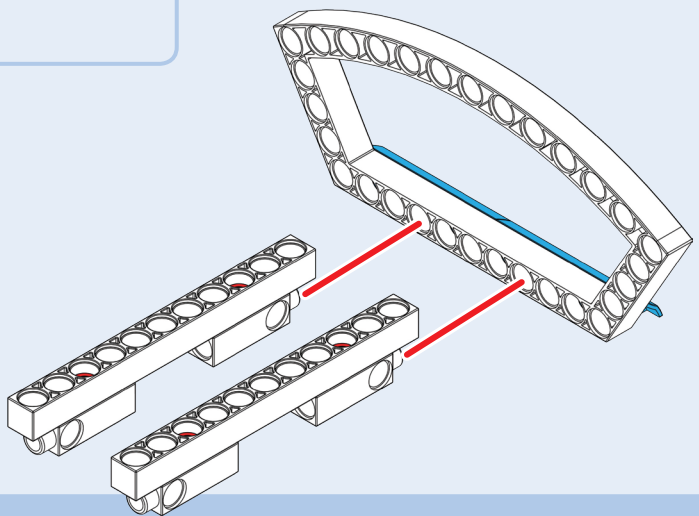

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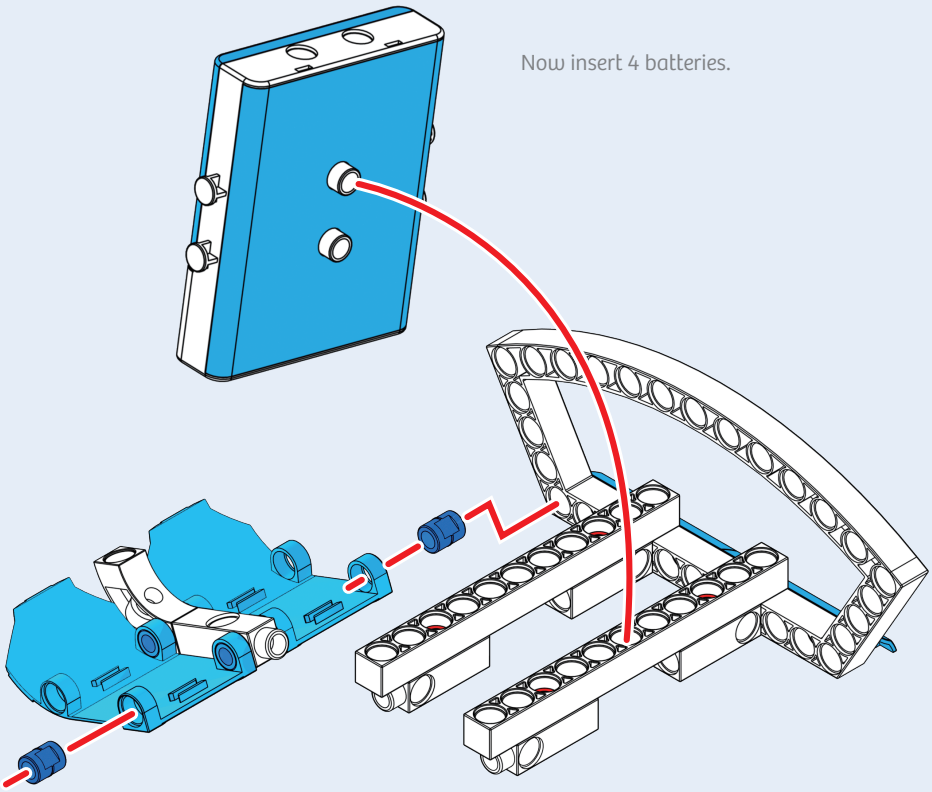
Now insert 4 batteries.



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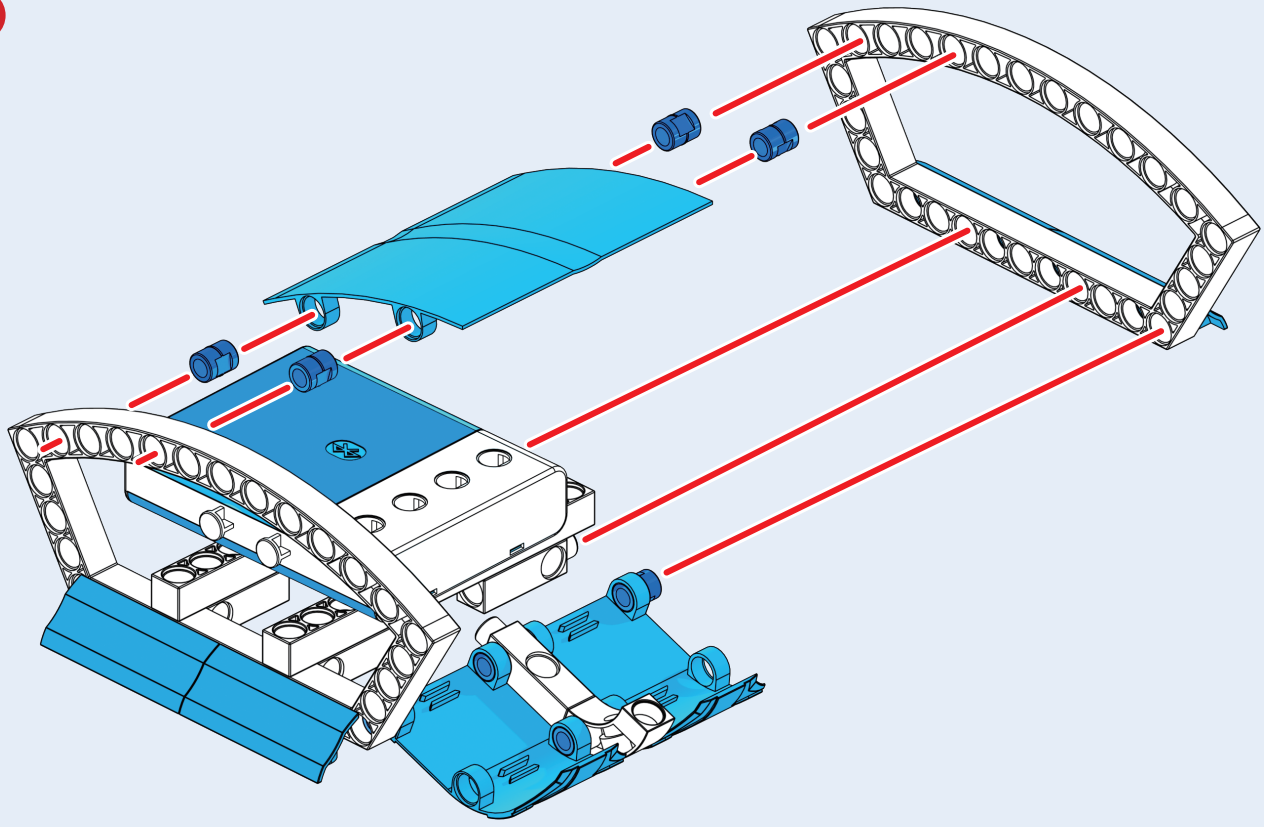

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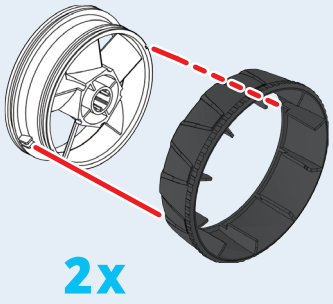

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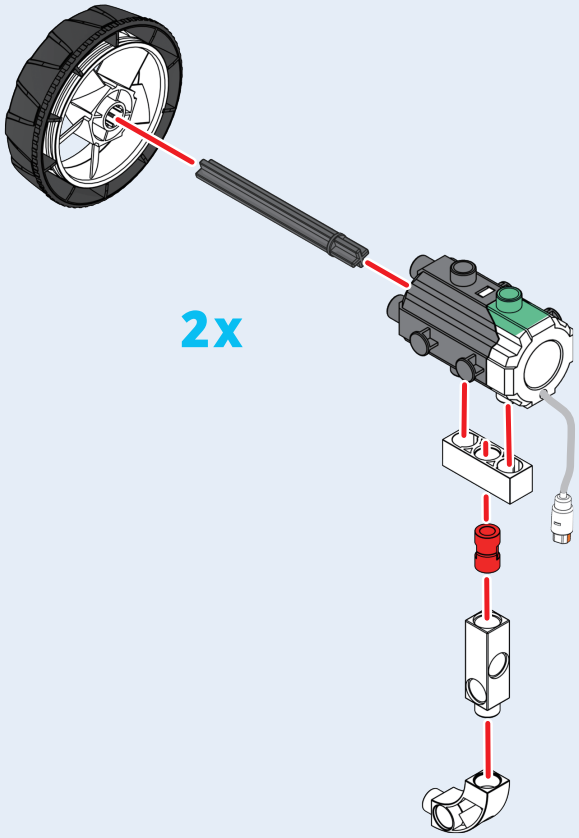

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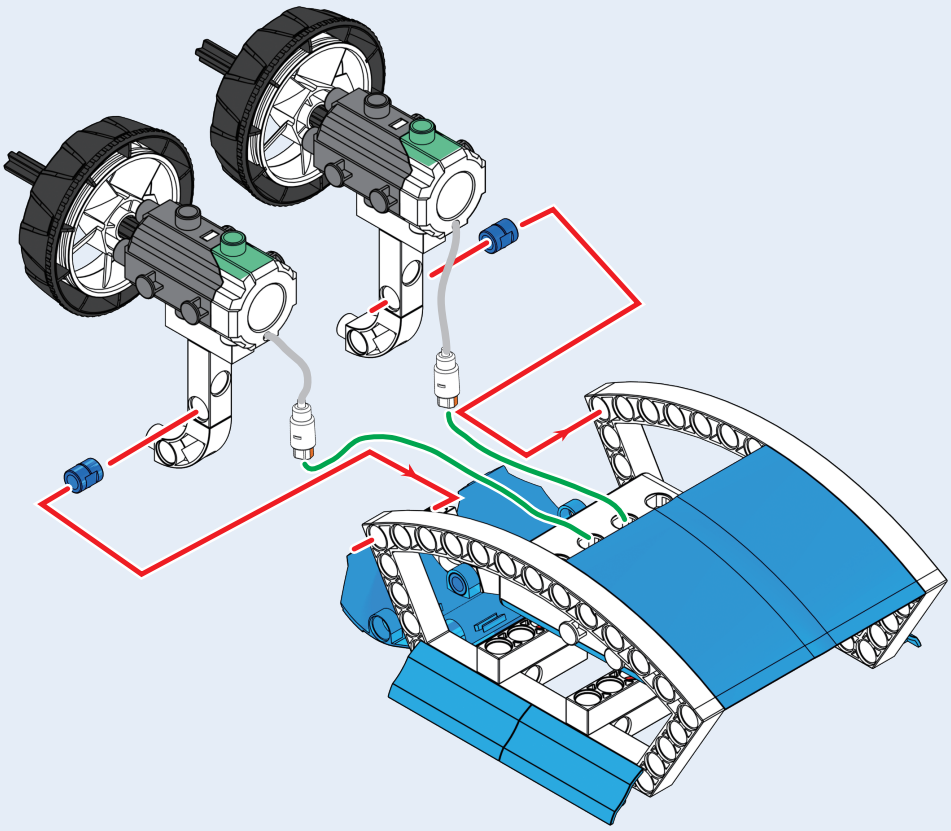

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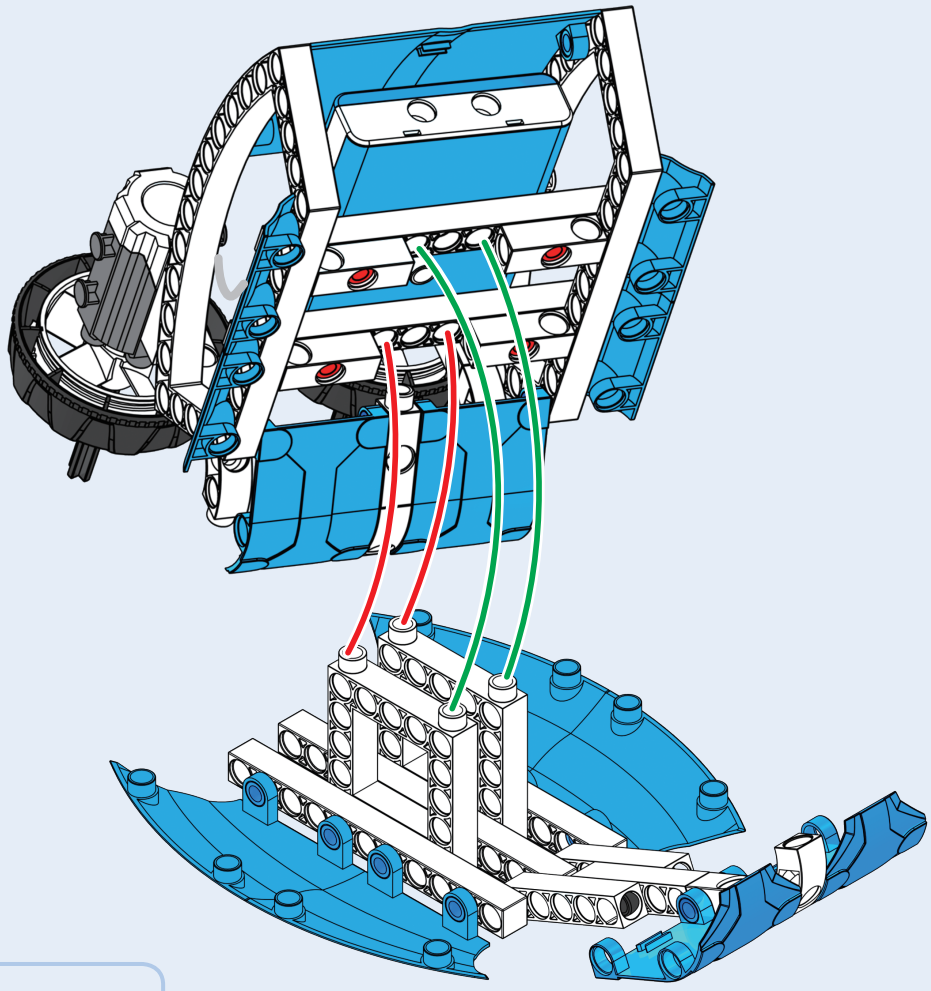
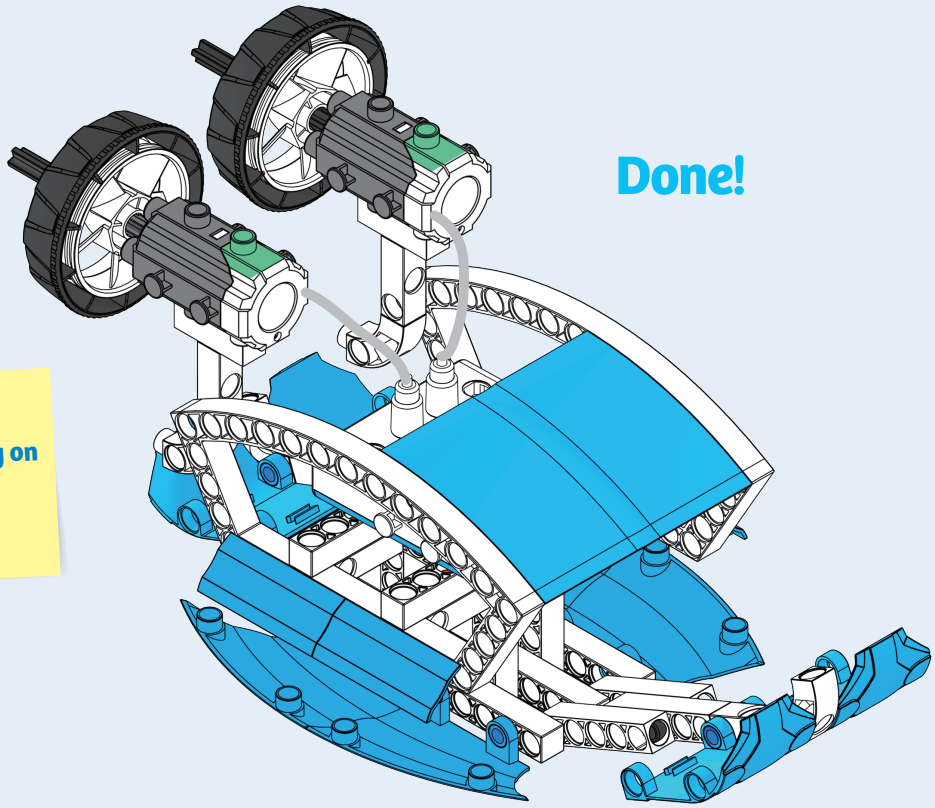




