EXPERIMENT MANUAL

GYROBOT

THAMES & KOSMOS

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Safety Information

The gyroscope can generate more force than you might expect. Therefore, for the gyroscope and the models that are powered by it, please follow these rules for proper use:
When starting up, always hold on tight to the gyroscope and the model until the disk has reached its top speed. When stopping, always hold the model firmly again, switch it off, and keep holding it until it is no longer moving or set it on the stand.
To avoid breaking the gyroscope, only tip it briefly and never operate it with the battery end pointed upward.
For the gear wheel on the underside of the gyroscope and wheels with gears: Do not insert hair, fibers, or string into the drive mechanism.

NOTE! 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, particularly the battery-powered gyroscope, and assembled models out of the reach of small children. There is a risk of strangulation if the long cord is wrapped around the neck.

NOTE! Only for use by children 8 years and older. Instructions are included for parents or other supervising adults. Please follow them!
Save the packaging and instructions. They contain important information.

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 three AAA batteries (1.5-volt, type AAA/LR03) or three AAA rechargeable batteries (1.2-volt, min. 1100 mAh), which are not included in the kit due to their limited shelf life.

››› The supply terminals are not to be short-circuited. A short-circuit 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.

››› Never recharge non-rechargeable batteries. 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. Always operate the gyroscope under adult supervision.
After you are done experimenting, remove the batteries from the battery compartments. Note the safety information accompanying the individual experiments!

Notes on disposal of electrical and electronic components

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

Please contact your local authorities for the appropriate disposal location.

Dear Parents,

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

An experiment to help you hit the ground running

Here's where unexpected forces are generated...
Check it out, and prepare to be surprised!

Are you strong enough for the gyroscope?

WANT TO KNOW MORE?
Then come with us into the fascinating world of gyroscopes ...

YOU WILL NEED

› **Gyroscope**
› *3 x AAA batteries (1.5-volt, type AAA/LR03)*

HERE'S HOW

1. Find the gyroscope in the box and open the cover on the underside. That's how you get to the battery compartments.
2. Insert the batteries into the battery compartments as indicated on the inside.
3. Now, place the cover back on.
4. Turn on the gyroscope using the switch on the underside.
5. Hold the gyroscope vertically and wrap your hand around it from the top. Hold on tight!

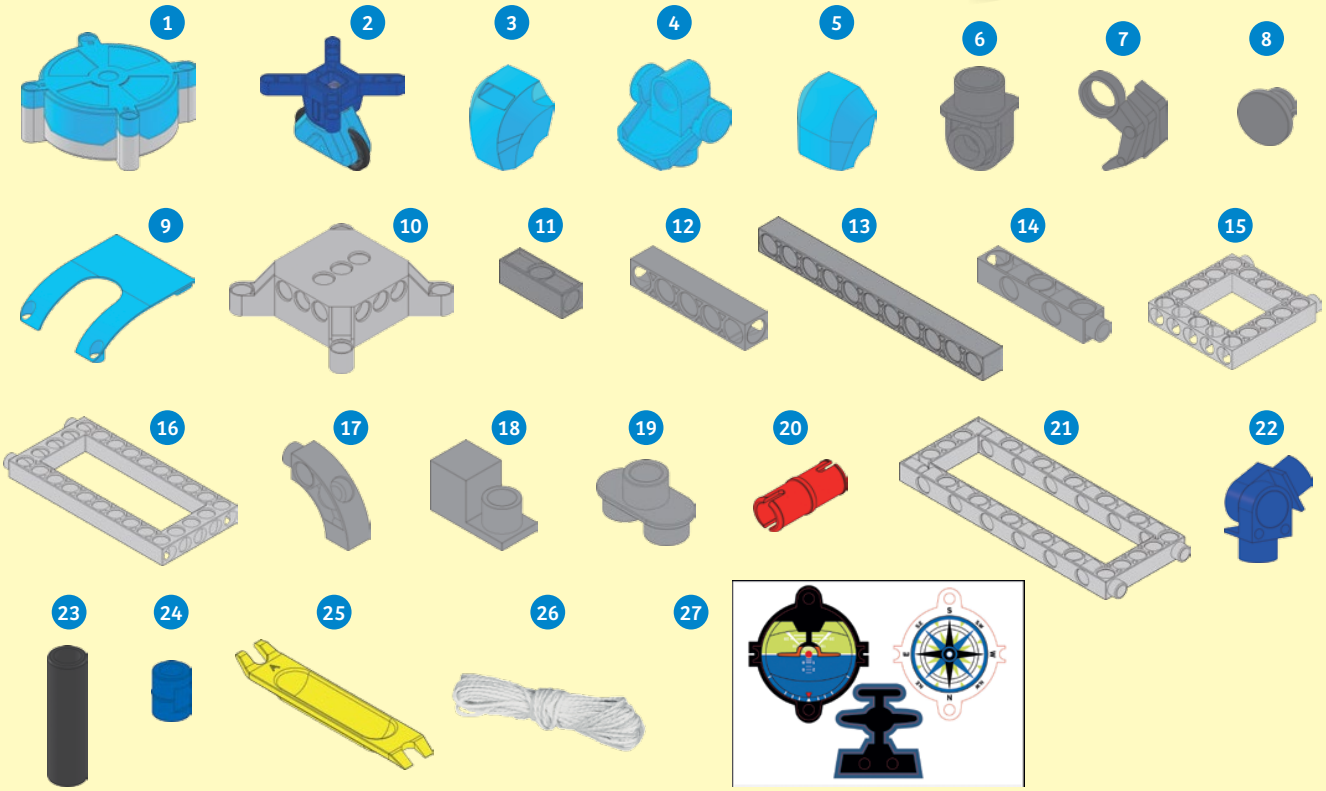
WHAT'S HAPPENING?

Look into the top of the gyroscope. Do you see how the disk inside starts to turn? It spins faster and faster. You don't just see it, you can actually feel it — and you have to hold the gyroscope tightly to keep it from getting away. It's the rapid rotation of this disk that generates the force you feel.

GOOD TO KNOW! If you are missing any parts, please contact Thames & Kosmos customer service.

Any materials not included in the kit are indicated in *italic script* under the "You will need" heading.

The parts in your kit:



Checklist: Find – Inspect – Check off

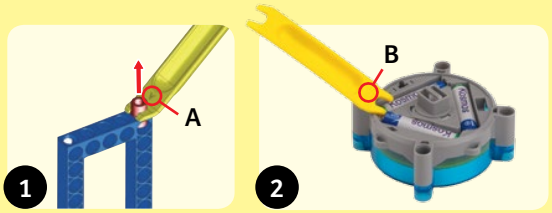
✔	No.	Description	Count	Item No.
❍	1	Gyroscope	1	714 210
❍	2	Wheels with gears	1	714 213
❍	3	Head 1 (front)	1	714 215
❍	4	Neck	1	714 216
❍	5	Head 2 (rear)	1	714 217
❍	6	Wrist	2	714 325
❍	7	Hand	4	714 218
❍	8	Rivet	4	714 326
❍	9	Shoulder	1	714 219
❍	10	Upper body	1	714 220
❍	11	3-hole cross rod	6	714 221
❍	12	5-hole rod	6	714 224
❍	13	11-hole rod	5	714 226
❍	14	5-hole dual rod	4	714 231

✔	No.	Description	Count	Item No.
❍	15	Square frame	2	714 227
❍	16	Short frame	2	714 228
❍	17	Curved rod	2	714 230
❍	18	Lengthwise connector	4	714 232
❍	19	Two-to-one converter	6	714 233
❍	20	Joint pin	4	702 524
❍	21	Dual frame	1	714 229
❍	22	Hinge	8	714 234
❍	23	Tube, 30 mm	2	714 287
❍	24	Anchor pin	30	714 129
❍	25	Anchor pin lever	1	702 590
❍	26	String, 2 m	1	714 240
❍	27	Paper cutout sheet	1	714 236

The anchor pin lever

In the box, you will find a little tool called 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.**

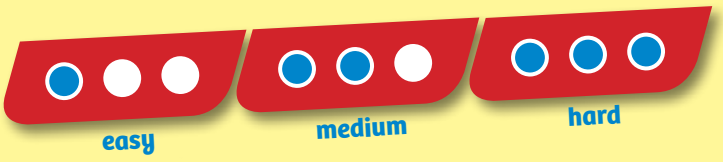


You will also need:
3 x AAA batteries (1.5-volt, type AAA/LR03) and a watch or clock

››› TABLE OF CONTENTS

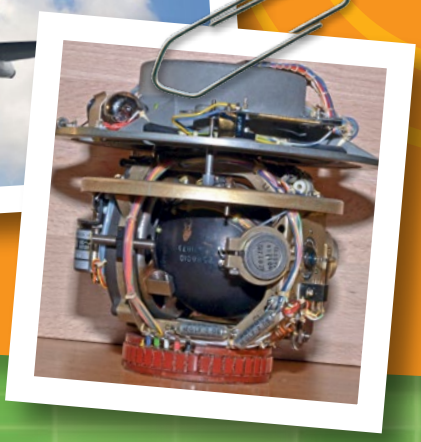
TIP!
You will find supplemental information here: "Check It Out" Pages 23 and 24.

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:



Gyro Technology

Gyro — what? The term "gyro" comes from Greek, and means circle or rotation. A gyroscope is more or less like a top containing a rapidly spinning disk. Gyroscopes can be used in ships, cars, and airplanes. And now you know why the Greek dish made from meat cooked on a rotating spit is called a "gyro!"



EXPERIMENT 1

What is the gyroscopic effect?

YOU WILL NEED

› **Gyroscope**
› *3 x AAA batteries*
› *Watch or clock*

HERE'S HOW

1. Open the cover on the underside of the gyroscope. That's how you get to the battery compartments.
2. Insert the batteries as indicated inside the battery compartments.
3. Replace the cover and switch on the gyroscope.
4. The disk inside will start to spin. Hold the gyroscope firmly in its upright position and **wait for the disk to reach its maximum speed. It will take about 20 seconds.**
5. Now try carefully tilting the gyroscope a little to one side — first a little to the left, then a little to the right.

DID YOU KNOW?

This effect is also at play when you tilt a bicycle while entering a curve. Of course, if you were to tip the bicycle to the side when the wheels were not turning, you would simply fall over.

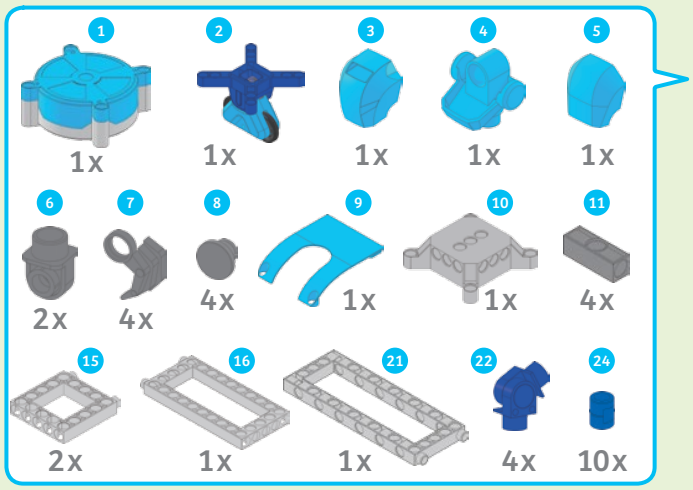
WHAT'S HAPPENING?

Do you feel the force that makes it so difficult to tip the gyroscope? What you're experiencing is something called the gyroscopic effect. It arises when an object (the disk, in this case) spins very rapidly. The force you feel when you tip the gyroscope is trying to maintain the disk's axis of rotation.

LET'S GO

Build your own gyrobot. It will be able to keep its balance as long as the gyroscope's disk is spinning.

