EXPERIMENT MANUAL

Gyroscopes & Flywheels

THAMES & KOSMOS

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Safety Information

››› **Warning!** Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled.

››› The models in this kit have moving parts. Please always be careful that fingers, hair, other body parts, or delicate objects are not harmed by or caught in the moving parts. Handle the models carefully.

››› Do not touch the rotating gyroscope or rotating flywheel when they are rotating rapidly.

››› Keep the packaging and instructions as they contain important information.

››› Store the experiment material and assembled models out of the reach of small children.

Dear Parents and Supervising Adults,

Physics is an exciting and varied science that is not hard to understand, especially when you use fun models to demonstrate physics principles in action. It can be a lot of fun to figure out the astonishing physical phenomena that we encounter every day and to put this understanding to use.

This experiment kit and the working models you can build with it introduce your child to physics concepts including gyroscopic forces, angular momentum, and rotational energy. With its wealth of simple examples, your child will gain basic insights into the world of physical units and laws — which will help him or her to understand and engage more deeply in the lessons taught in school.

The individual experimental models are assembled step by step using an adjustable building system. It will require a little practice and patience at first. And your child will be particularly happy to have your help with the models that he or she finds more difficult.

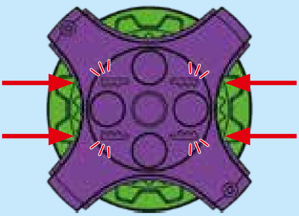
Some of the experiments may require some additional common items from your household. Help your child select these items.

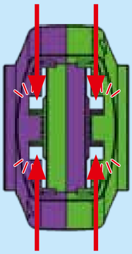
We wish you and your child lots of fun experimenting, discovering, and learning!

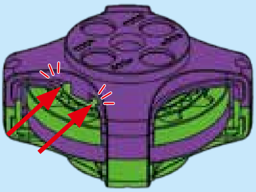
››› TIPS AND TRICKS

USING THE GYROSCOPE

There are eight possible insertion slots in the rip-cord gyroscope for the rip cords. Use only one at a time. Please note the markings on the top and bottom of the gyroscope housing which indicate the direction in which to insert the rip cords. Do not insert the rip cord into a slot if the gyroscope is still spinning.







USING THE FLYWHEEL ENGINE

The wheel with the rubber ring is the drive wheel. This is the wheel that provides the final driving force for the vehicle. This wheel is driven by the flywheel inside the device.

There are six possible insertion slots in the flywheel engine for the rip cords. Use only one at a time. Do not insert the rip cord into a slot if the flywheel is still spinning. Try the rip cord in different slots to see which way the drive wheel turns and which direction the vehicle moves for each slot.

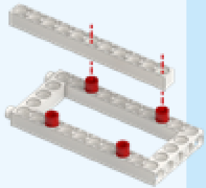
BUILDING TIPS

ANCHOR PINS AND CONNECTORS

Take a careful look at the different assembly components. Blue short anchor pins, purple joint pins, red shaft plugs, and purple 30-mm tubes can look pretty similar at first glance. When you assemble the models, it's important to use the right ones.

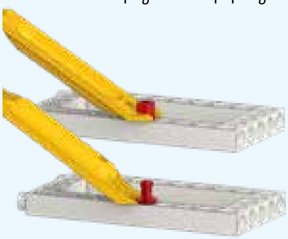
CONNECTING FRAMES AND RODS

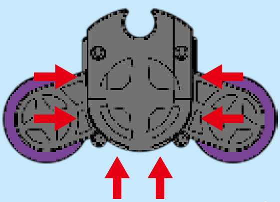
Use the anchor pins to connect frames and rods.

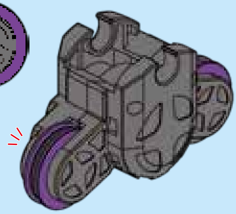


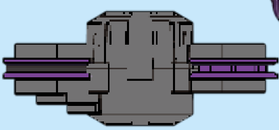
ANCHOR PIN LEVER

When you want to take your model apart again, you will need the anchor pin lever. Use the narrow end of the lever to remove the anchor pins. You can use the wide end to pry out shaft plugs.