Done!

TIP!
Use the model only on land, not in water!

The next step: programming

YOU WILL NEED

› **The assembled airboat model**
› **Smart car app**
› *Smartphone or tablet*
› *4 Batteries*

HERE'S HOW

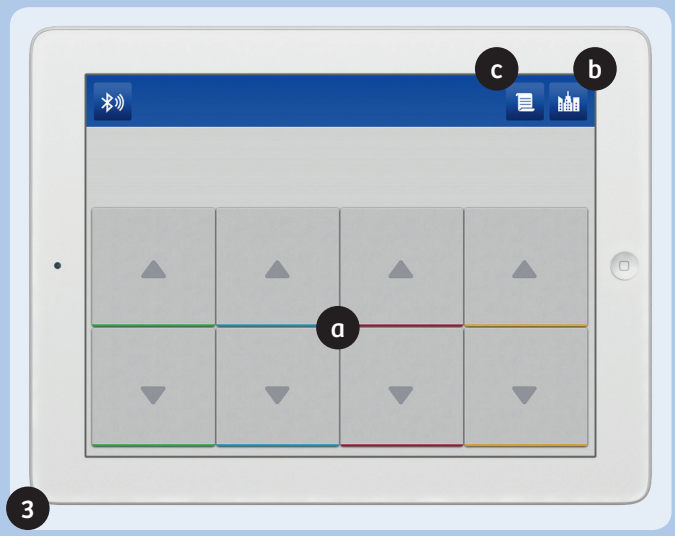
1. Check to make sure that all four batteries have been inserted correctly in the battery box and that the motors are properly connected.

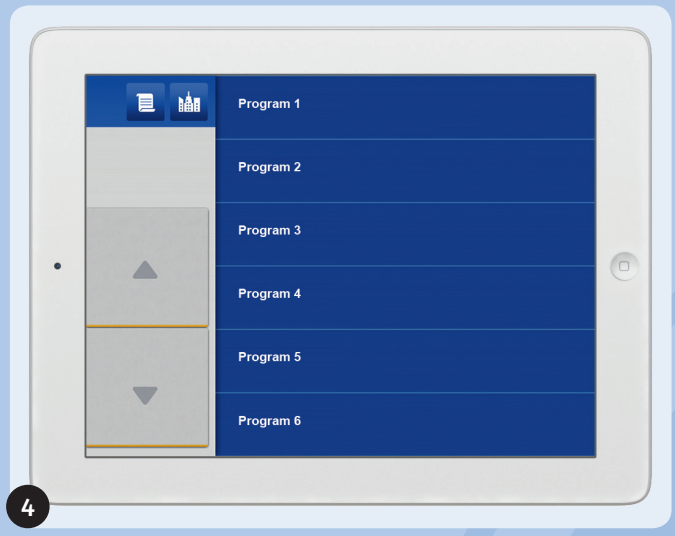
2. Start up your tablet or smartphone and the app. Connect the tablet/smartphone to the airboat via Bluetooth.

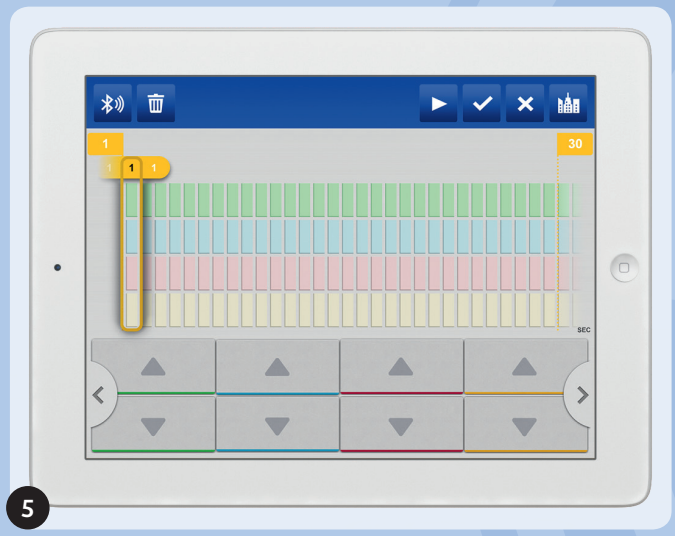
3. Tap on the programming button at the top right of the screen. That will take you to the programming mode.
   a. Use the arrow buttons to control each motor individually. **The arrow buttons indicate the direction in which the motor's drive shaft will turn. Looking at the motor from in front of the drive shaft, the up arrow turns the drive shaft clockwise, and the down arrow turns the drive shaft counterclockwise.** Try it! Now you also know which arrow button controls which motor.
   b. You can get back to AR mode by pressing the AR button.
   c. Use the script button to open a list of programs.

4. At first, all of these program scripts will be empty. Inside the individual programs, you can create, run, change, save, or delete your program commands.

5. When you tap on a new program, it opens a new empty time scale. You can slide the time scale left or right with your finger. Each vertical column of green, blue, red, and yellow cells represents one second of running time. In the time scale, you will see a yellow frame that indicates which second(s) you will program when you tap the arrow buttons below it. You can move this frame to the left or right, or expand or shrink it, depending on which second(s) you want to program. You can expand or shrink the frame by clicking and dragging on the yellow tabs at the top of the frame.







You can move the entire frame to the left or right in second by second increments by using the left and right arrow buttons at the bottom of the screen.

6. Now you can use the control panel with the eight arrow buttons to program your model's individual motors in one second increments.
7. The program can last up to a total of 3 minutes, or 180 seconds.
8. Ready to run the program? Place the frame on second 1 and press the play button. Off you go!
   In principle, you can start the program at any point. Do you see how the control panel displays the running program by highlighting each arrow button as the program runs?
9. This image shows how a profile of a model might look if it's running all four motors.
10. If you call up a program script that you have already saved, it will open at the point (at the second) where you last closed it.

9

WANT TO KNOW MORE?

You can also use all of these functions with the helicopter, airplane, and flying car models. Of course, you can program your smart car and other driving models as well. Then they will drive all by themselves!

IMPORTANT!

The arrow buttons indicate the direction in which the motor's drive shaft will turn, not necessarily the direction in which the final output wheel or gear will turn!

TIP!

Important for the driving models: Always program each motor for every second in order to make the models drive well.

WHAT'S HAPPENING?

As soon as you enter a profile, you will find these functions in the bar at the top:

› Use this to clear the program. It deletes all of the commands in the program.

› This runs the program.

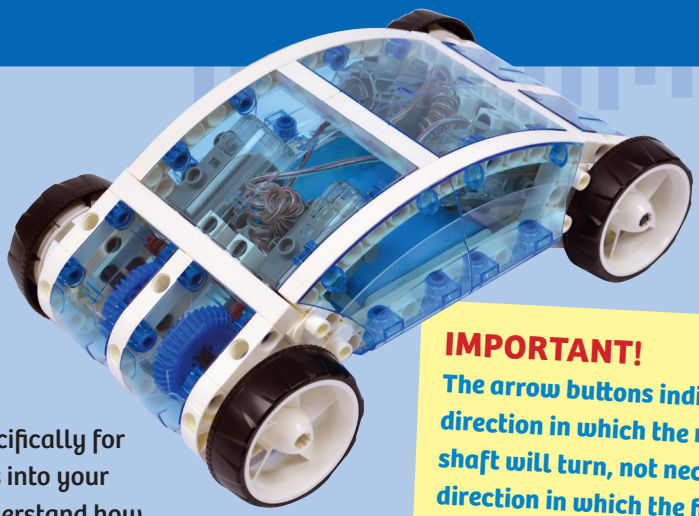
› Use this button to stop or pause the program.

› Save the program by pressing this button.

› Use this to close the program.

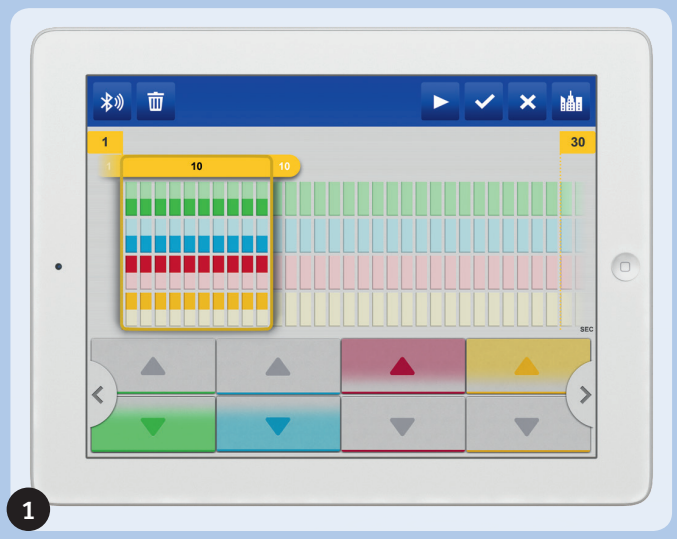
In this experiment, you wrote your own little computer program, which describes the temporal (second-by-second) sequence of commands for controlling the individual motors. This kind of program is also known as a script.

Example Programs for the Smart Car



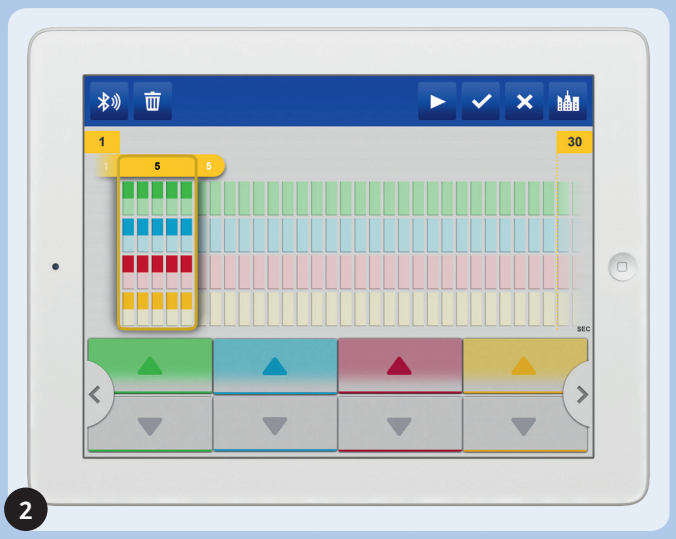
IMPORTANT!
The arrow buttons indicate the direction in which the motor's drive shaft will turn, not necessarily the direction in which the final output wheel will turn!

Here are some example programs written specifically for the smart car model. Copying these programs into your app and testing them will help you better understand how the individual commands turn each wheel of this model. Try these and then try writing your own programs!



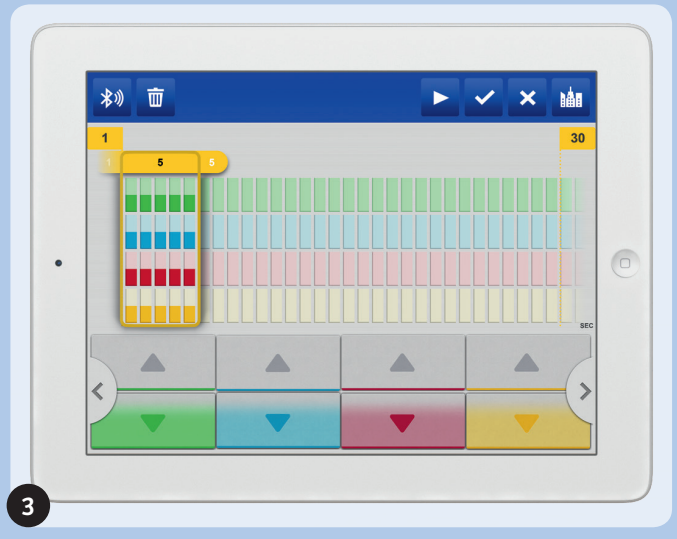
1

1. This program powers the two right-side motors counterclockwise and the two left-side motors clockwise for ten seconds, resulting in all wheels driving forward.