GYROBOT



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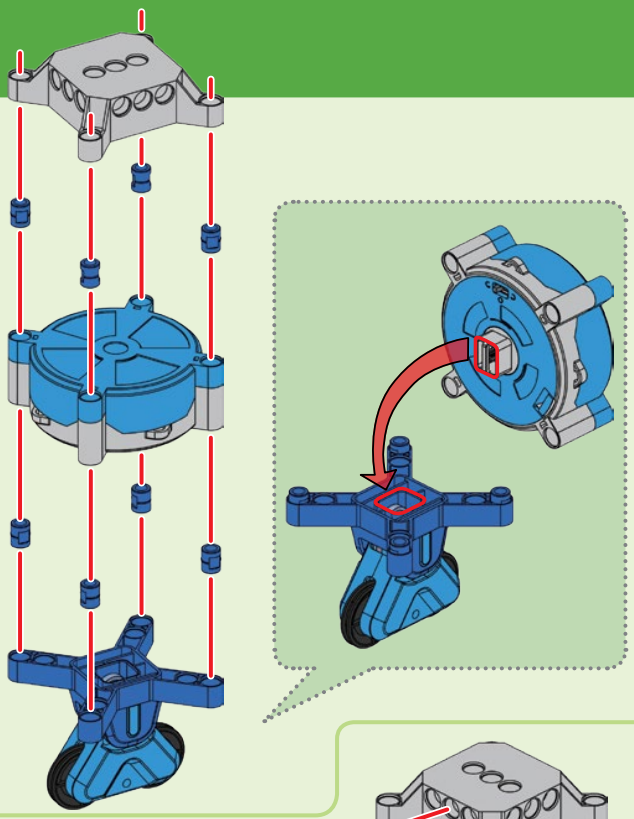

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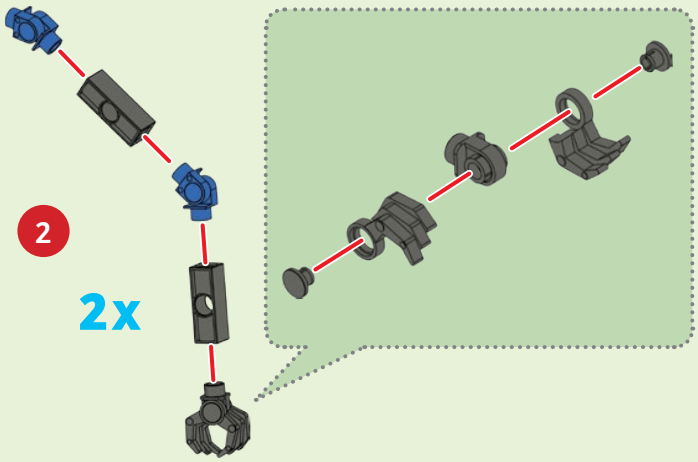

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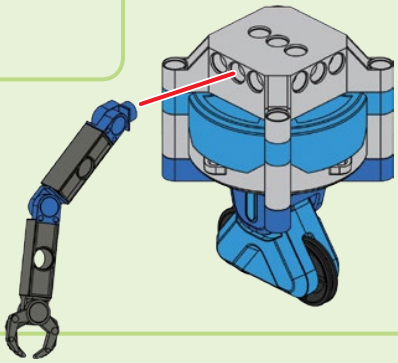

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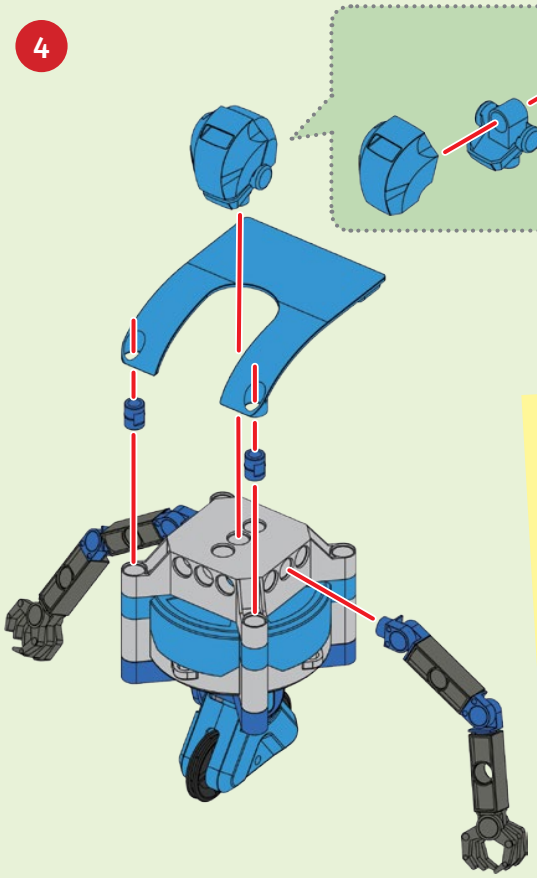

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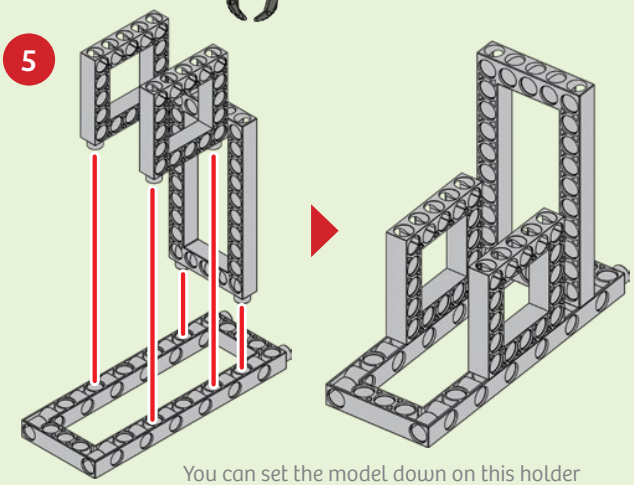
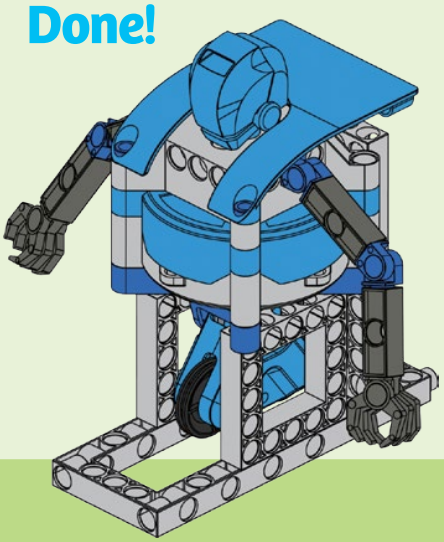


You can set the model down on this holder when you want to let the gyroscope run down.

TIP!

Wow! Your gyrobot can even run along a rope. Stretch out the rope. Wait for the disk to reach top speed, and then set the wheels carefully on the rope and let the robot go! For extra safety, tie a leash (or tether) to one of the gyroscope's eyelets. Tie a loose loop at the other end of the rope and place that loop around the taut rope.

Done!



EXPERIMENT 2

Driving with the gyroscope

YOU WILL NEED

- **Gyroscope**
- **Wheels with gears**
- **4 anchor pins**
- *3 x AAA batteries*
- *Watch or clock*

HERE'S HOW

1. Open the cover on the underside of the gyroscope. That's how you get to the battery compartments.
2. Insert the batteries as indicated inside the battery compartments and replace the cover.
3. With the help of the anchor pin, firmly attach the wheels with the gears to the underside of the gyroscope.
4. Now switch on the gyroscope.
5. The disk inside will start to spin. Hold the gyroscope straight and wait for the disk to reach its top speed. This will take about 20 seconds.
6. Set the model on a table or on the ground. How does it move?

WHAT'S HAPPENING?

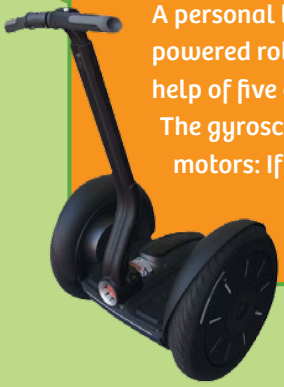
Your model is not only stable, it can also move forward! The motor powers the disk and gear system (consisting of several gear wheels) via the axle. The gears then set the wheels in motion.

LET'S GO

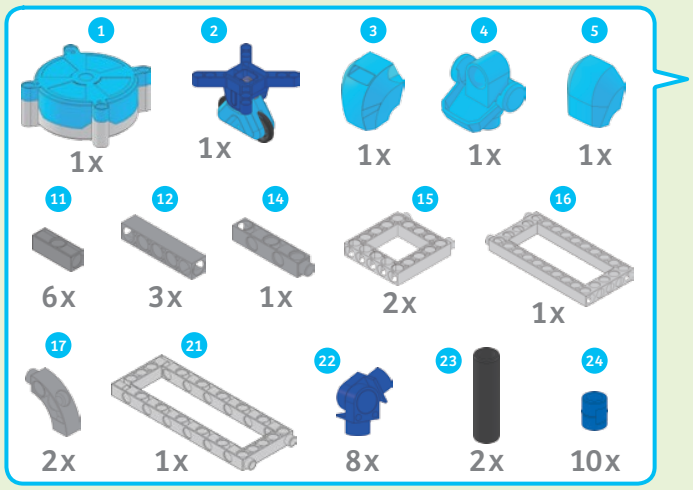
Build your own personal transporter model. Just like a real one, this model can keep its balance as it moves along.

KEYWORD: PERSONAL TRANSPORTER

A personal transporter consists of an electrically powered rolling platform that keeps its balance with the help of five gyroscopes. The driver stands on the platform. The gyroscopic effect is used to control the speed of the motors: If the driver leans slightly or strongly in a given direction, the roller moves in that direction a proportional amount.



PERSONAL TRANSPORTER



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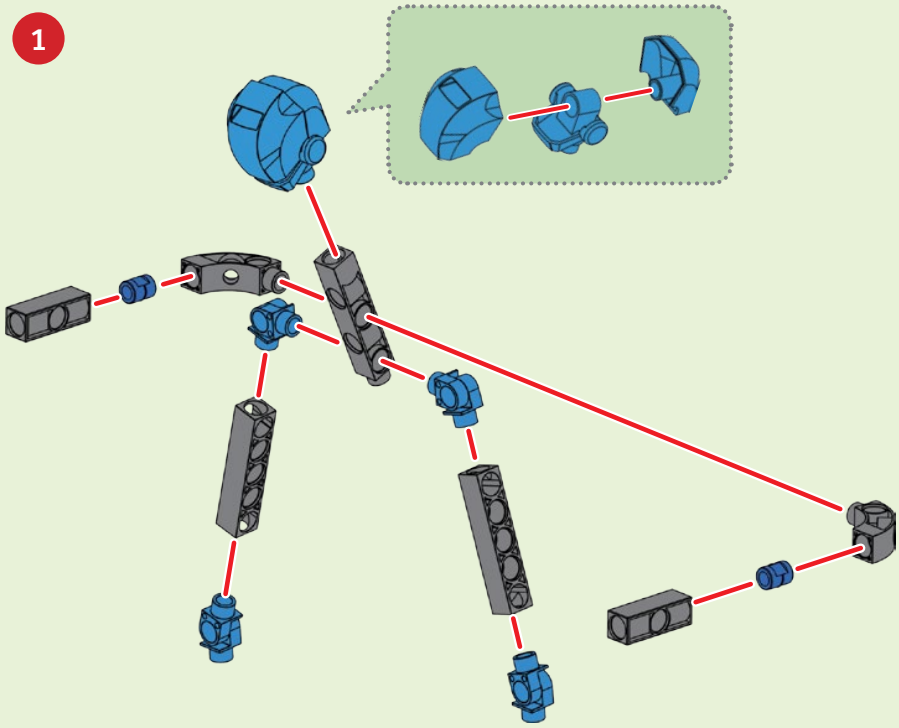

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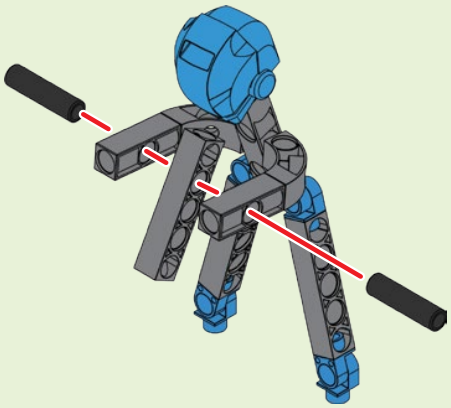