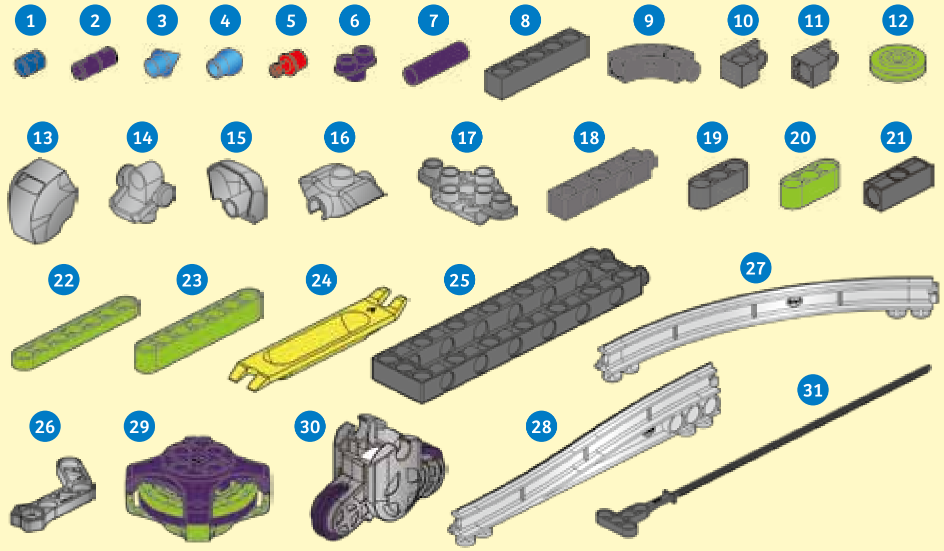


››› KIT CONTENTS

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

US: techsupport@thamesandkosmos.com
UK: techsupport@thamesandkosmos.co.uk

What's inside your experiment kit:



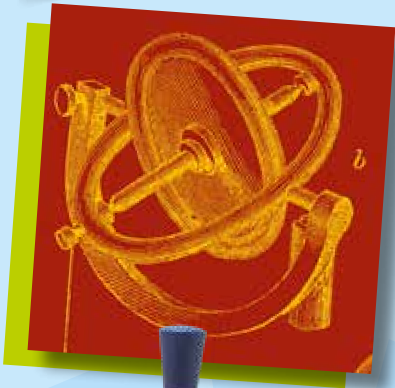
Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
○	1	Short anchor pin	19	7344-W10-C2B
○	2	Joint pin	3	1156-W10-A1P1
○	3	Cone pin	1	7128-W10-E2TB
○	4	Sphere pin	1	7128-W10-E1TB
○	5	Shaft plug	2	7026-W10-H1R
○	6	Two-to-one converter	6	7061-W10-G1P
○	7	Tube, 30 mm	3	7400-W10-G1P
○	8	5-hole rod	4	7413-W10-K2D
○	9	Curved rod	4	7061-W10-V1D
○	10	90-degree converter - X	2	7061-W10-J1D
○	11	90-degree converter - Y	2	7061-W10-J2D
○	12	Small pulley	2	7344-W10-N3G
○	13	Head 1, front	1	7396-W10-G1TD
○	14	Head 2, neck	1	7396-W10-G2TD
○	15	Head 3, back	1	7396-W10-G3TD
○	16	Gyro cover plate	2	7395-W10-E2TD

✔	No.	Description	Qty.	Item No.
○	17	Rod-to-tube connector	1	7395-W10-E3TD
○	18	5-hole dual rod B	1	7026-W10-S2D
○	19	3-hole wide rounded rod, black	5	7404-W10-C1D
○	20	3-hole wide rounded rod, green	3	7404-W10-C1G2
○	21	3-hole cross rod	3	7026-W10-X1D
○	22	7-hole flat rounded rod	2	7404-W10-C3G2
○	23	7-hole wide rounded rod	2	7404-W10-C2G2
○	24	Anchor pin lever	1	7061-W10-B1Y
○	25	13x3 Frame	2	7406-W10-A1D
○	26	Arm flat rod	2	7395-W10-E1TD
○	27	45-degree curved track	4	7395-W10-F1
○	28	Sloped track	4	7395-W10-F2
○	29	Rip-cord gyroscope	1	7395-W85-A
○	30	Flywheel engine	1	7395-W85-B
○	31	Rip cord	2	7395-W10-D1D

››› TABLE OF CONTENTS

TIP!
You will find supplemental information in the "Check It Out" sections on pages 8, 21, 26, and 32.