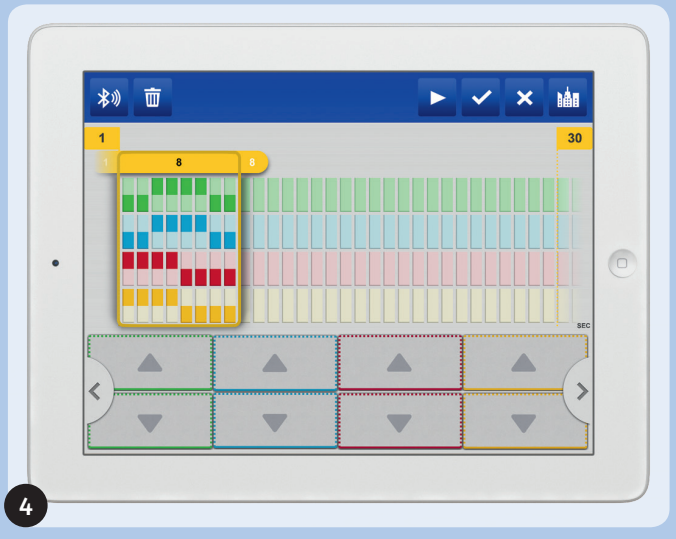
2

2. This program powers all motors clockwise for five seconds, resulting in the right-side wheels driving backward and the left-side wheels driving forward. This turns the whole car clockwise.



3

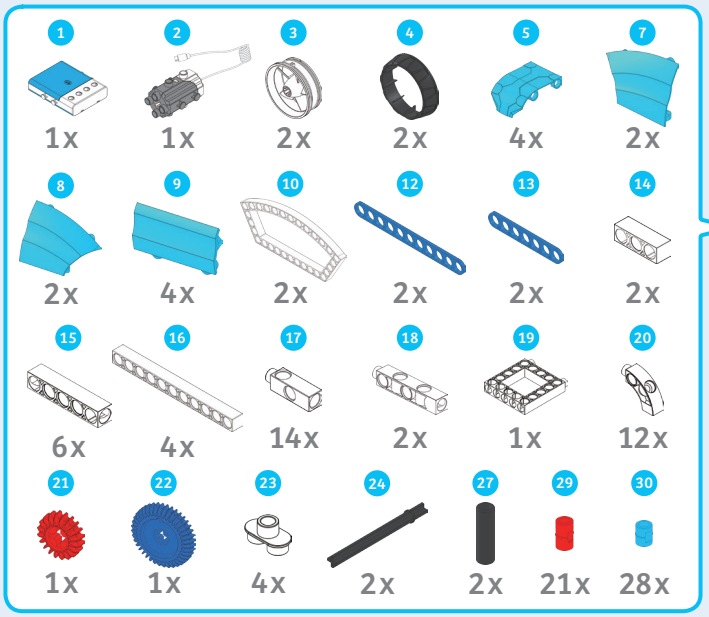
3. This program powers all motors counterclockwise for five seconds, resulting in the right-side wheels driving forward and the left-side wheels driving backward. This turns the whole car counterclockwise.



4

4. This program drives the car forward for two seconds, clockwise for two seconds, backward for two seconds, and then counterclockwise for two seconds.

HELICOPTER



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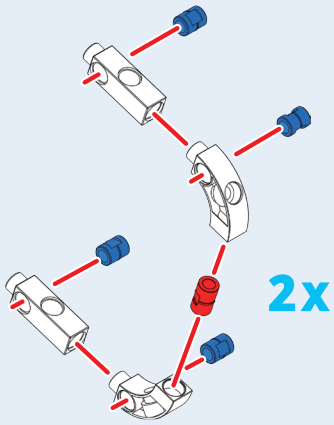

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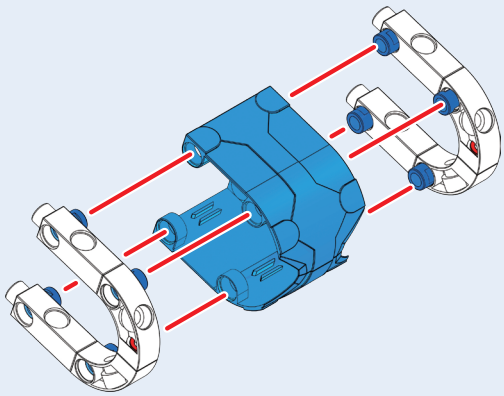

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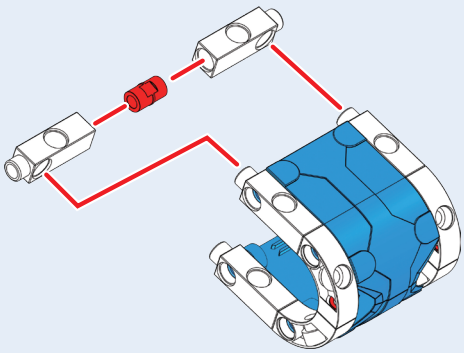

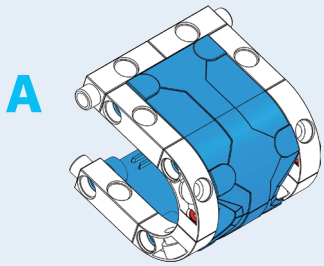

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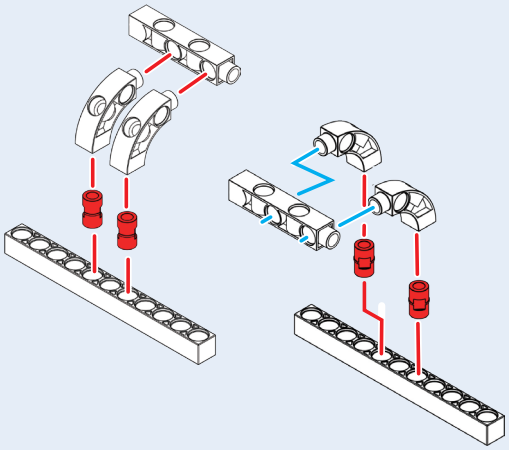

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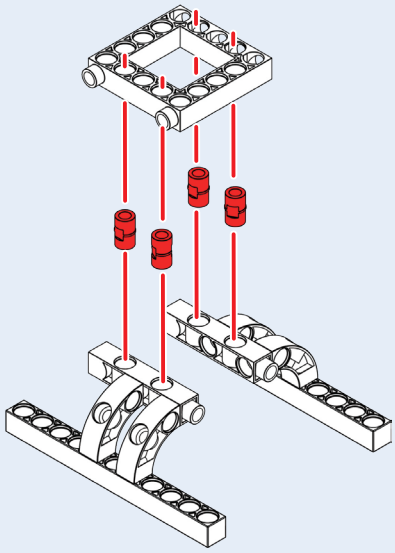

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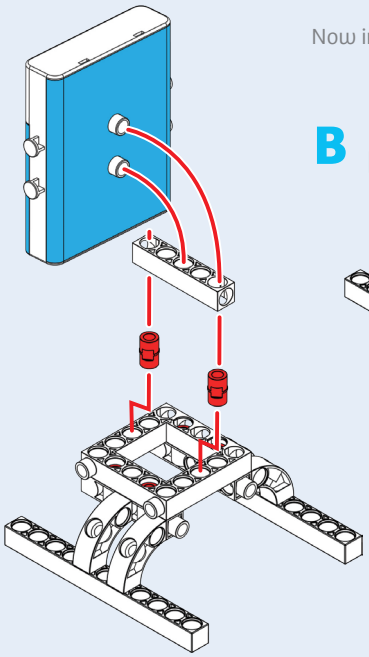
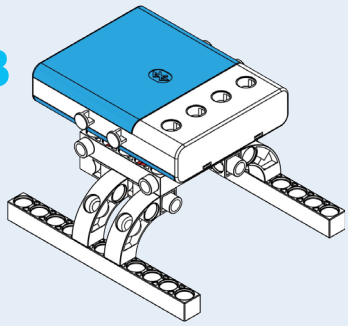


Now insert 4 batteries.

B



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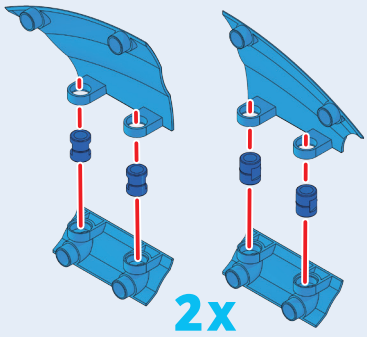

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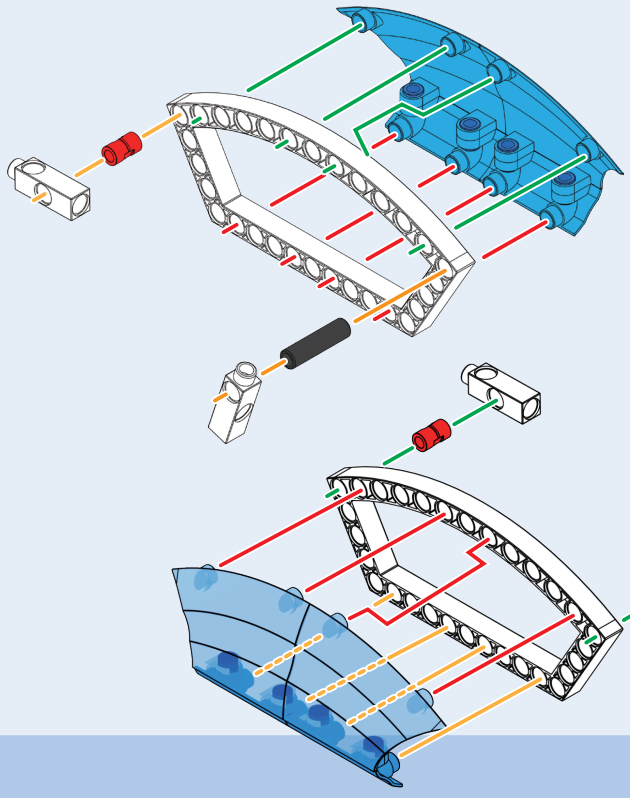

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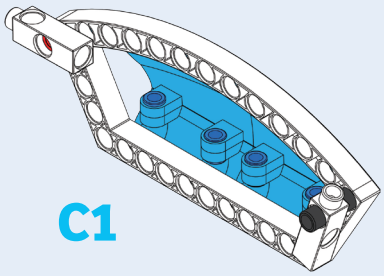

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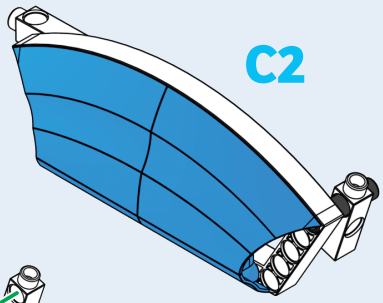

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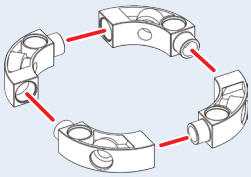

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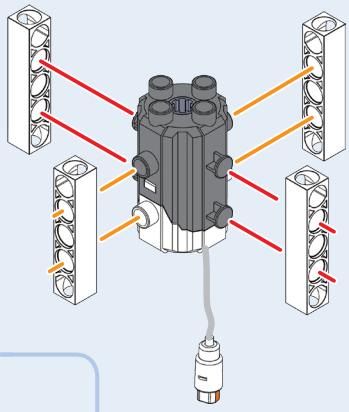

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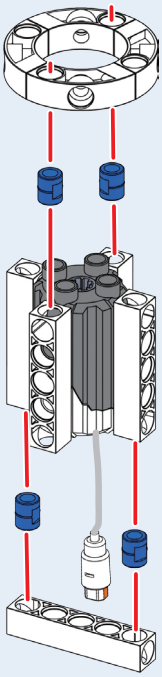

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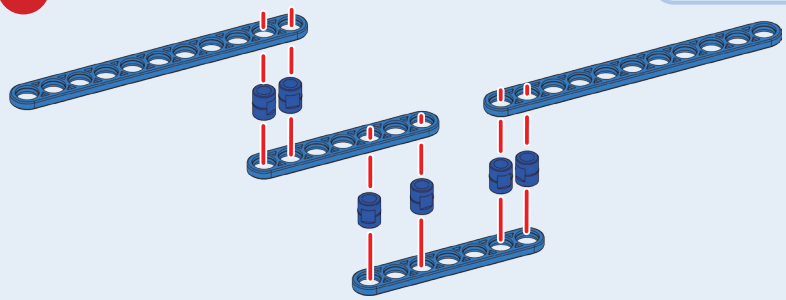

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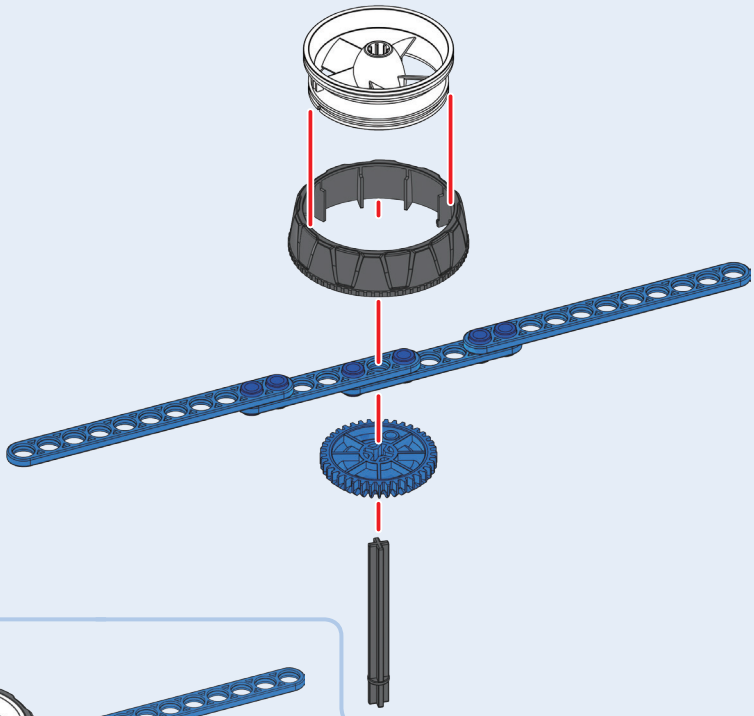