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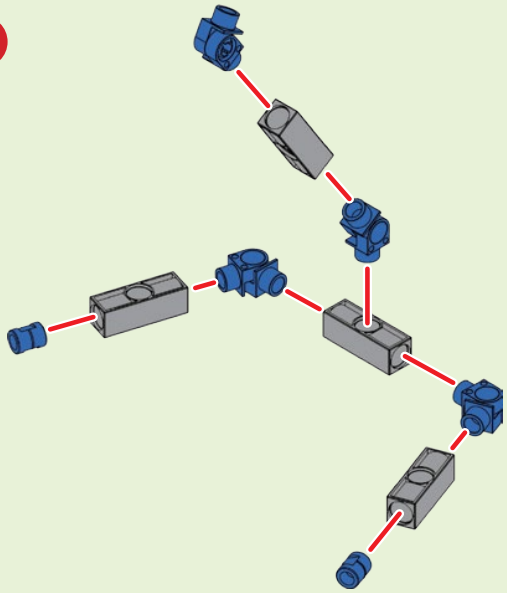

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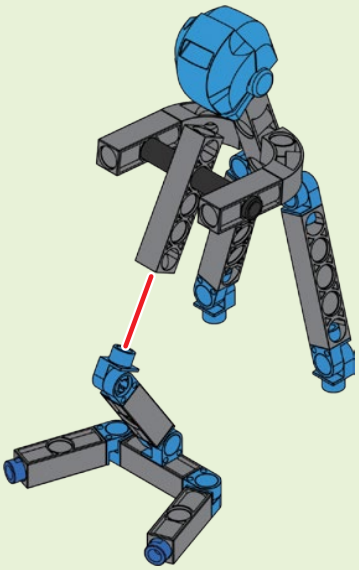

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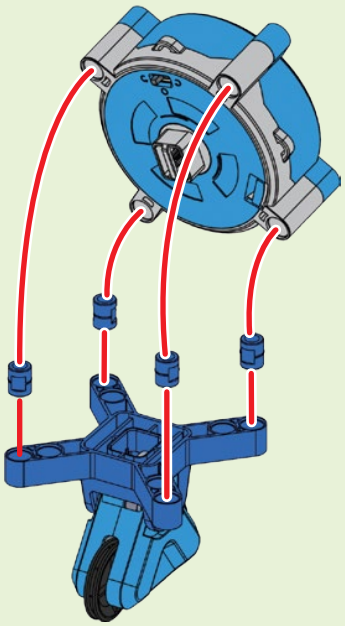

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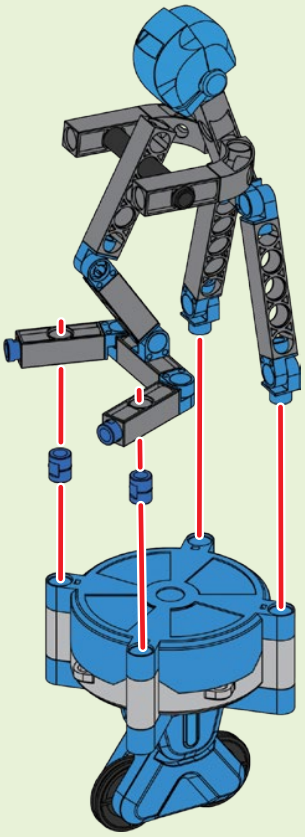

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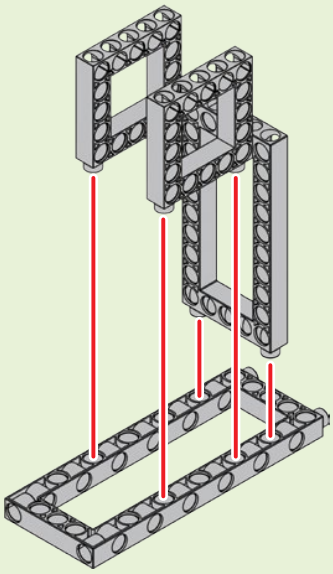
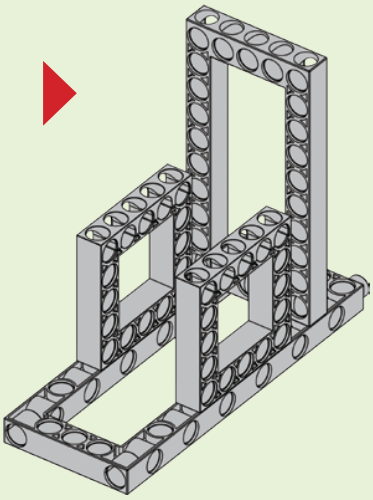
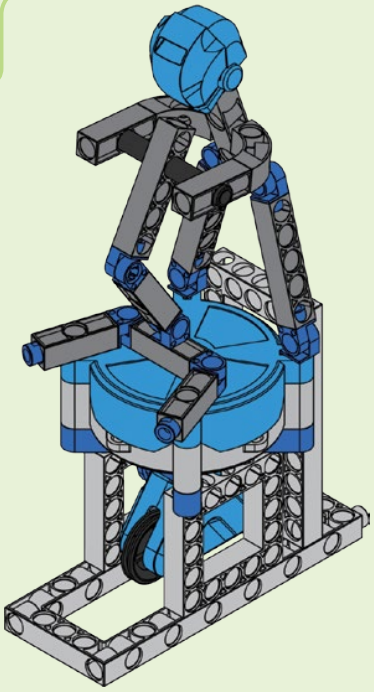




You can set the model down on this holder when you want to let the gyroscope run down.

Done!



TIP!
Don't forget that the gyroscope has to be switched on before you drive the personal transporter.

EXPERIMENT 3

Gyroscopes in airplanes

YOU WILL NEED

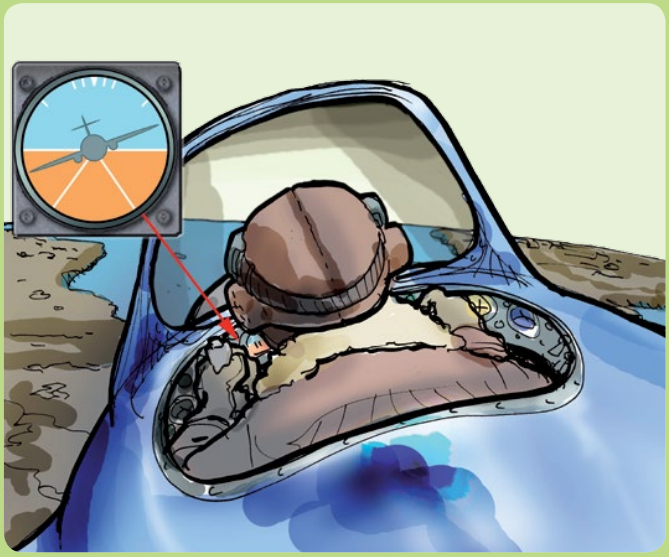
› **Gyroscope**
› *3 x AAA batteries*
› *Watch or clock*

HERE'S HOW

1. Open the cover on the underside of the gyroscope. That's how you get to the battery compartments.
2. Insert the batteries as indicated inside the battery compartments and replace the cover.
3. Now switch on the gyroscope, hold it tightly, and wait for the disk to reach its top speed. It will take about 20 seconds.
4. First hold the gyroscope straight, and then tilt it a little to the side as if the gyroscope were flying into a curve. What do you feel? Briefly tip the gyroscope a little more to the side.
5. Also try tipping the gyroscope forwards and backwards.

WHAT'S HAPPENING?

The more the gyroscope is tipped, the greater the tilt of the airplane you're simulating here, and the greater the corresponding force. The force counteracts the tilt, working to re-establish the original position. If the gyroscope is suspended in such a way that it can move freely, it will maintain its orientation regardless of the tilt of the airplane.



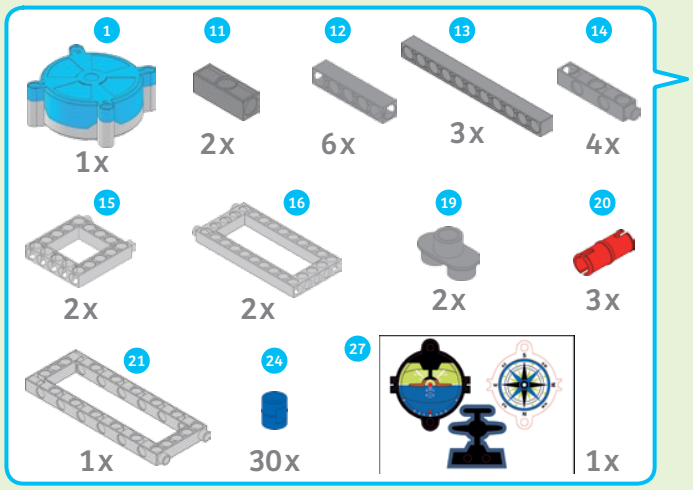
LET'S GO

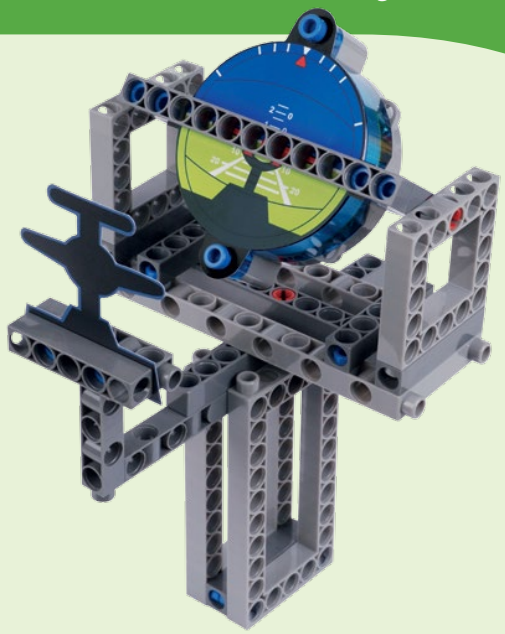
All modern airplanes have something called an altitude indicator, also known as a gyro horizon or artificial horizon.

Now you can build your own altitude indicator model! While it's true that your gyroscope is mounted vertically in your model, it will maintain its orientation even when you take the model in your hand and tip it forwards or backwards, simulating a climb or descent.

Note: You do not turn on the power for this display model!

GYRO-HORIZON





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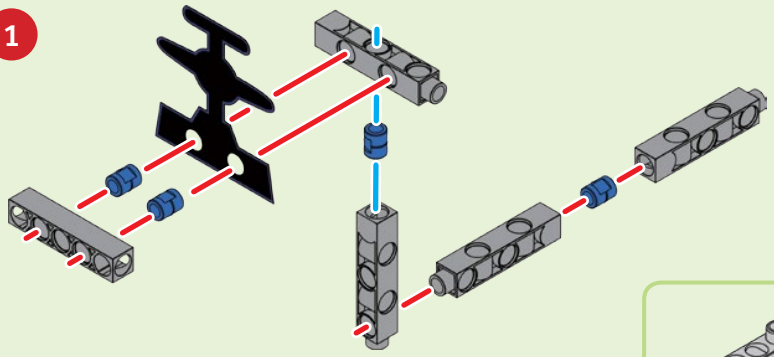

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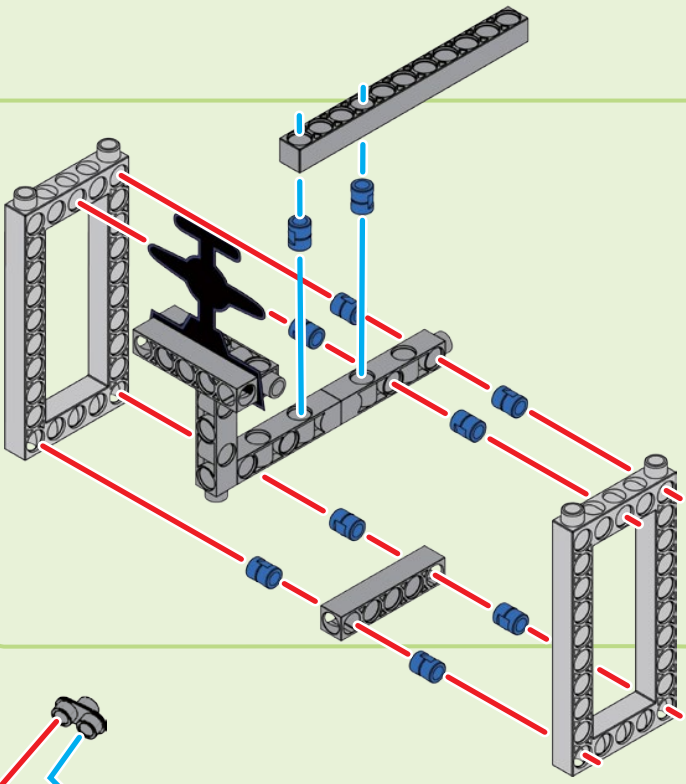