The Gyroscopic Effect

How is a spinning top able to balance on one small point? How does your smartphone know to change the orientation of its screen when it is turned on its side? Both of these things work because of gyroscopes and gyroscopic forces!

In the following experiments, you will investigate how a gyroscope works and how gyroscopes are used in many different ways.

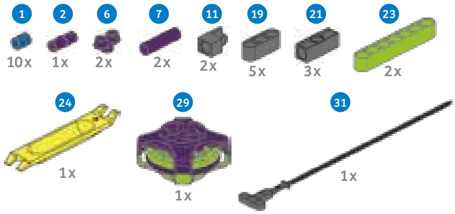
A gyroscope is a spinning wheel or disk that is mounted in such a way that it can rotate freely and assume any orientation on its own. The wheel or disk is usually mounted inside of two rings which are free to rotate in all three directions.

A gyroscope is like a spinning top held inside a frame by its axis. Gyroscopes were invented as tools to help scientists study Earth's rotation. Today gyroscopes are used in many applications such as compasses, flight instruments, and stabilization devices.

EXPERIMENT 1

The amazing gyro

YOU WILL NEED

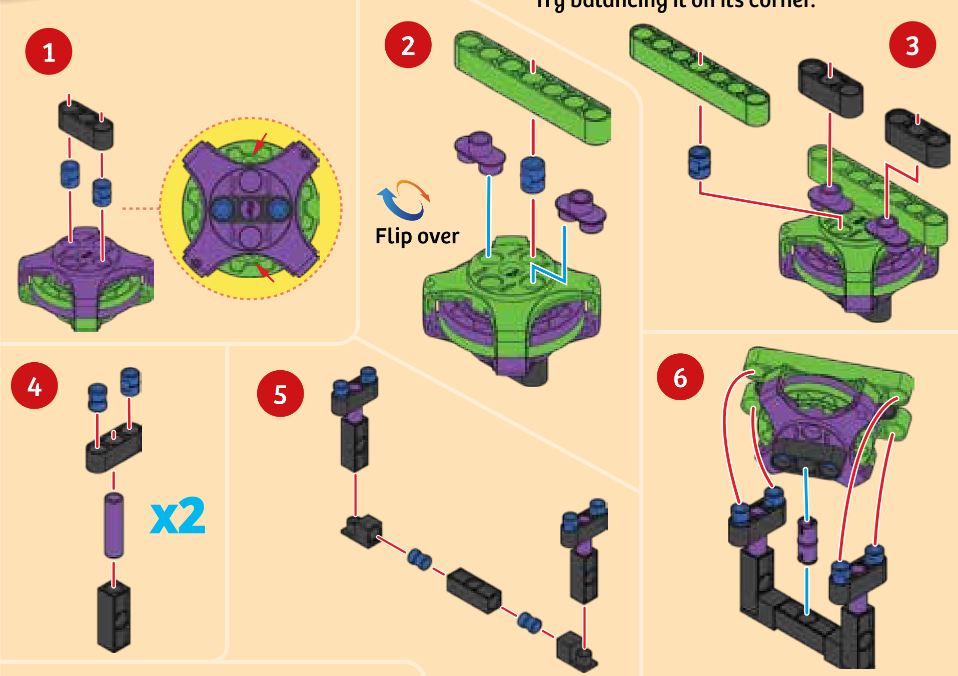


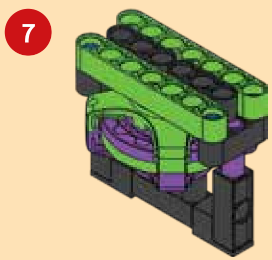
HERE'S HOW

1 to 7 Assemble the gyroscope model.

8 Place one of the rip cords through the rip cord slot in the side of the gyroscope. Pull the rip cord quickly and forcefully to start the gyroscope's rotor turning. Hold the gyroscope in your hand and turn it upside down.

9 Turn the gyroscope from side-to-side, both with and against the direction that the rotor disk in the gyroscope is spinning. Try balancing it on its corner.