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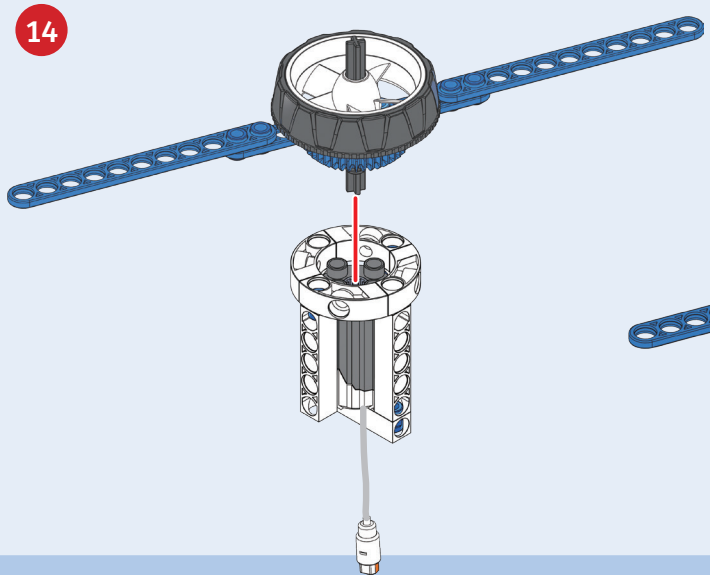

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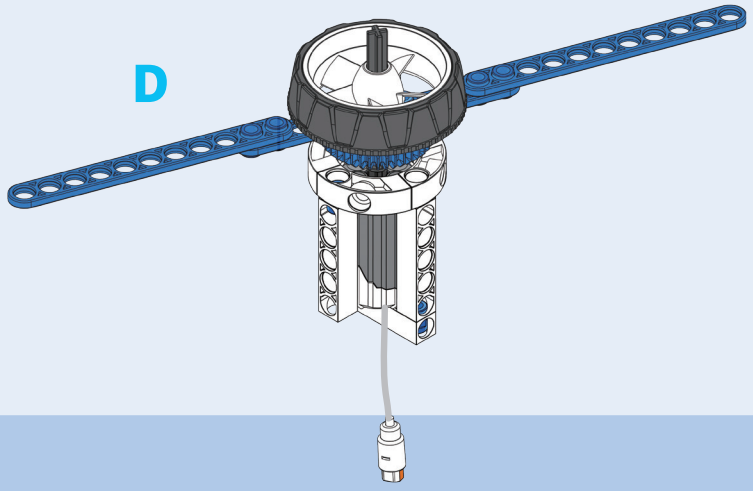

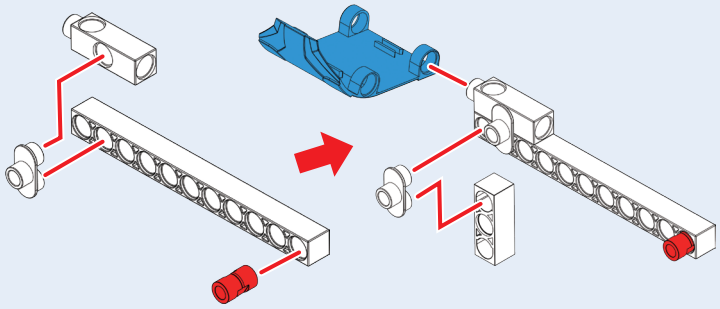

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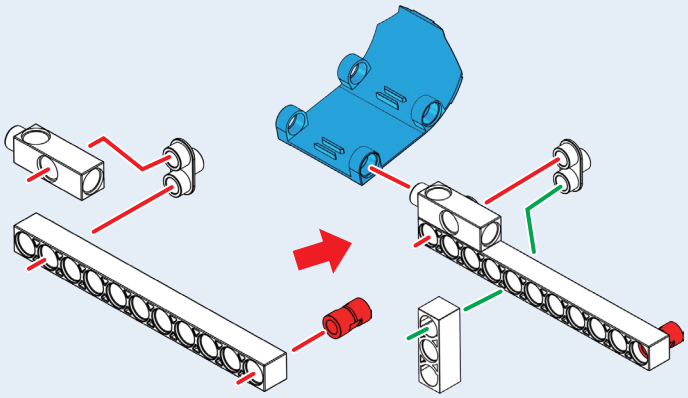

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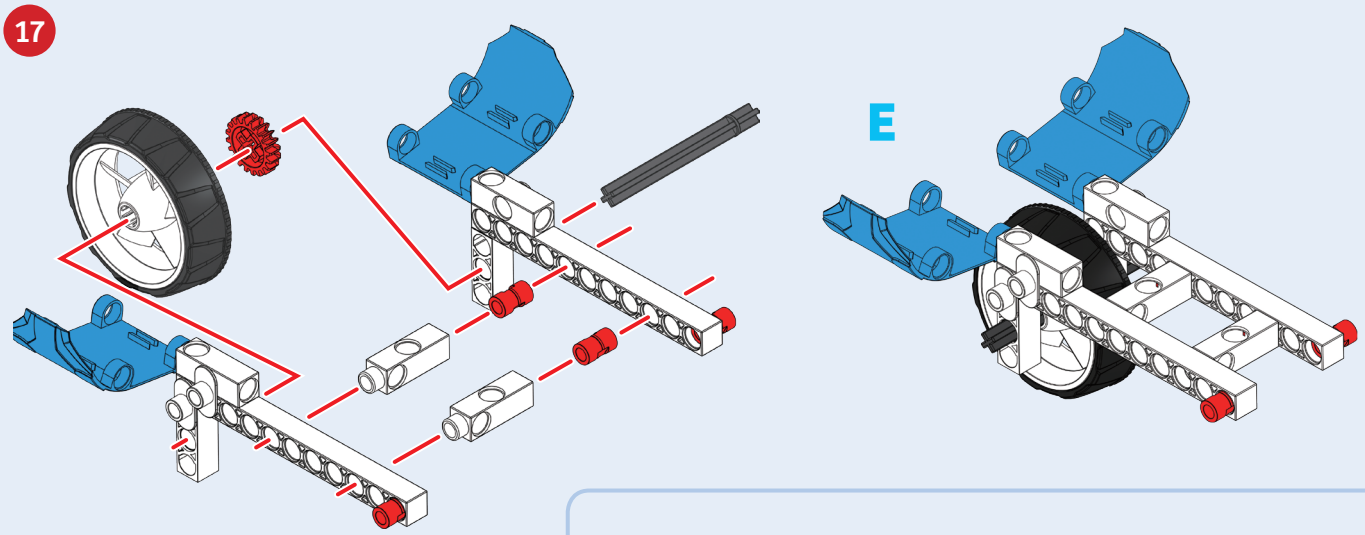

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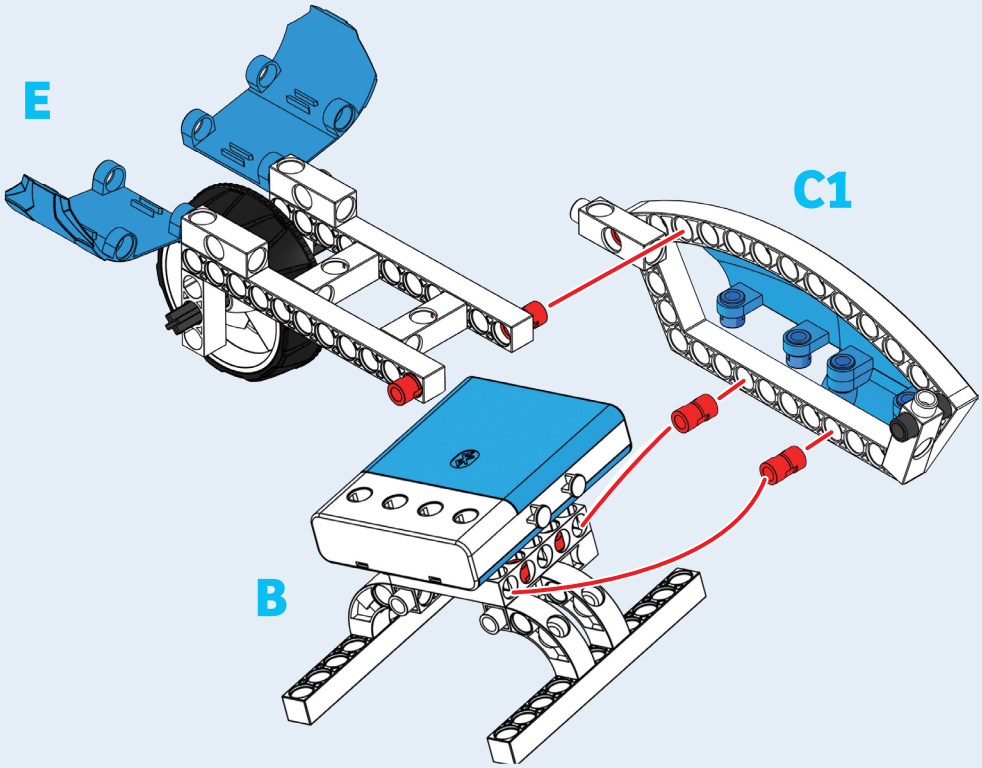

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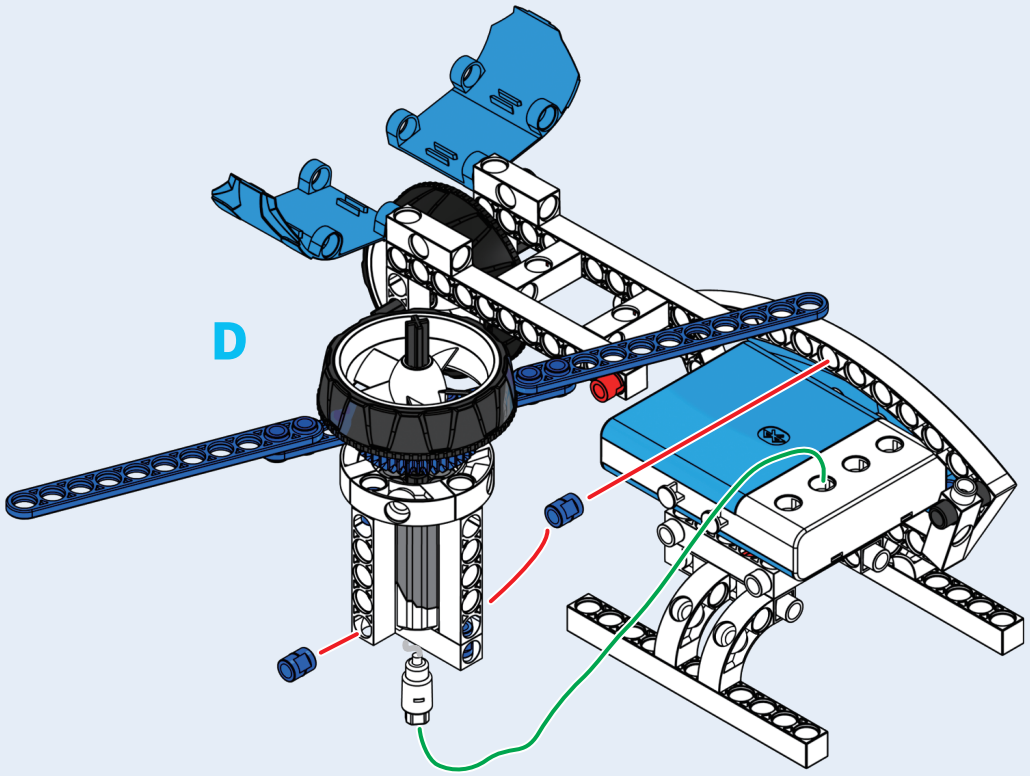

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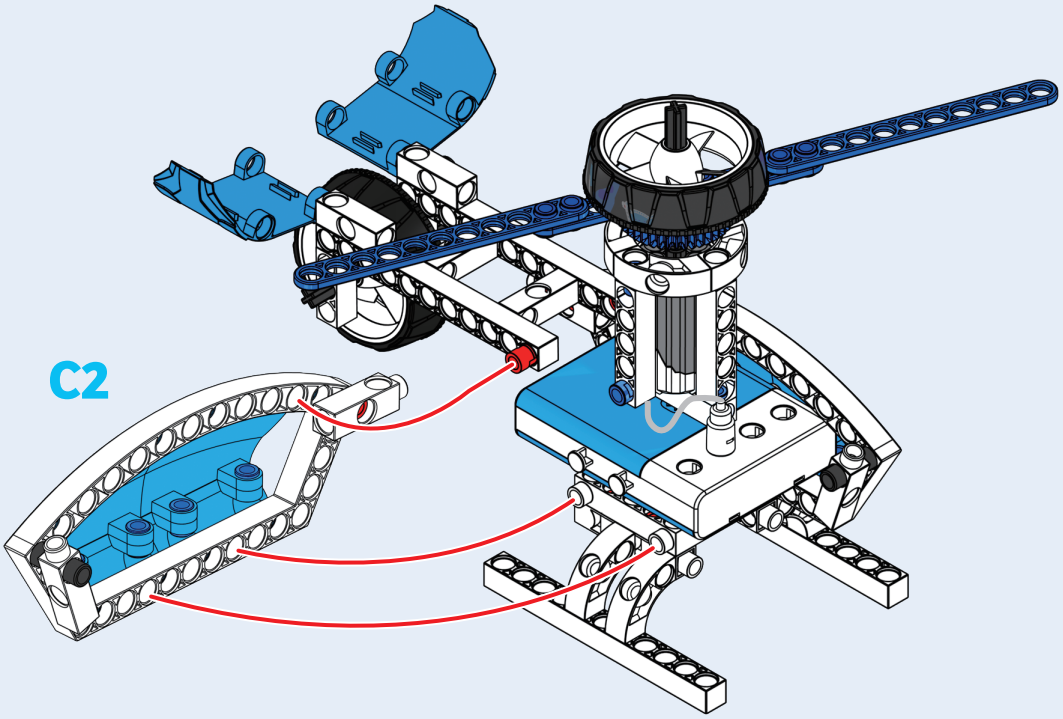