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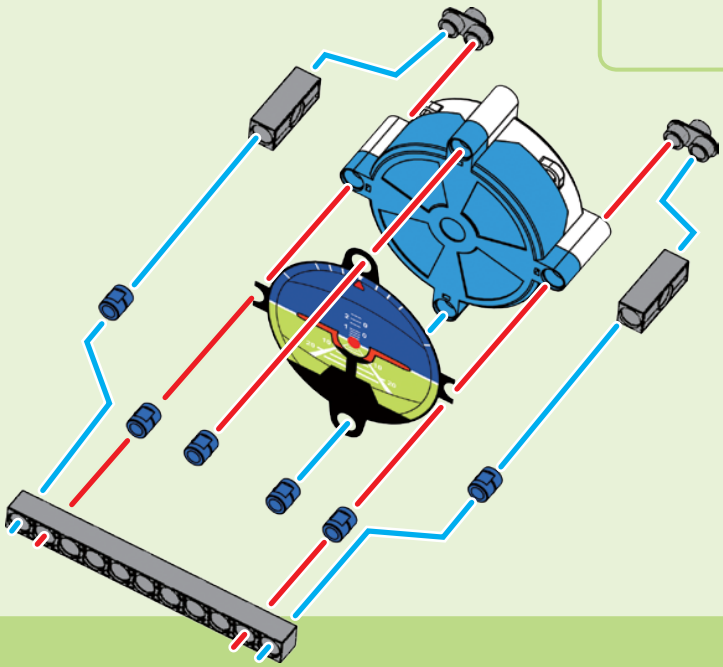

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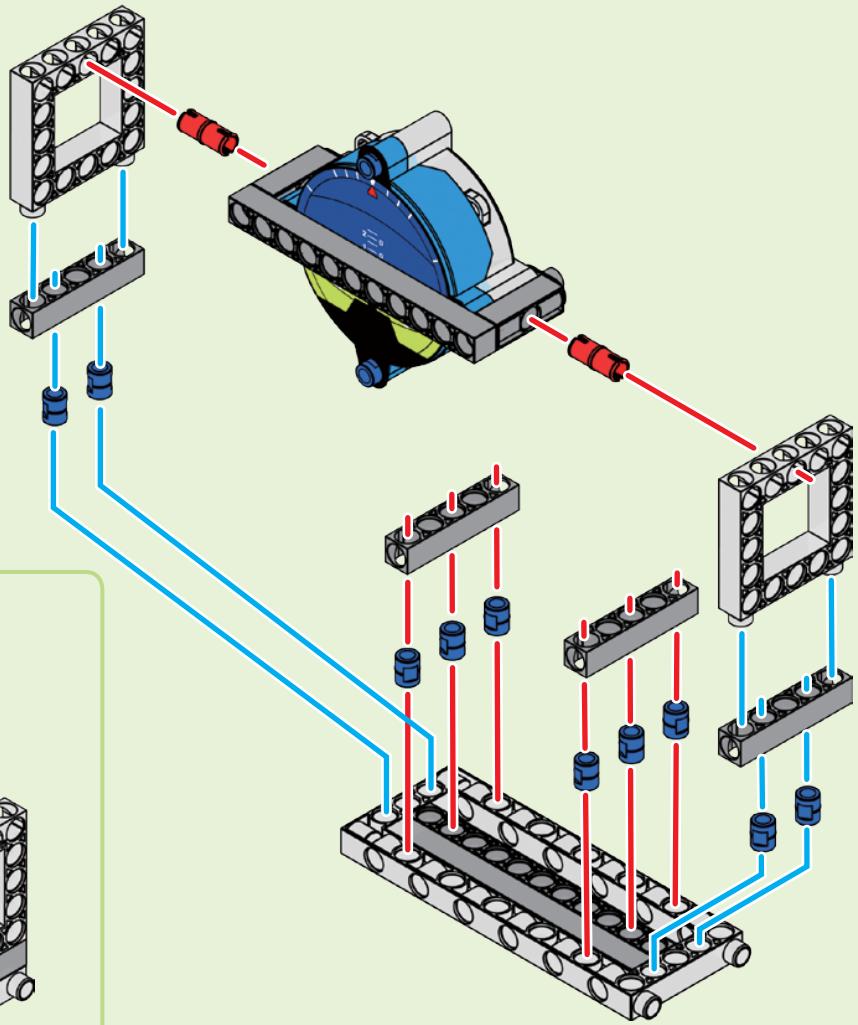

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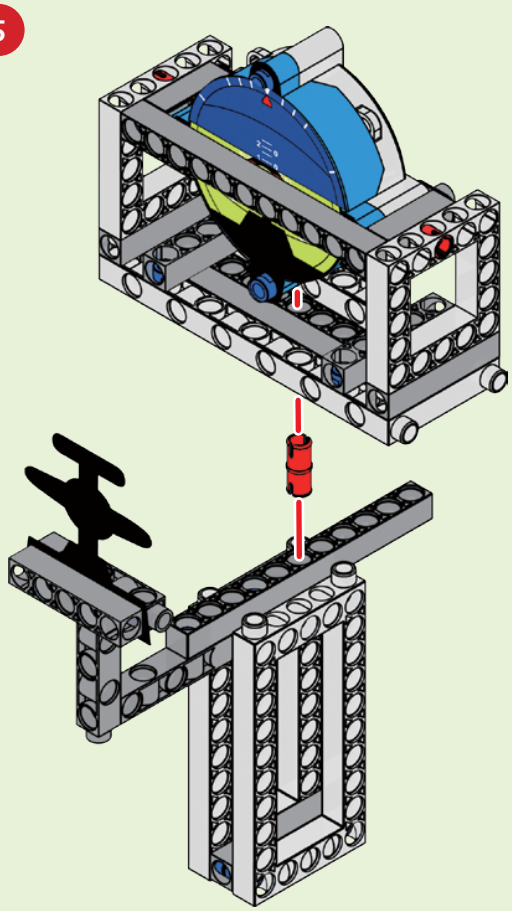
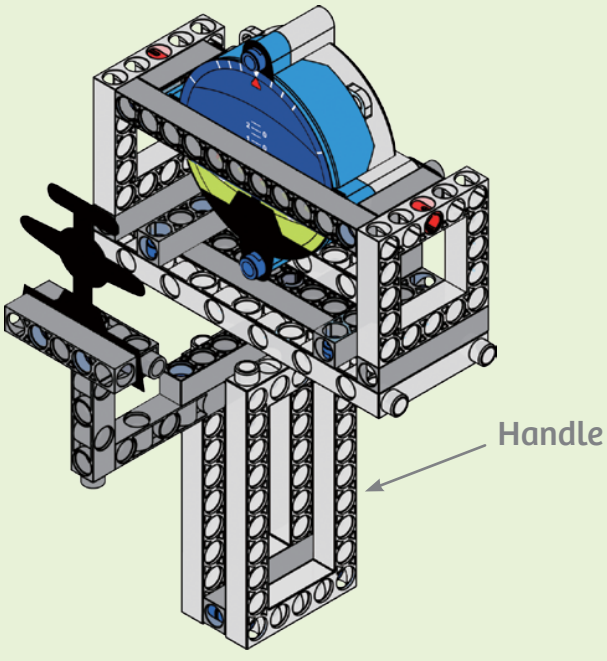
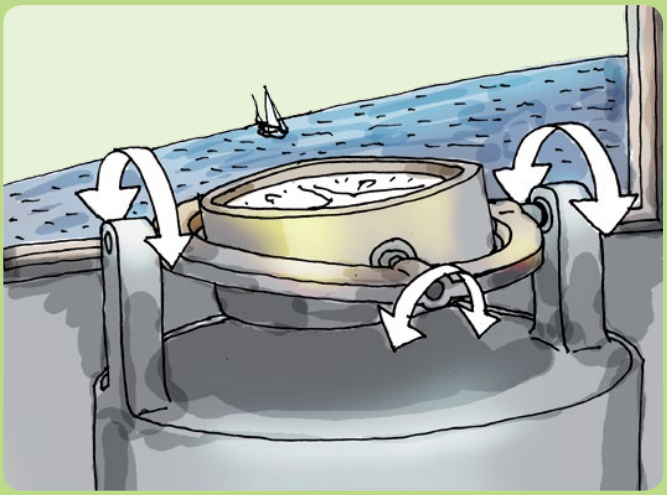




TIP!
Do not switch on this display model!

Done!

EXPERIMENT 4



How does a gyrocompass work?

YOU WILL NEED

› **The assembled gyrocompass**

HERE'S HOW

1. First, follow the gyrocompass assembly instructions provided here. You will find them on the next page.
2. Next, take the frame holding the gyrocompass in your hand.
3. Tip the frame forwards and backwards, and then to the right and left.
4. Keep your eye on the gyroscope. What does it do as you move the frame?

WHAT'S HAPPENING?

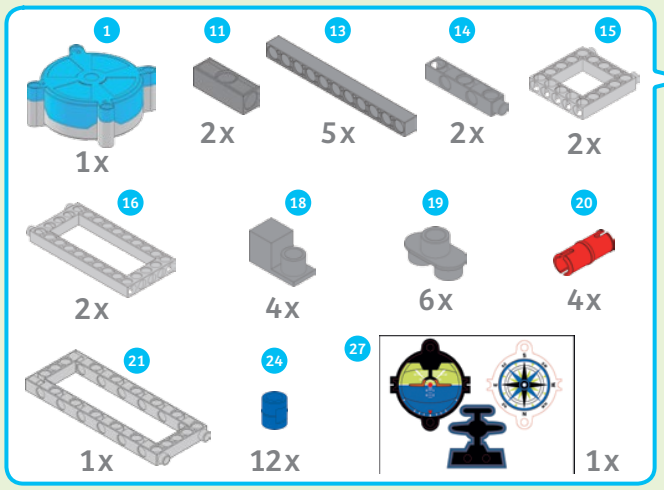
Did you notice how the gyroscope always stays in the same position regardless of how you tip the frame?

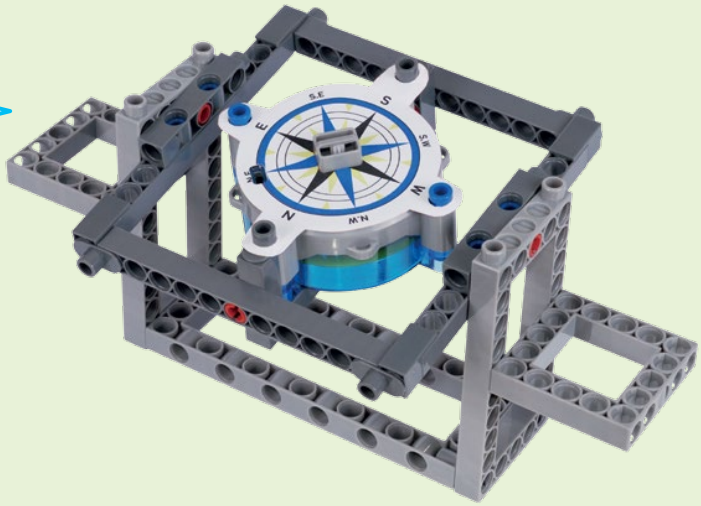
This kind of joint — known as a Cardan joint, or universal joint — is used to hold gyrocompasses, too. It keeps the gyrocompass from being thrown off by the ship's position no matter how the vessel moves. At the same time, Earth is rotating as well. So the switched-on compass has a force acting on it that serves to keep the rotational axis of the compass and that of the Earth pointed in the same direction: north-south.

DID YOU KNOW?

On large ships, gyrocompasses are used even more commonly than magnetic compasses. A gyrocompass is not affected by Earth's magnetic field, so it always points to the true geographic north.

GYRO-COMPASS





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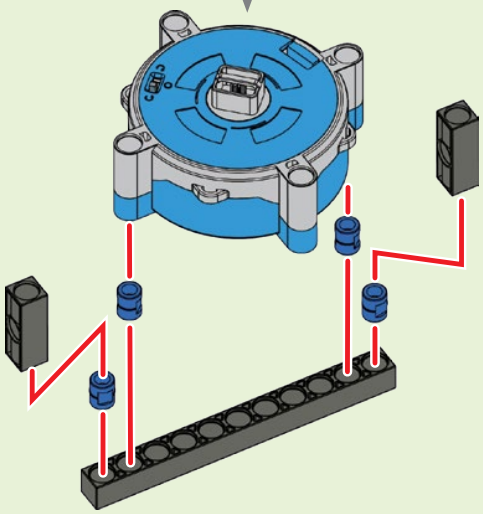
Gyroscope without batteries



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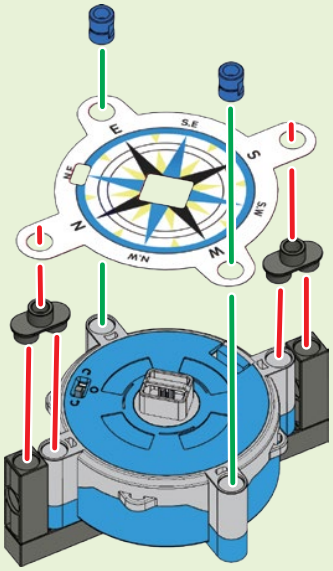

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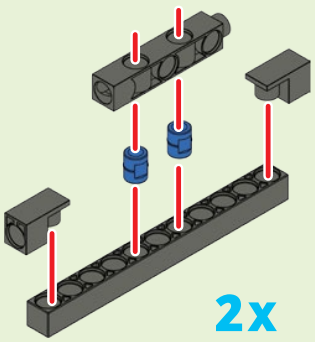

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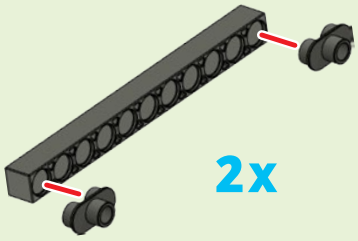

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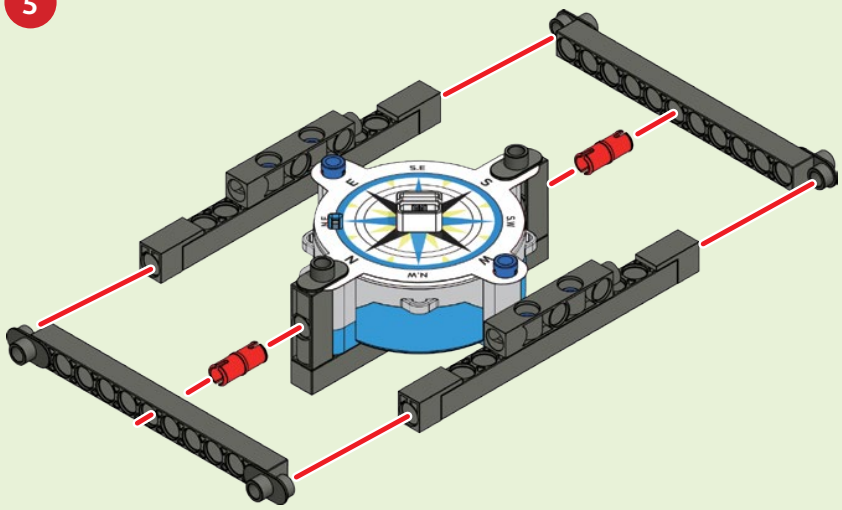

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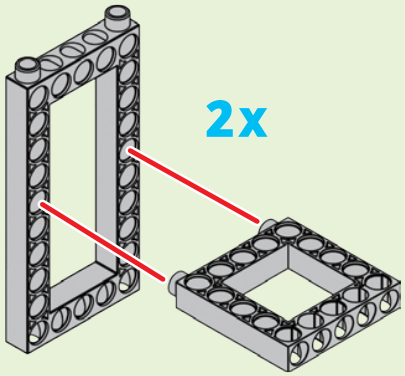

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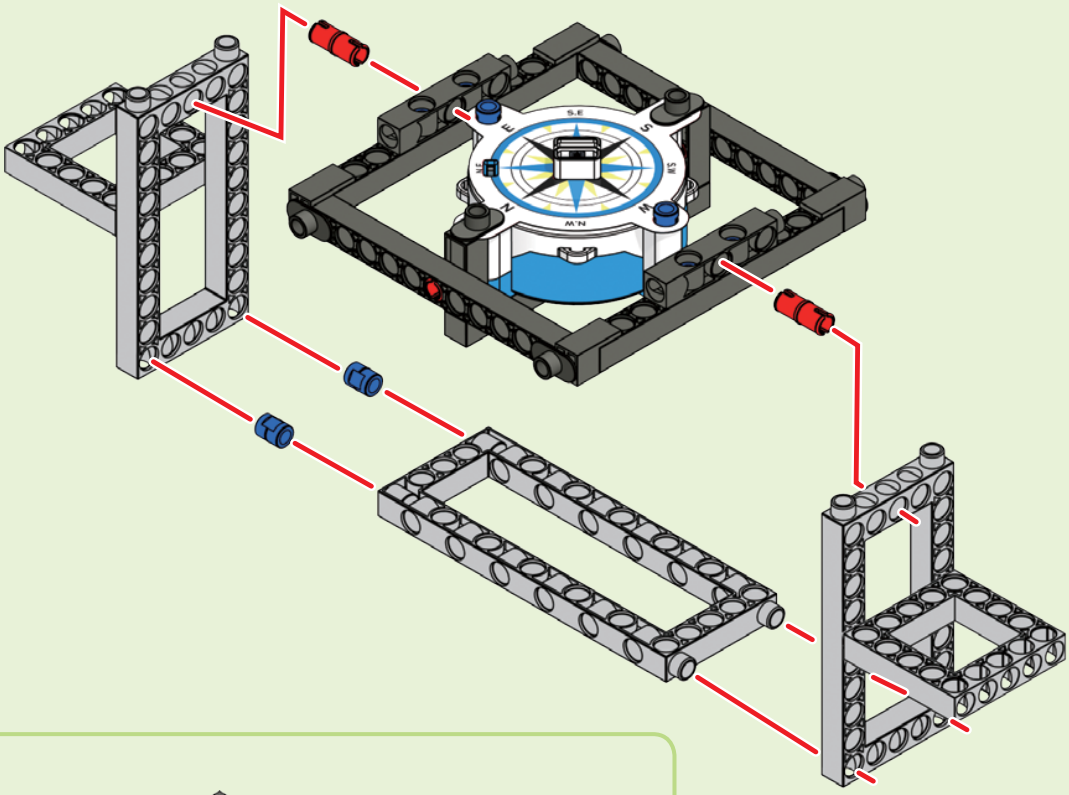
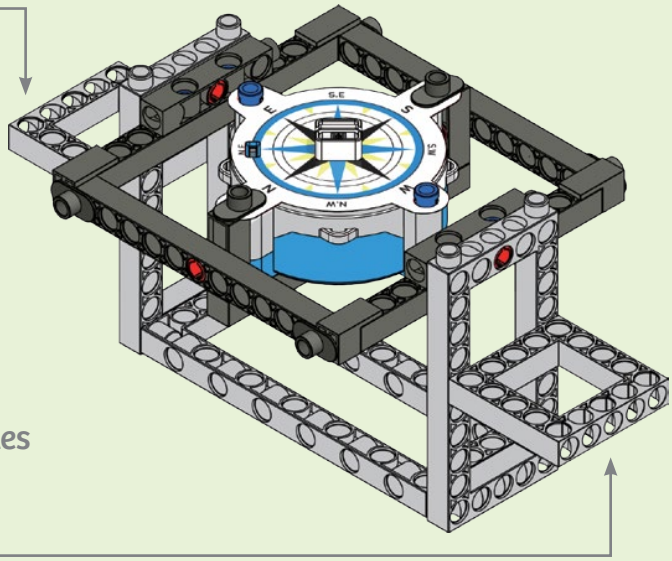




Done!

TIP!
Do not switch on this display model!

EXPERIMENT 5

Can you find the center of gravity?

YOU WILL NEED

- **A few construction pieces of your choice from the kit box**
- **Gyroscope**
- *3 x AAA batteries*
- *Watch or clock*

HERE'S HOW

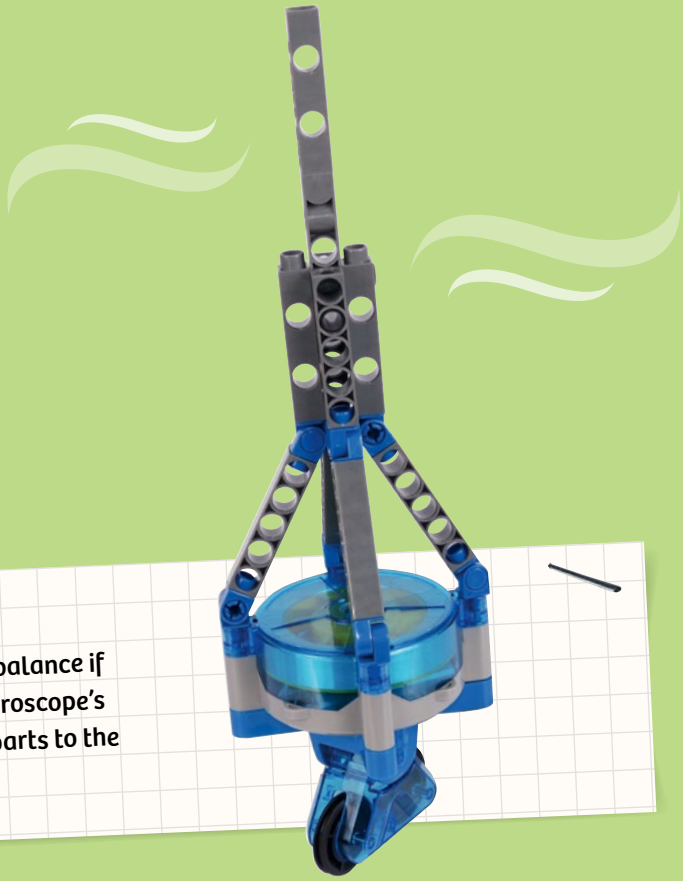
1. Use a few pieces from the box to build whatever simple figure (without the gyroscope) you like.
2. Try to balance the figure on your index finger. If you can't do it, try resting a different part of the figure on your finger.
3. As soon as you manage to balance the figure on your finger, attach another piece to any part of the figure you like, and try balancing it again. Do you have to rest a different part of the figure on your finger than you did before?
4. Next, try balancing the switched-off gyroscope on your finger. Is it difficult?
5. Now switch on the gyroscope, hold it firmly, and wait 20 seconds. Try balancing it on your finger again. Does it work better now? Where do you automatically place your finger when you try to balance it?

KEYWORDS: FORCE AND LEVER ARM

Picture a see-saw with a person on either end. If the two people are the same weight and the pivot point (or fulcrum) is in the middle, then the see-saw is balanced. If one person is heavier, he or she must slide in toward the fulcrum, so the weight balances out. The force that a load exerts on a lever is equal to the weight of the load times its distance from the fulcrum, otherwise known as the lever arm.

WHAT'S HAPPENING?