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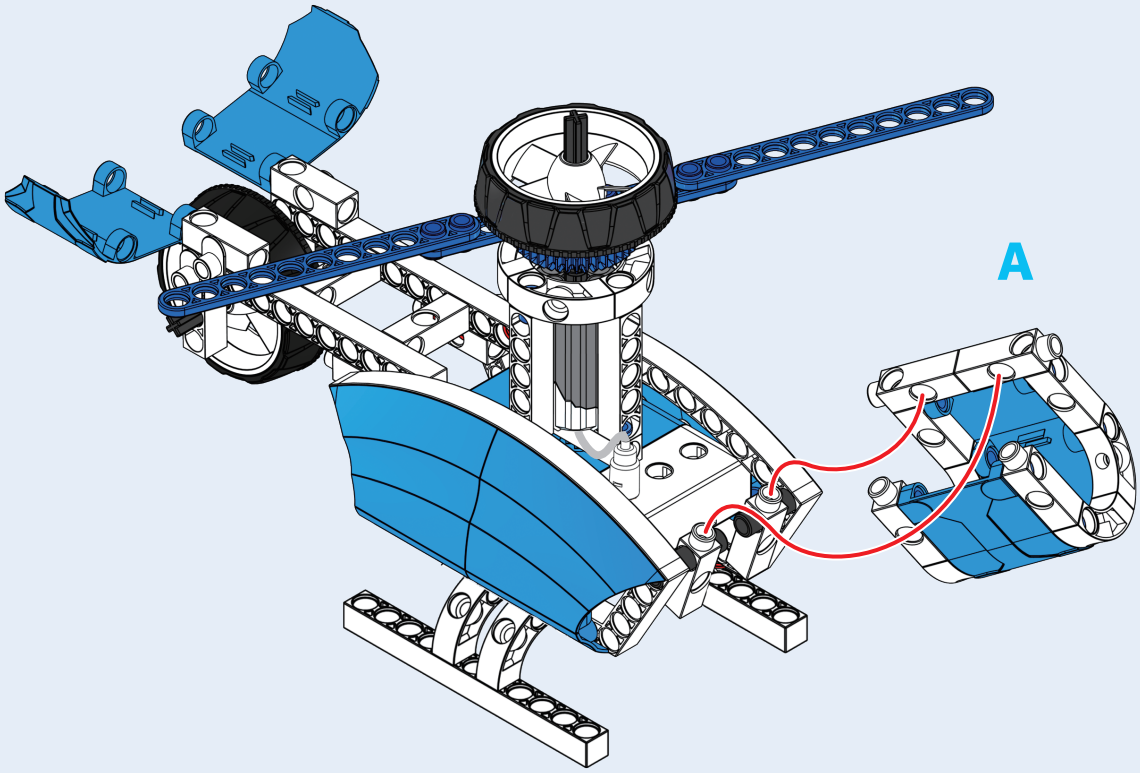
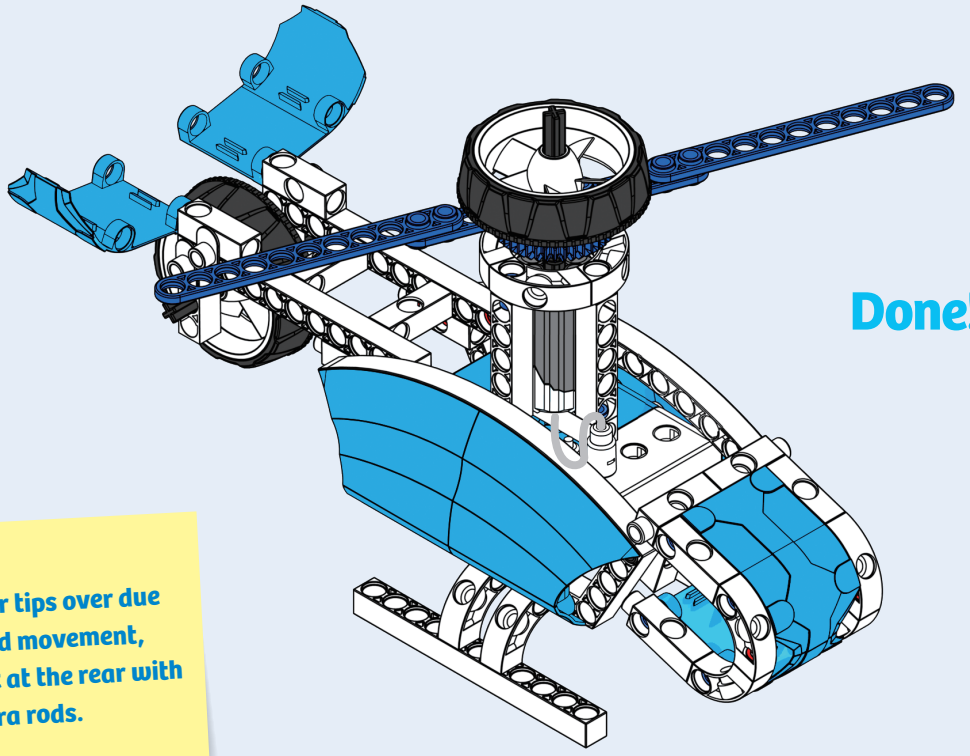
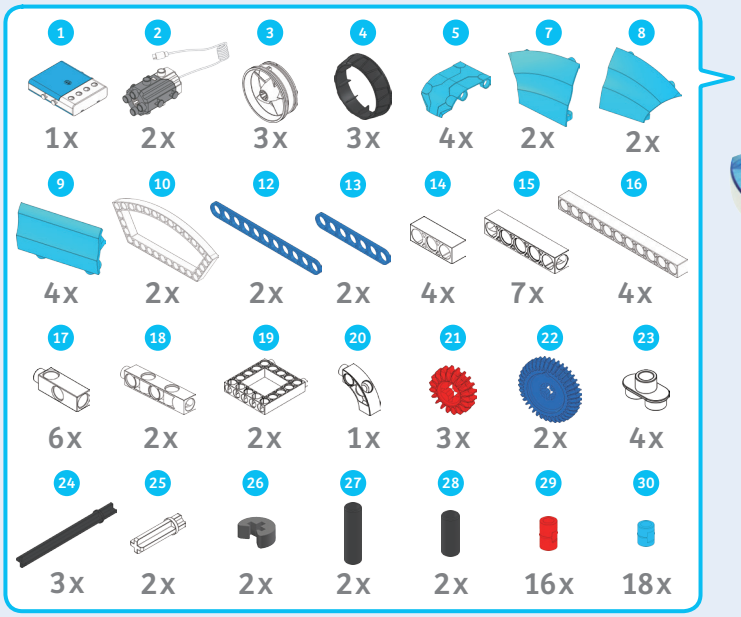




Done!

TIP!
If the rotor tips over due to its rapid movement, support it at the rear with a few extra rods.

AIRPLANE



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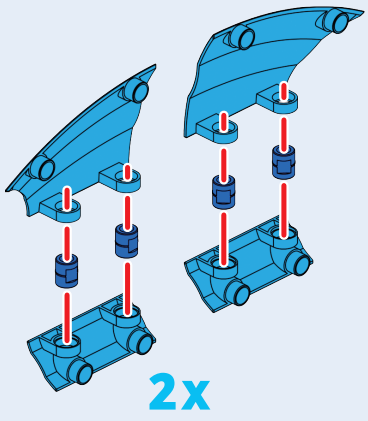

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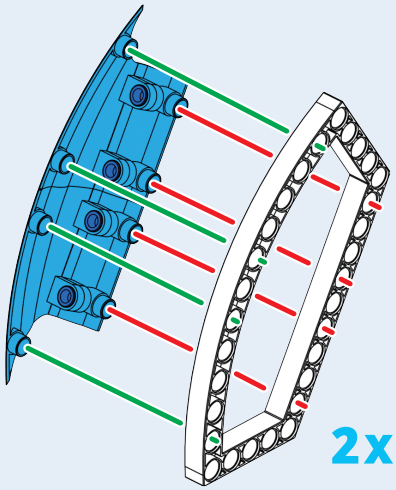

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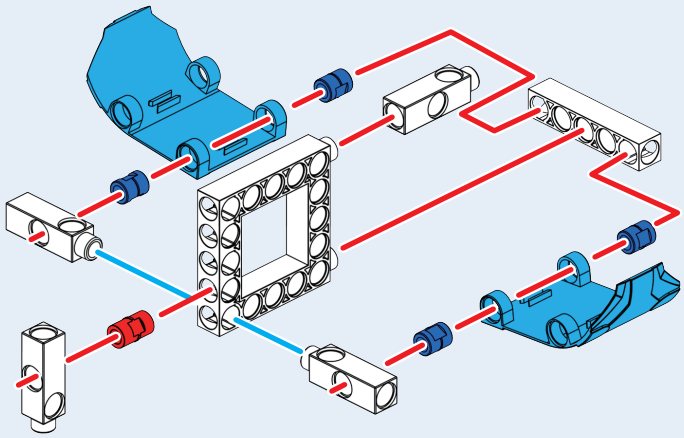

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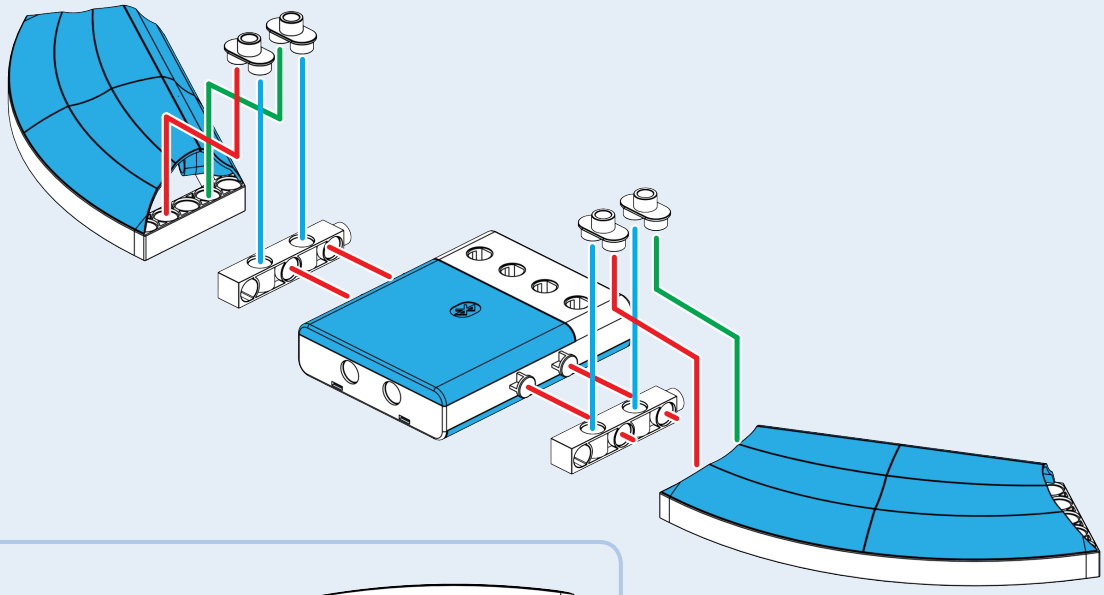

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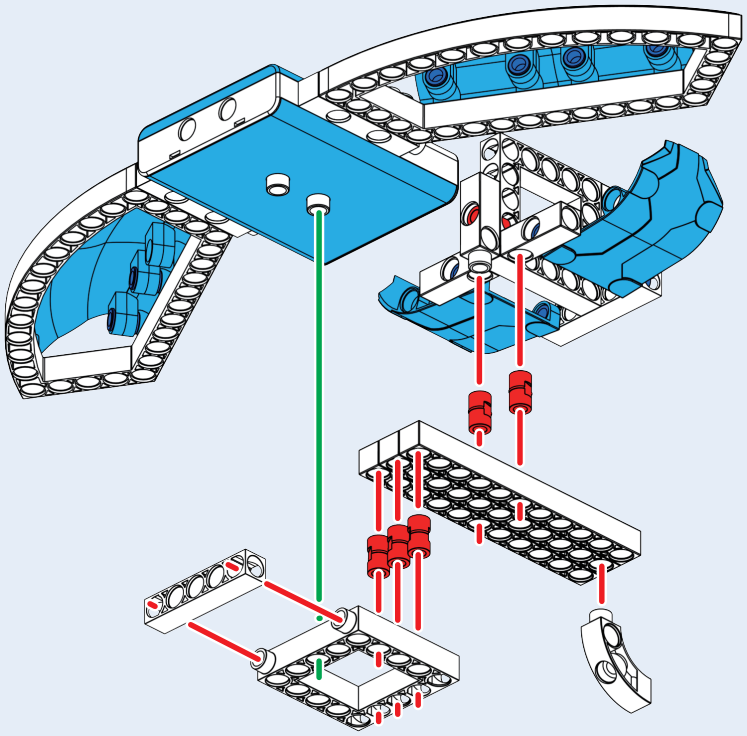

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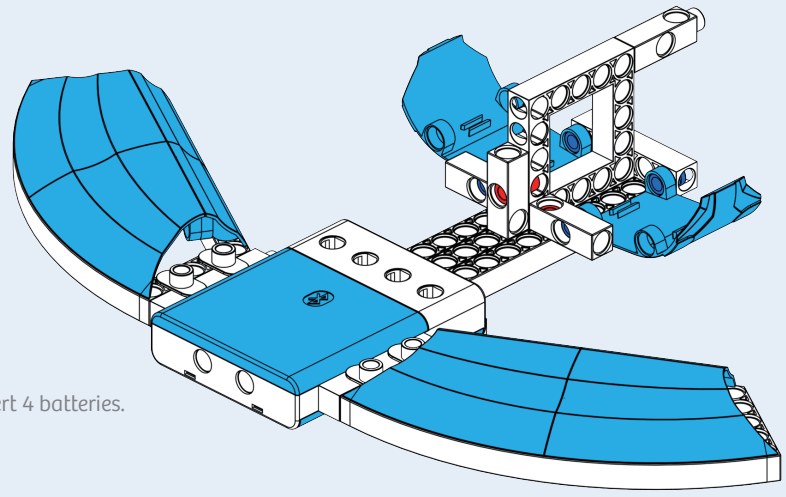
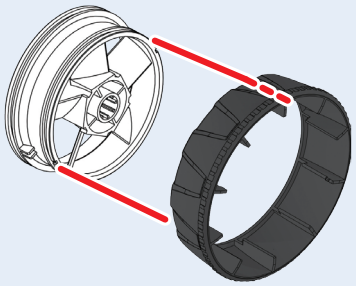


Now insert 4 batteries.