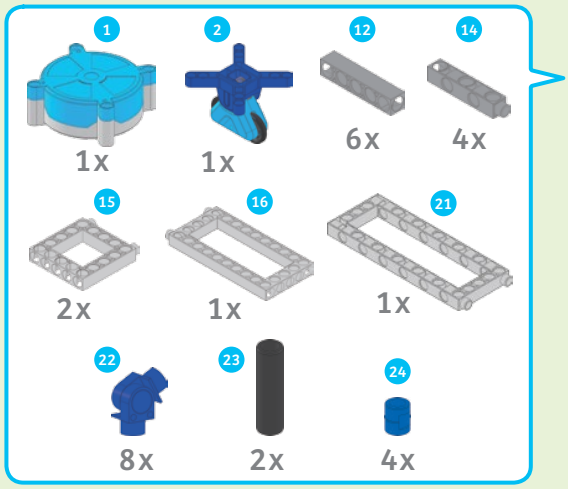
The part of the figure resting on your finger when you balance it is called the center of gravity. If you alter the figure, its center of gravity will shift to a different spot. Any object will have a center of gravity, which is the location where its weight is equal on all sides.



LET'S GO

Create your own balancing game with the gyroscope! It is also easier for the gyroscope to keep its balance if the structure around it has its center of gravity above the gyroscope's own center of gravity (that is, in the middle). Try attaching parts to the sides and see what happens.

BALANCING GAME



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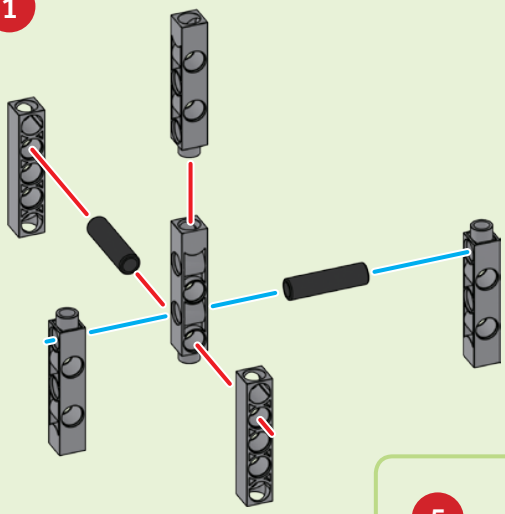

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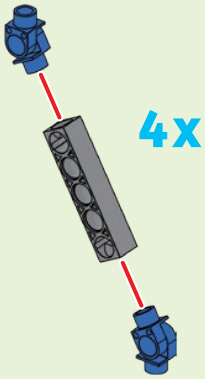

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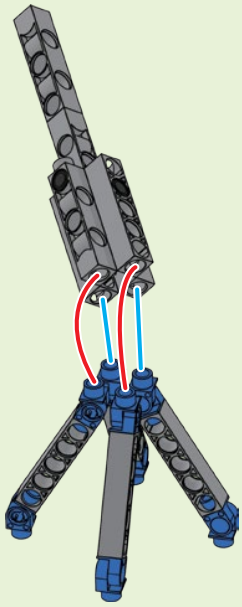

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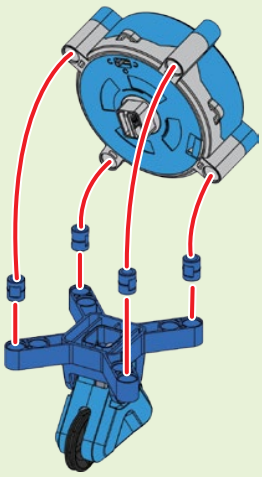

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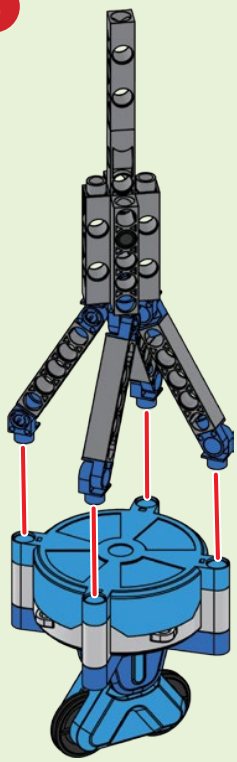

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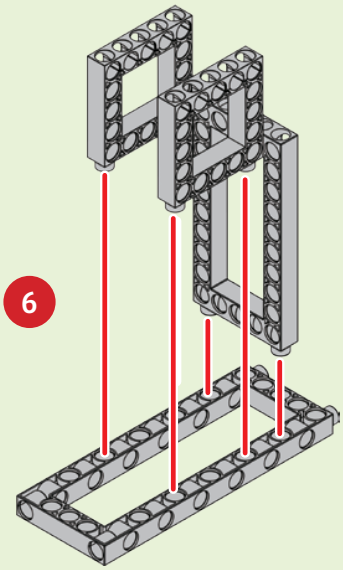
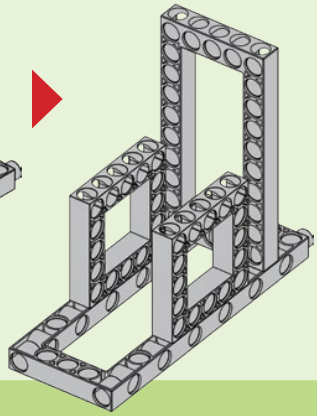
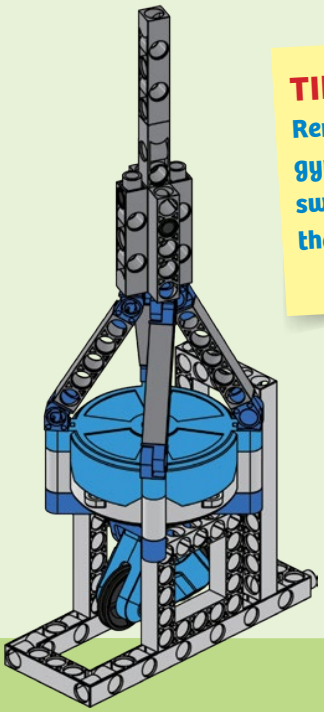


You can set the model down on this holder when you want to let the gyroscope run down.





TIP!
Remember that the gyroscope has to be switched on if you want the model to balance.

Done!

EXPERIMENT 6

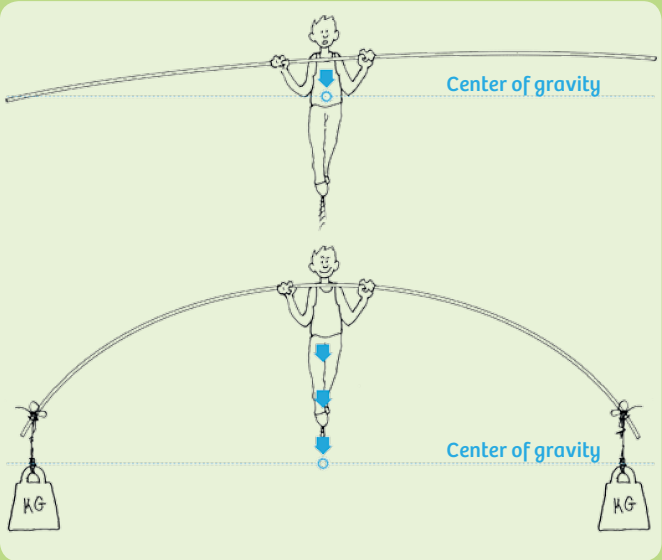
High wire act

YOU WILL NEED

› **Various-sized rods from the kit box**

HERE'S HOW

1. Try balancing the various rods on your index finger. Does it work better with long rods or short ones? Can you balance them when they are vertical in addition to lying flat? If so, then the rod has two centers of gravity.
2. Mount an 11-hole rod on the tip of a 5-hole dual rod to serve as a balancing pole. When you do this, the long bar's center of gravity is above the center of gravity of the short bar.
3. Is the 5-hole dual rod easier to balance on your finger tip with or without the balancing pole?



WHAT'S HAPPENING?

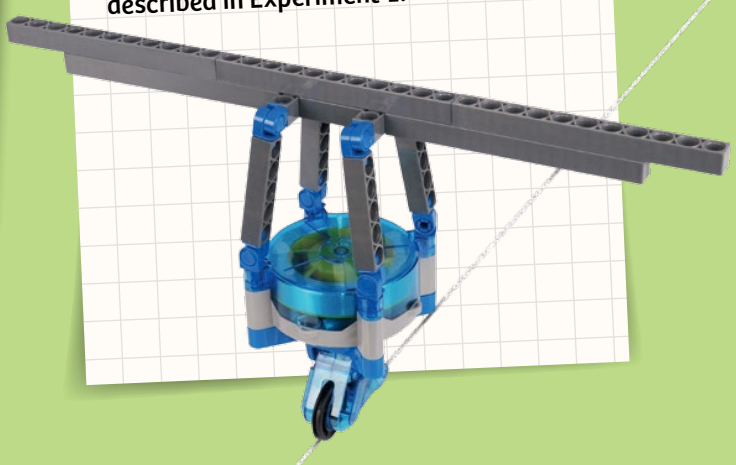
The bar is easier to balance if another bar is placed crossways on top of it. That's why tightrope walkers often carry a balancing pole or hold their arms stretched out to their sides. When a tightrope walker loses his balance, his body's center of gravity shifts so that it is no longer above the rope (which is where it is supposed to be). By tipping the pole a little, he can shift his body's center of gravity back to its position above the rope. The heavier the pole, the lower the location of the center of gravity. A balancing pole can weigh up to 30 kg!

KEYWORD: SLACKLINE

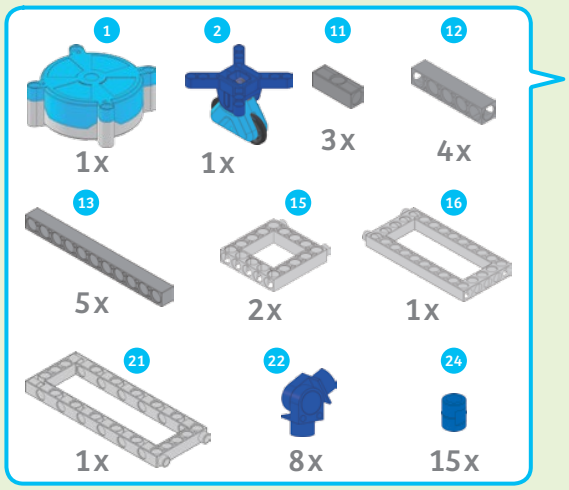
About to depart on a rock climbing trip when the weather turns nasty? No problem, thought some climbers in Yosemite National Park. Starting in the early 1980s, instead of inching up the rock face they would "dance" on their ropes or climbing harnesses stretched between the trees. Today, this fun sport is popular among non-climbers as well.

LET'S GO

Build your own tightrope walker! Do you think it can manage to cross your room on tightrope? Why not give it some secret messages to deliver? To avoid falls, secure it with a tether as described in Experiment 1.