7



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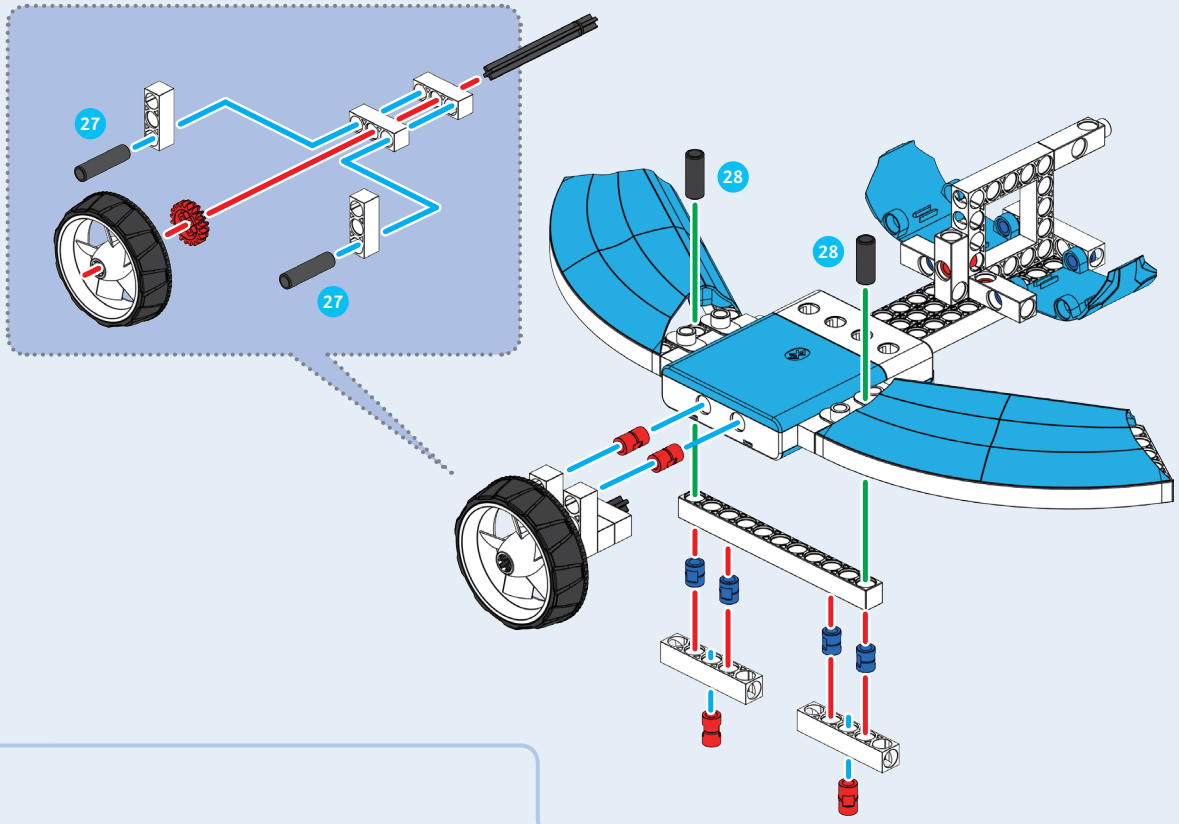

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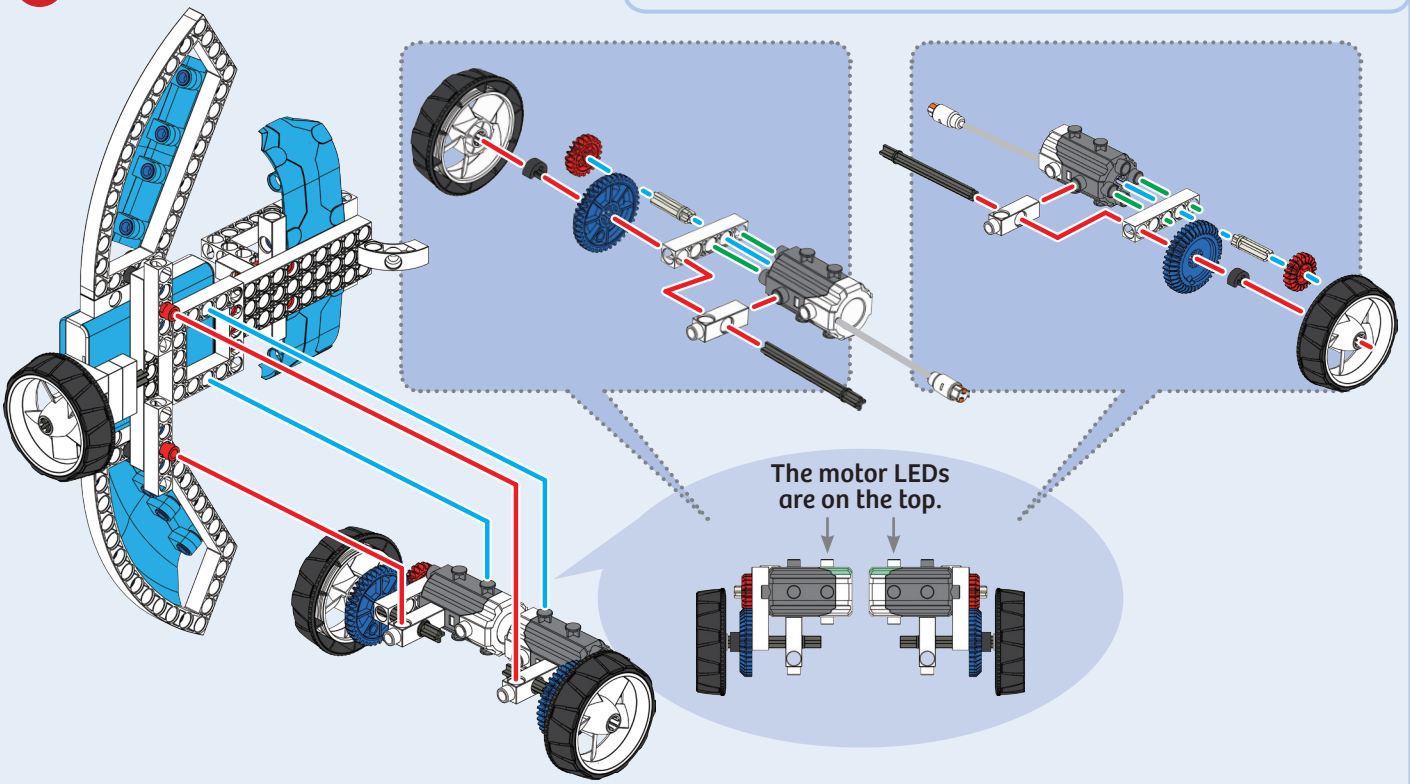

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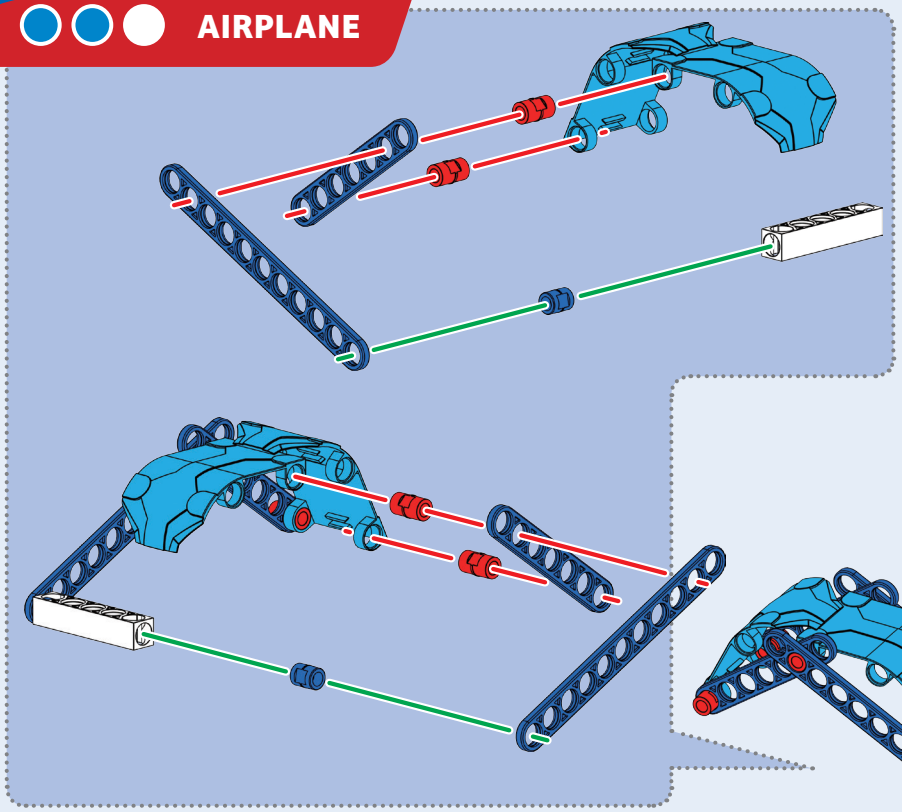
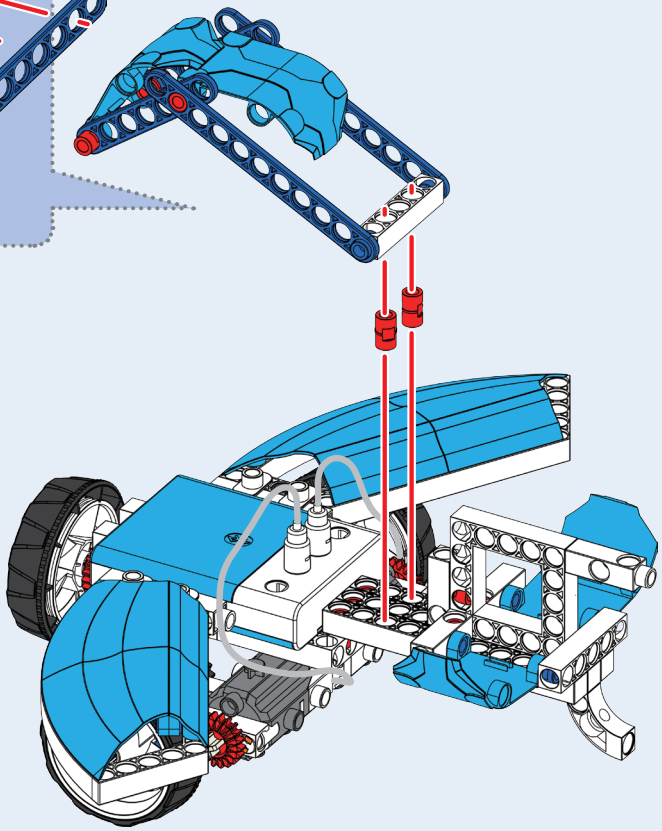
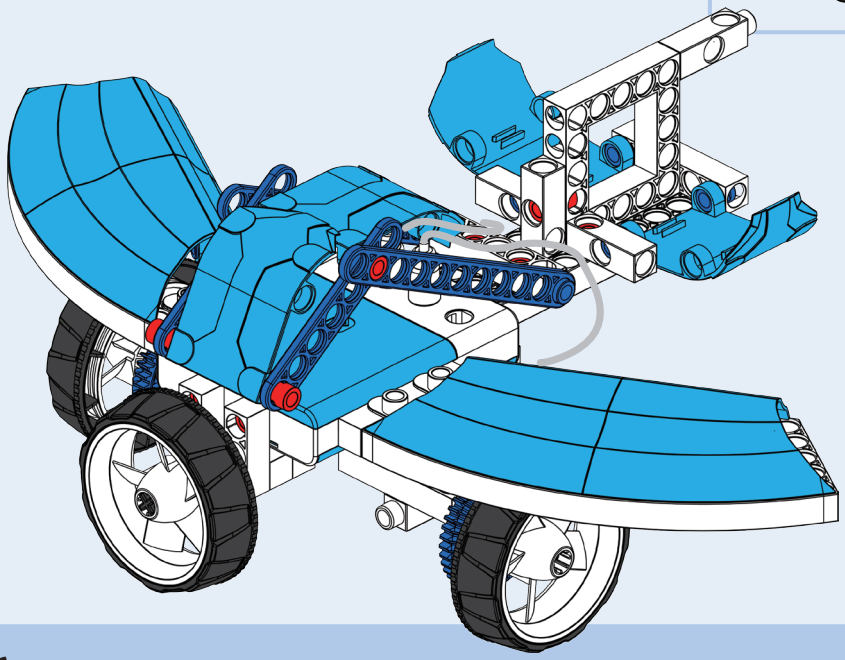
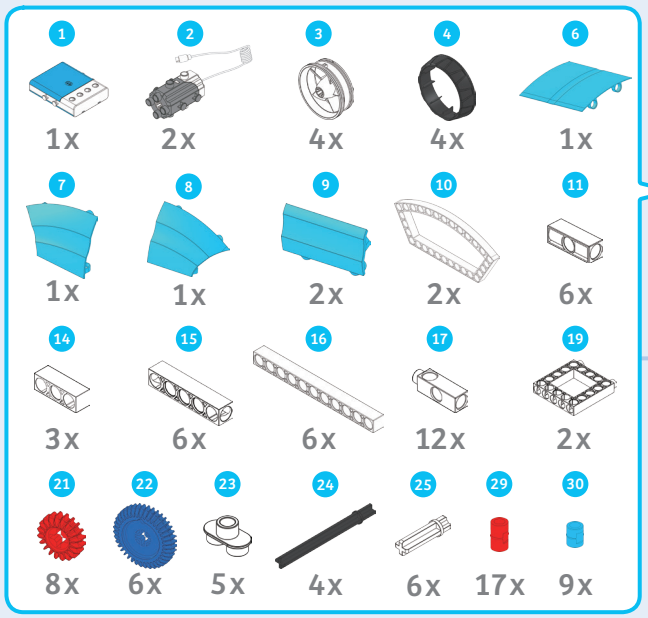






Done!