TIGHTROPE WALKER



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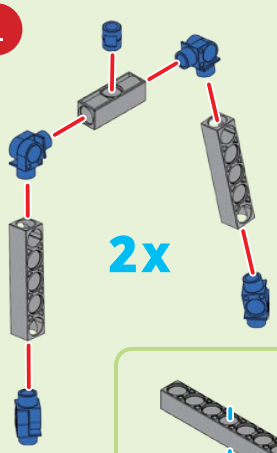

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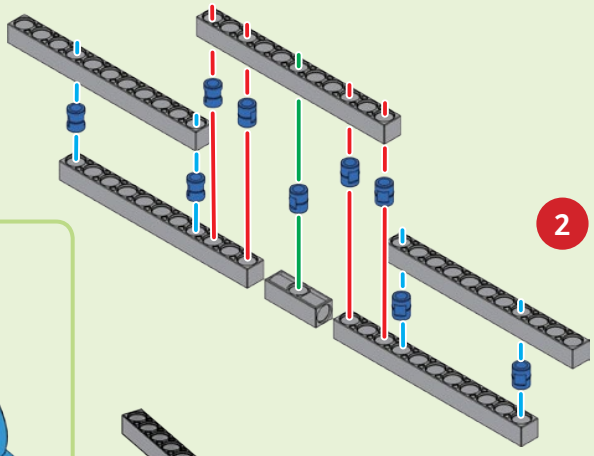

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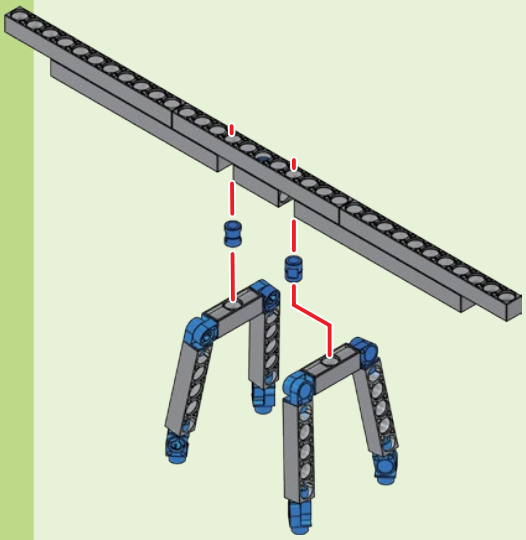

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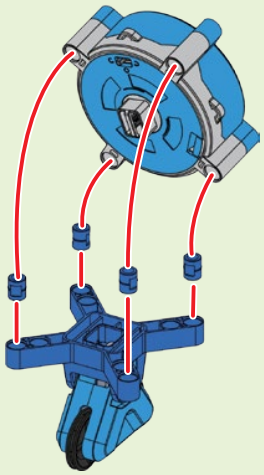

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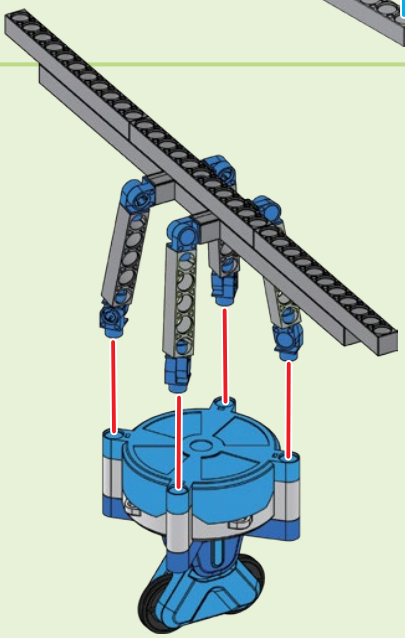

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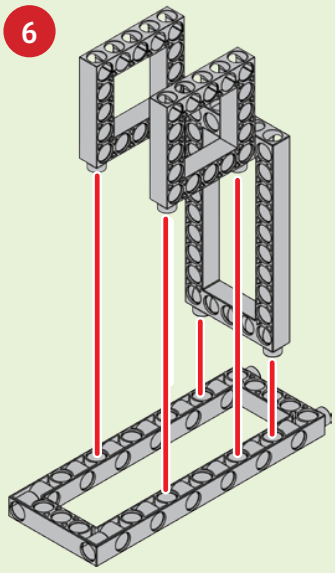
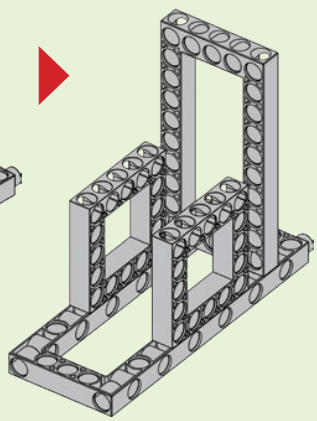
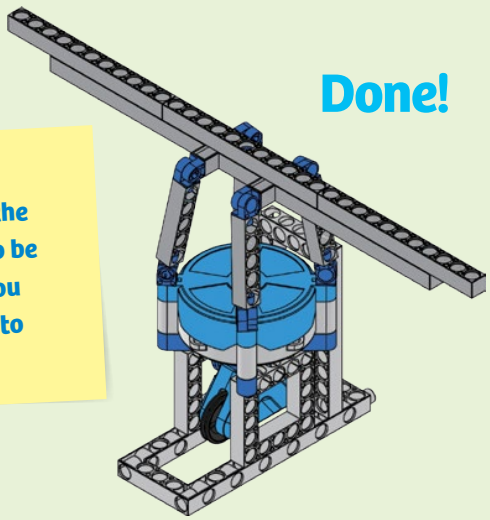


You can set the model down on this holder when you want to let the gyroscope run down.



Done!



TIP!
Remember that the gyroscope has to be switched on if you want the model to balance.

EXPERIMENT 7

Now you're the test pilot!

YOU WILL NEED

- **Gyroscope**
- **Wheels with gears**
- **6 anchor pins**
- **Various-sized rods from the kit box**
- *3 x AAA batteries*
- *Watch or clock*

HERE'S HOW

1. Insert the batteries as indicated inside the gyroscope's battery compartments.
2. Firmly mount the wheels with gears on the bottom of the gyroscope, and switch the gyroscope on.
3. The disk inside will start to spin. Hold the gyroscope tightly in its upright position, and wait about 20 seconds.
4. Can your model balance itself and drive across the table top?
5. Switch the gyroscope back off, wait until the disk is no longer spinning, and insert two anchor pins into the holes on the right or left side at the top of the gyroscope.
6. Attach a couple of rods to the anchor pins so the bars stick out to one side.
7. Switch the gyroscope on again and let it run. Can it still keep its balance?

WHAT'S HAPPENING?

If the bars are projecting out on one side, it shifts the center of gravity toward that side. When you do that, it may be too difficult for your gyroscope to compensate for this shift, and it won't be able to stay balanced on two wheels for very long.

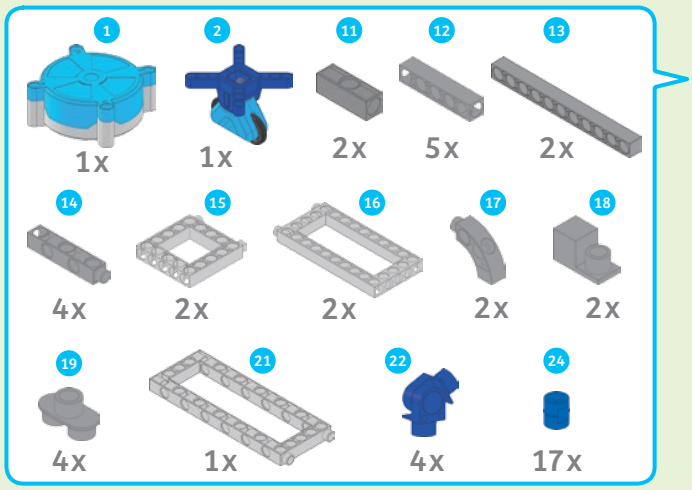
DID YOU KNOW?

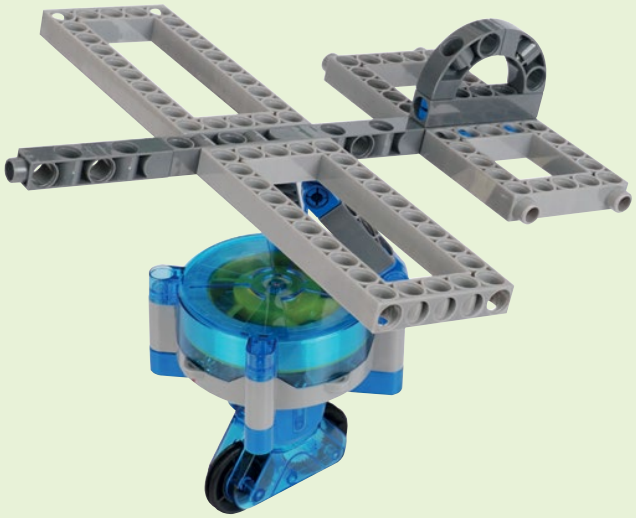
A flight simulator replicates a flight in an airplane or space ship. That lets the pilots train for hazardous situations while landing or taking off without harming themselves or the vehicle. The simulator can move like a real airplane, while the pilots watch an image of their surroundings generated by a computer.

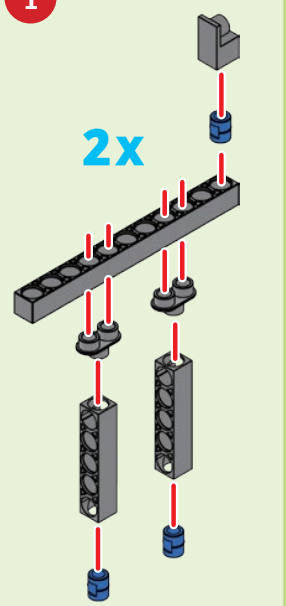
LET'S GO

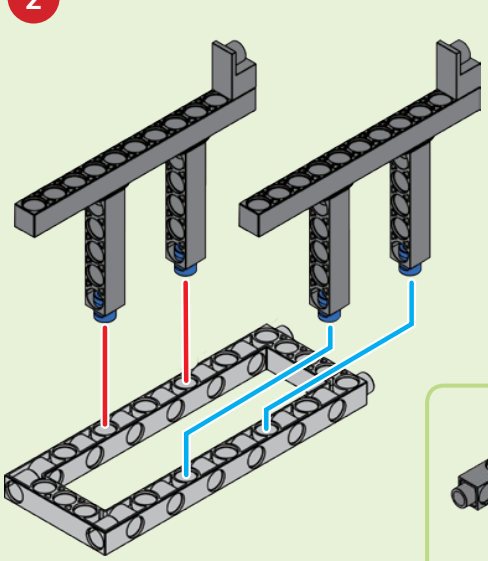
With the flight simulator that you build, it is important that all of the components project equally from the gyroscope. Only then can it balance properly and roll down the runway just like a real plane.

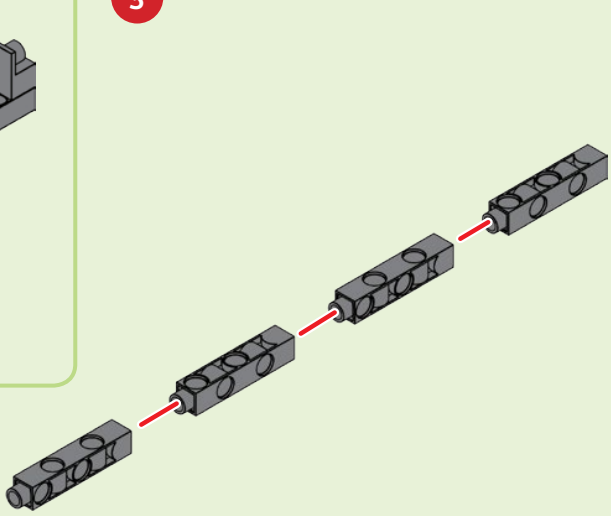
FLIGHT SIMULATOR

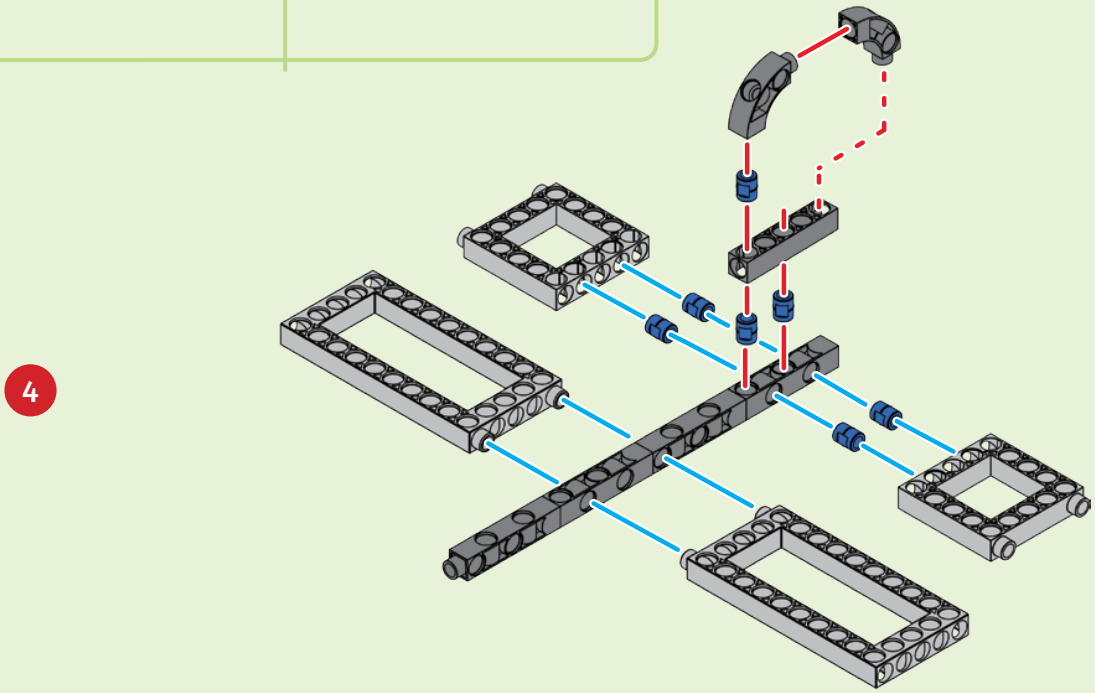












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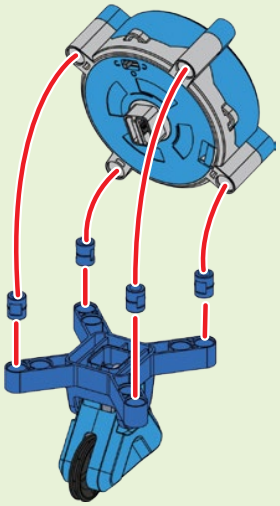