FLYING CAR


1 1x
2 2x
3 4x
4 4x
6 1x
7 1x
8 1x
9 2x
10 2x
11 6x
14 3x
15 6x
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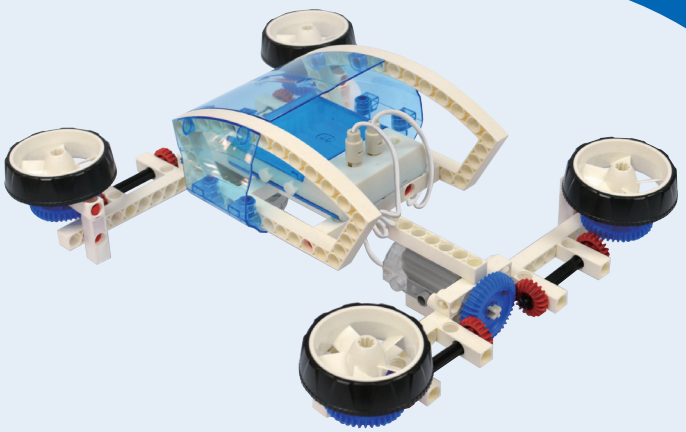
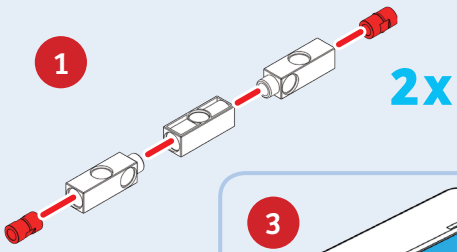
22 6x
23 5x
24 4x
25 6x
29 17x
30 9x

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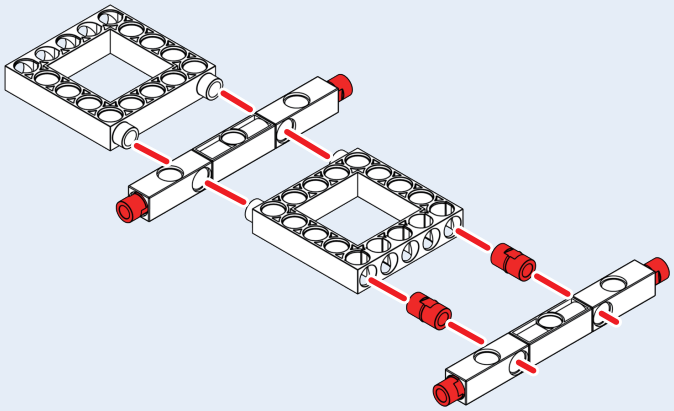
2x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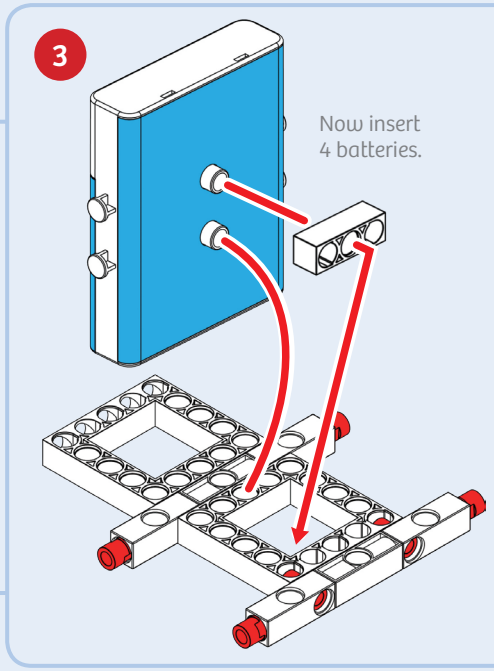
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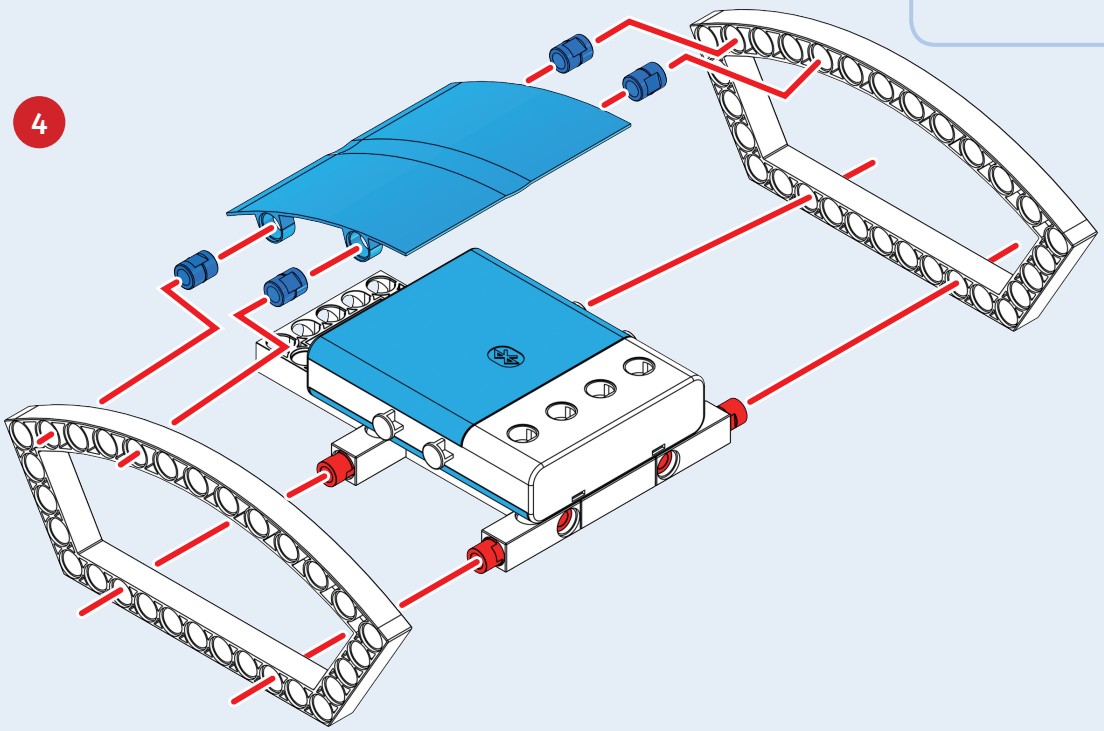
Now insert
4 batteries.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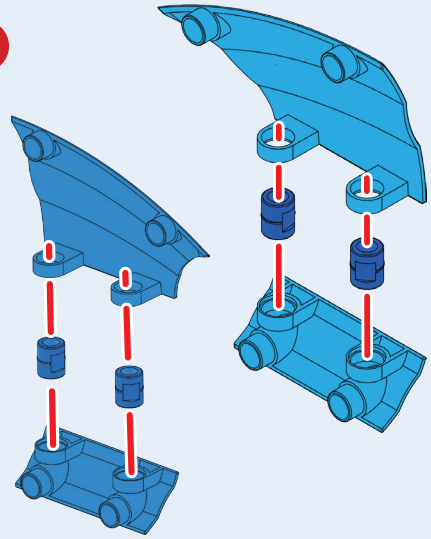

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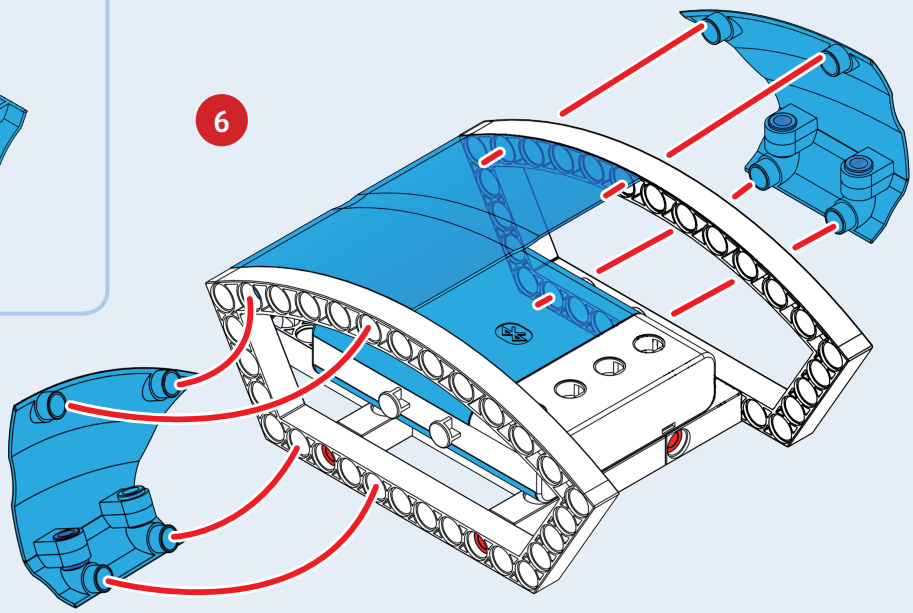

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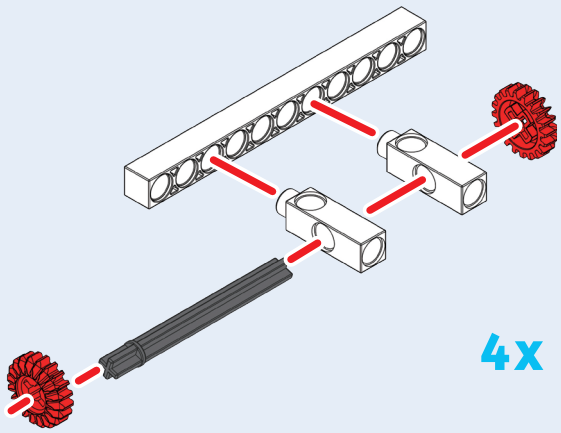

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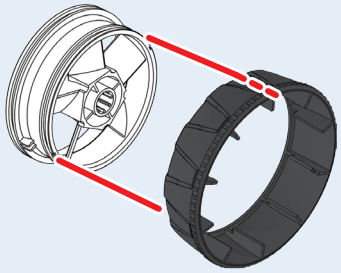

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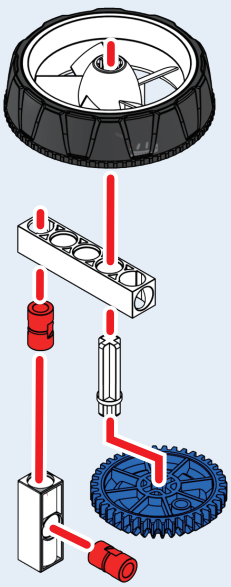

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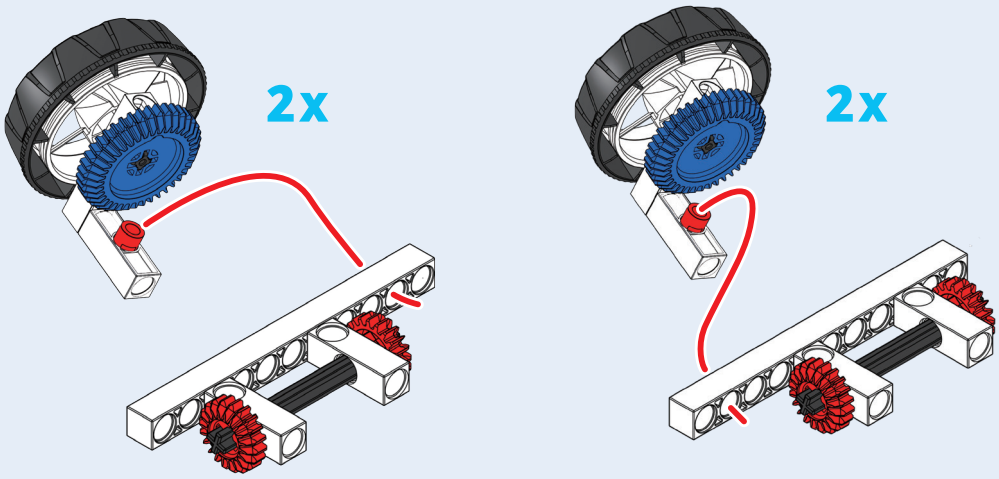

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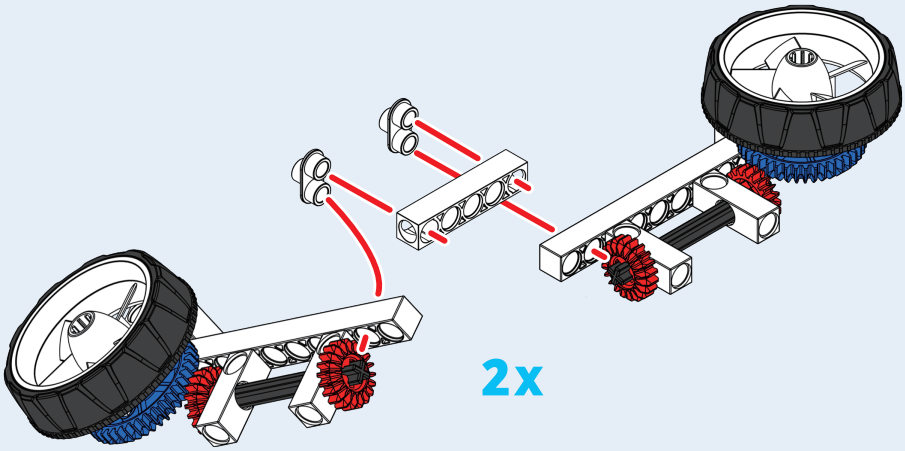

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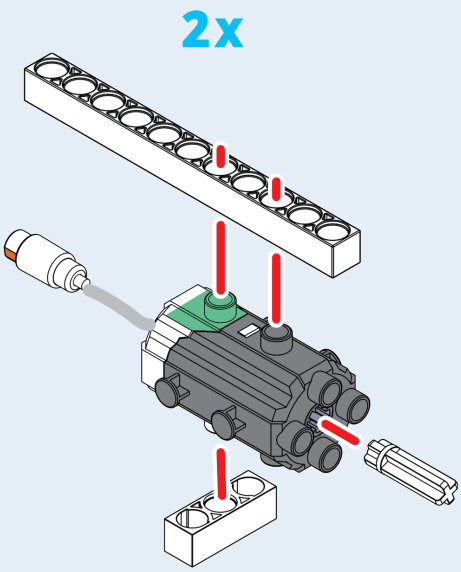

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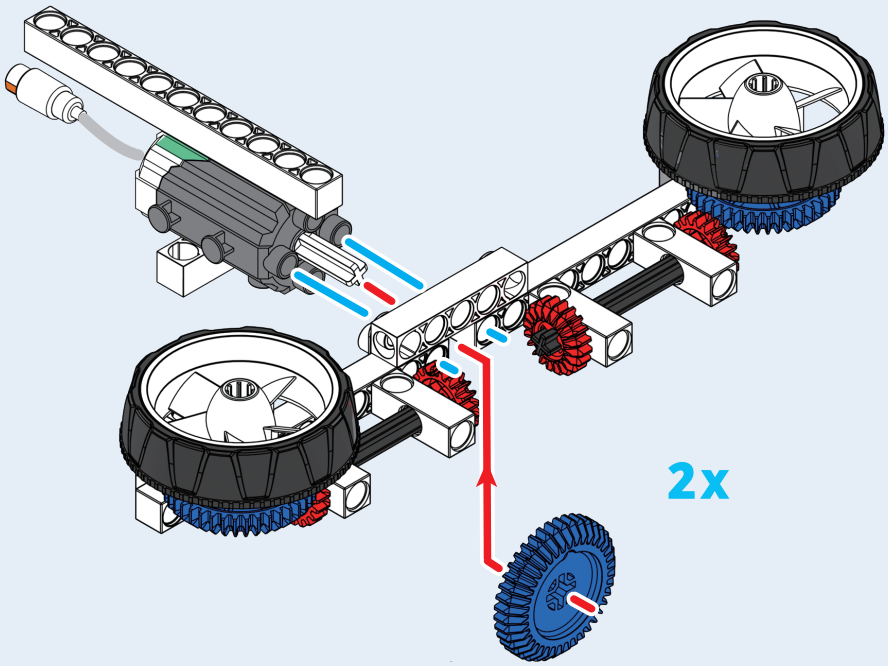

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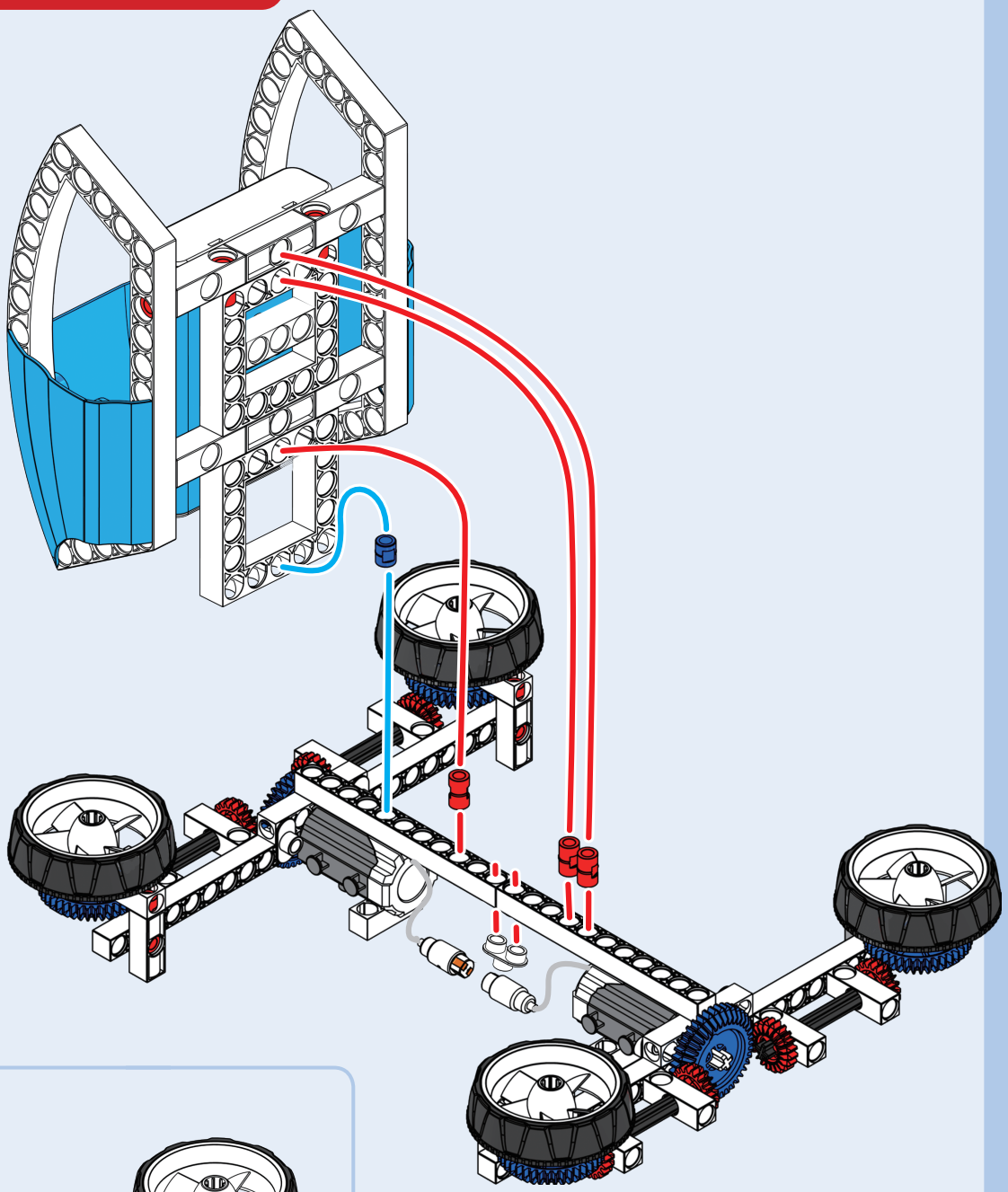
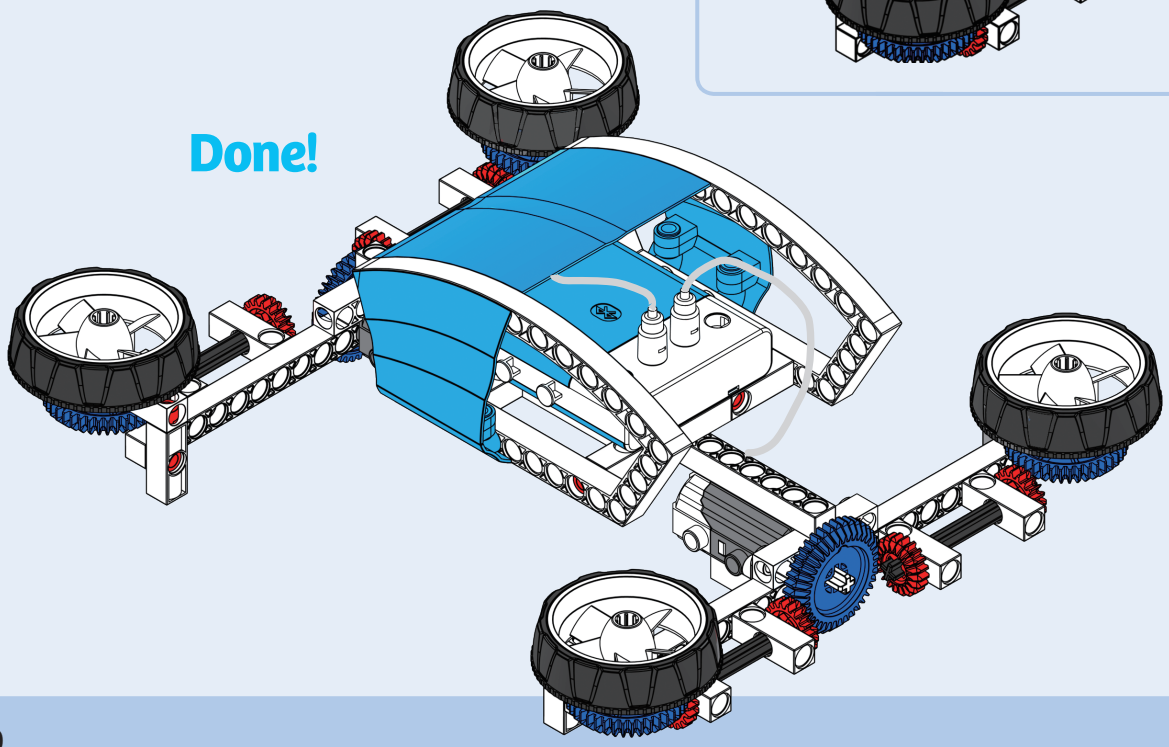


Done!



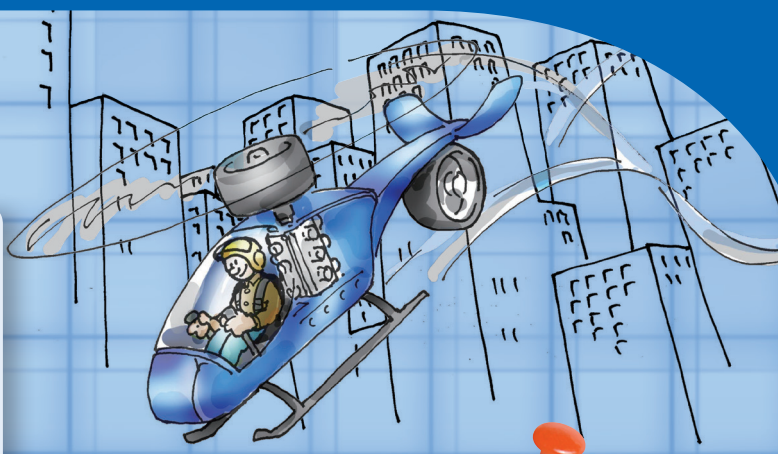
CHECK IT OUT

Airboat

An airboat is a propeller-powered aquatic vehicle mostly used in swamps and shallow water, such as in Florida by people who want to explore the wildlife in the swamps.

As long as there's some water on the surface, or even snow or ice, airboats can run on land as well. So you can also call an airboat an amphibious vehicle. Amphibians such as frogs and salamanders can live on land as well as in water, after all.

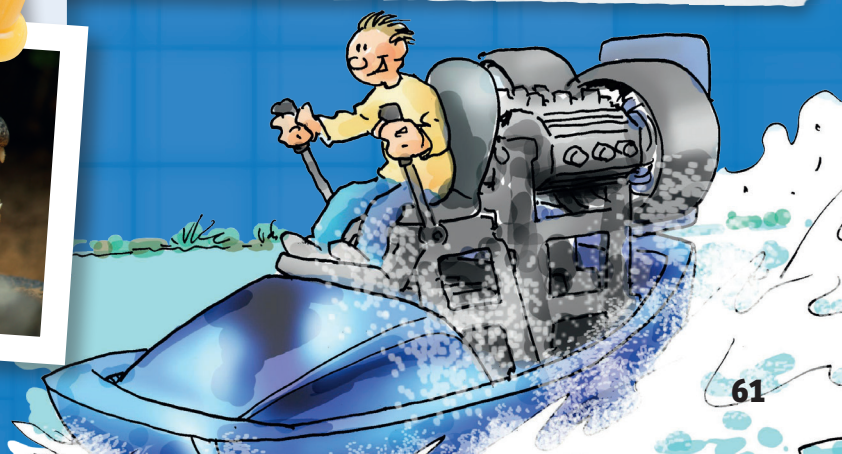
Steering is done with air rudders mounted right behind the propellers. The pilot usually sits high up in order to see above the reeds and water plants.



HELICOPTER

A helicopter is a flying vehicle that can take off and land vertically. The main advantage of a helicopter lies in its ability to hover in one place in the air, to fly backwards or sideways, or circle slowly around its vertical axis. In addition, since it can land and take off straight up and down, it requires no runway.

Helicopters cannot match the speed of airplanes, flying only around 300 km/h at most. But they are powerful transporters. The largest helicopter ever built, the Mil V-12, carried over 44 tons at an altitude of 2,255 meters!



Do flying cars exist yet?

A flying car combines the qualities of an airplane with the advantages of a car. In other words, it is small and compact, can move in reverse, and is easy to operate. In addition, it shouldn't require more than a very short takeoff and landing strip, so you wouldn't need an airport.

An early attempt, the Curtiss Autoplane invented by American Glen Curtiss in 1917, could not actually fly. The first car to actually fly was built by American inventor Waldo Waterman in 1937.

Since then, there have been repeated attempts to market flying cars, all without success. Flying cars require more gasoline than ordinary cars, they are more expensive to buy, and they have to be maintained much more carefully if they are to fly safely, which makes them even more expensive.

But flying cars would have certain advantages over regular cars. You would certainly be able to travel much faster with them than in a car driven on the ground. Do you think the flying car of the future might look like this?

Flying car with its wings folded up.

The Future of the Car, Part II: Power Technologies

Will the cars of tomorrow run on gasoline, or on electricity instead?

For the time being, experts say, the internal combustion engine will still hold sway. These are the engines that run on gasoline or diesel fuel, found in almost all cars of today. But more and more, combustion engines will be replaced by electric ones. By the year 2050, the automotive traffic in our cities may be completely converted to electric power.

But we're still far away from that. In 2012, car companies reported sales of a little over 50,000 electric cars in the U.S. — versus around 6 million combustion-engine cars.

An important question is where the electricity for driving comes from. Well, from an outlet, of course! Ideally the original source of the electricity should be green, or renewable.

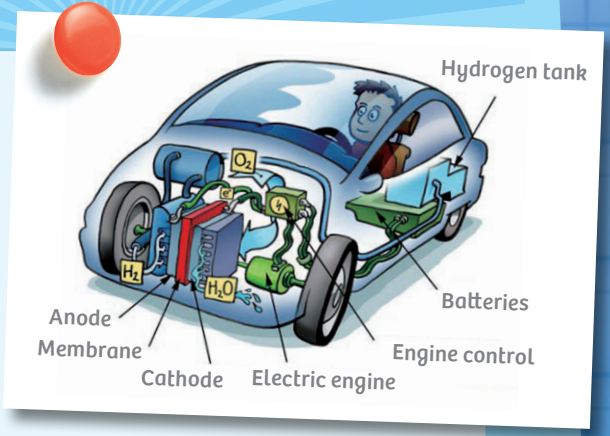
The electricity is used to charge large batteries inside the car, which in turn power the electric engine. Their greatest disadvantage lies in the fact that electric cars don't have much of a driving range. They're great for driving short distances in town. But a long driving vacation would be a little inconvenient, since the batteries would have to be recharged every hundred kilometers, which takes a long time — much longer than filling up with gasoline anyway.

CHECK IT OUT

The Future of the Car, Part II: Power Technologies

FUEL CELLS

An important alternative energy source is the fuel cell, which can be powered with pure hydrogen. A car fuel cell is barely bigger than a car battery. Inside it, hydrogen reacts with oxygen to make water. A common type of fuel cell is constructed like a sandwich.

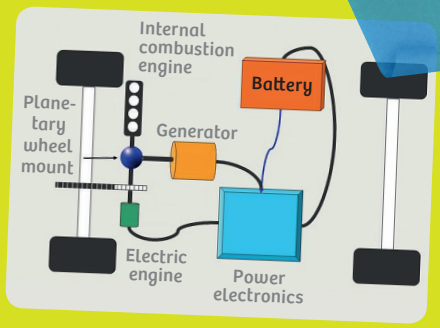


At the anode, which forms one of the "bread slices" in our fuel cell sandwich, hydrogen molecules are split into atoms, which are then divided into one proton and one electron. Only the protons travel through the membrane to the cathode side (which is the second slice of bread). This creates an electron surplus at the anode, or an excess negative charge. The other side, the cathode, is positively charged by the protons. Between anode and cathode, then, an electrical voltage forms.

If you then connect the two bread slices to each other outside the cell, you get a flow of electricity, which can be used to power an engine. So instead of recharging at an outlet, this kind of car fills up at a hydrogen pump — which takes much less time than recharging a battery.

HYBRID VEHICLES

This is the term for vehicles that use a combination of different power technologies.



For example, a gasoline engine may power the front wheels. Surplus energy travels to the generator, which conveys it to the electric engine or the battery. Through this collaboration with an internal combustion engine, the batteries don't require any kind of extra charge from an outlet.

So hybrid cars are cars that run only partly on electricity. The electric engine with its limited battery is often enough for around 50 kilometers of in-town driving. For longer trips, the combustion engine is used.

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