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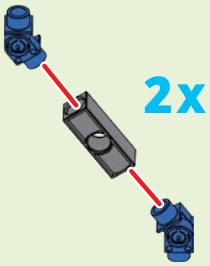

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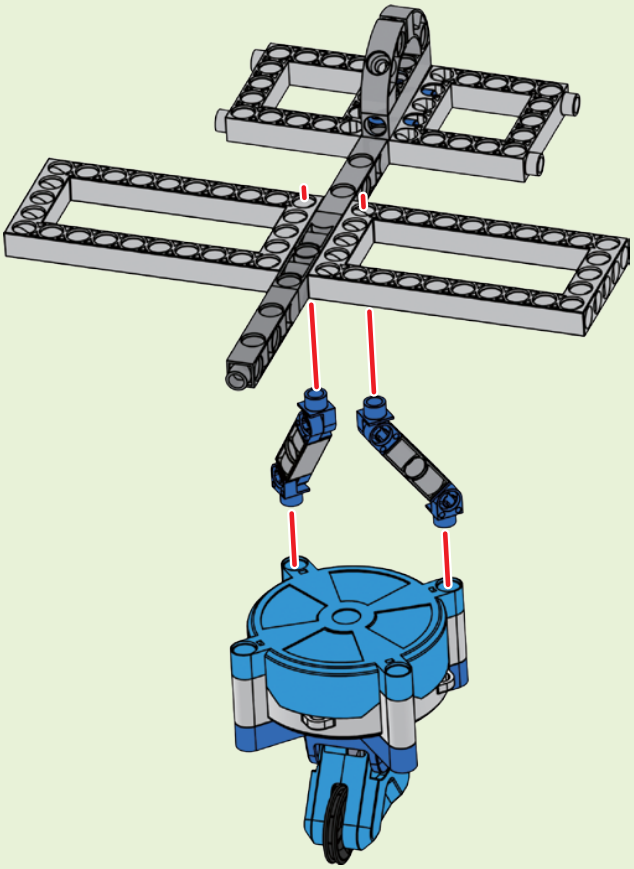

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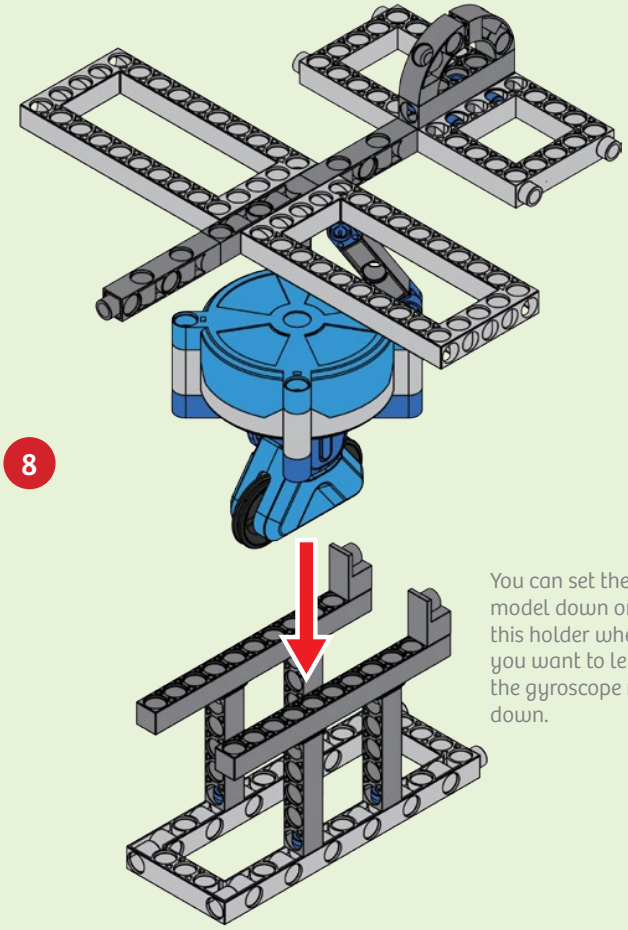
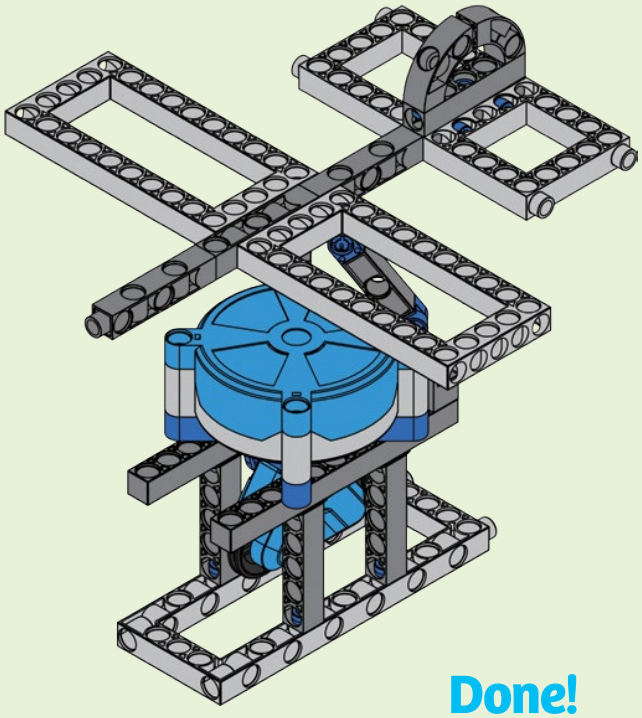


You can set the model down on this holder when you want to let the gyroscope run down.



TIP!
Remember that the gyroscope has to be switched on if you want the model to balance.

Done!

CHECK IT OUT

Multiple talents ...

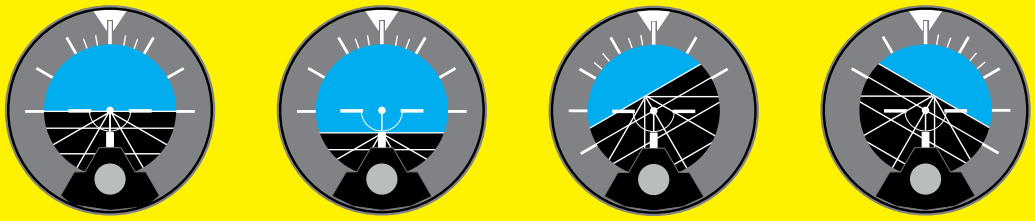
Personal Transporters can travel at speeds up to 20 km/h over distances of 40 km if their batteries are fully charged. They are often used by police and rescue crews in crowded locations — at airports, for example, or large exhibits. They also work off-road!

YET MORE "GYROS" FROM EVERYDAY LIFE

You often encounter objects that maintain a stable position by turning or rotating — and not just tops or bicycles. For example, have you ever given a diabolo a whirl?

AN AIRPLANE CHOCK FULL OF TECHNOLOGY

All modern airplanes have altitude indicators, also known as a gyro horizons or artificial horizons. These instruments show the pilot any deviation of the plane from its horizontal position. That is particularly important if visibility is poor or at night, when the pilot can't see the natural horizon.



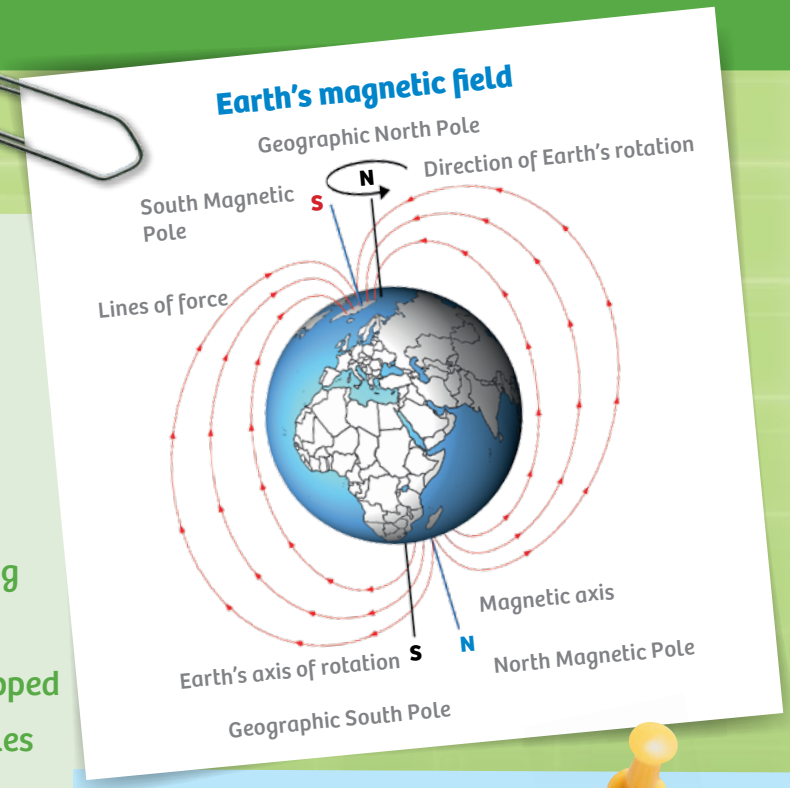
From left to right: Artificial horizon in horizontal flight, when ascending, when descending and banking to the right, when descending and banking to the left.

CHECK IT OUT

The Earth's liquid core ...

... has powerful electrical currents running through it. This is what produces Earth's magnetic field, with its lines of force wrapped around the entire globe. The magnetic poles are the locations where these lines emerge into or out of Earth.

A magnetic compass needle orients itself relative to this magnetic field. Since the positive and negative (north and south) ends or poles of a magnet attract each other, the north (positive) tip of the needle points to the South Magnetic Pole.



FUNNY BIRD

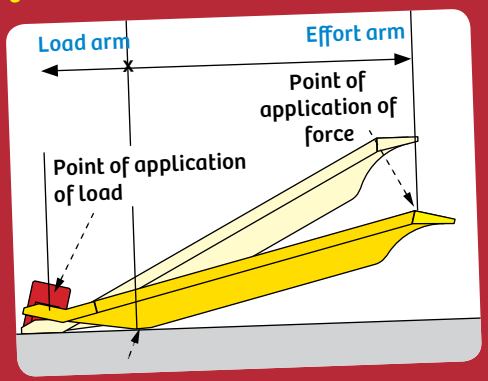
Some objects are built to have a center of gravity somewhere far away from their middle. This principle can be used to build fascinating toys such as this bird, which almost seems to float in thin air. Its center of gravity is right in its beak. Amazing!

Your arms and legs are levers, too.

LEVERAGE

You will find levers all over the place, some hidden and some in plain sight, in everyday life: door handles, the pedals of your bicycle, a pair of pliers, to name a few. Your arms and legs are levers too!

A lever is a rigid body that can be rotated around an axis. It can be any shape. Usually, it will be shaped like a rod. You can use a lever to amplify force. The end of the lever on which the force acts is called the effort arm, while the end used to lift a load is called the load arm.



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.

1st Edition 2013

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