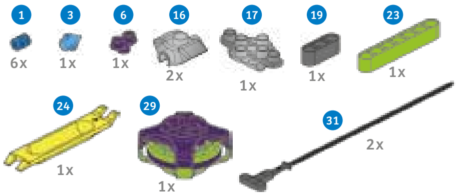
WHAT'S HAPPENING?

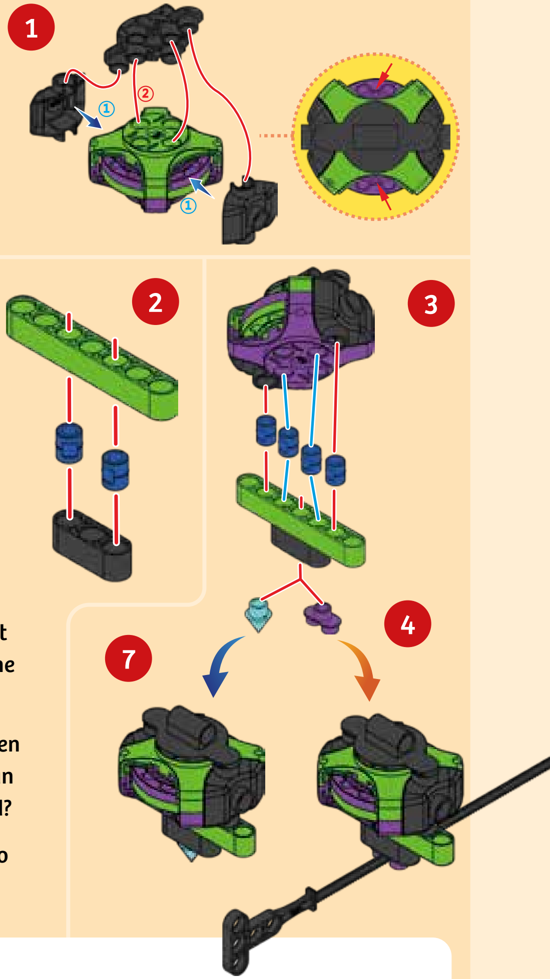
Do you feel the force that makes it so difficult to tip the gyroscope? What you're experiencing is something called the **gyroscopic effect.** It arises when an object (the rotor disk, in this case) spins very rapidly. The force that you feel when you tip the gyroscope is the gyroscope trying to maintain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

EXPERIMENT 2

Balancing top

YOU WILL NEED





HERE'S HOW

1 to 4 Assemble the model first with the purple two-to-one converter piece on the bottom.

5 Place one of the rip cords on the table. Insert the other rip cord into the gyroscope. Pull the rip cord to start the gyroscope spinning.

6 Place the gyroscope on the first rip cord. Then lift the cord up in the air with two hands. Can you get the model to balance on the rip cord?

7 Replace the purple piece with the cone pin to turn the gyroscope into a top!

WHAT'S HAPPENING?

Gravity is a force of attraction between objects. The more massive an object, the stronger its gravity. Earth's gravity acts so strongly on us because it is so large compared to us. Earth's gravity pulls all objects near Earth toward its **center of gravity.**

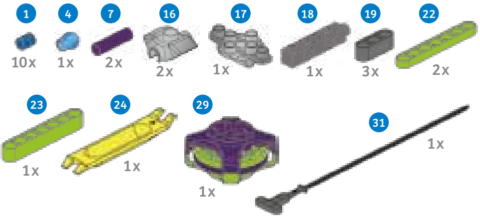
The spinning top stays balanced because of the **gyroscopic principle,** which says that a spinning object tends to stay in its plane of rotation unless an external force acts on it. The gyroscopic effect counters the force of gravity and keeps the top from falling over.

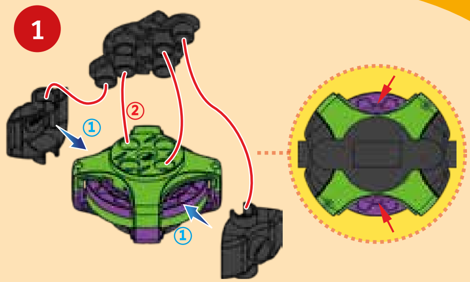
Friction between the top and the tabletop as well as between the top and the air eventually causes the top to slow down and fall over. That's why a top can't stay spinning forever! How long can you get your top to spin?

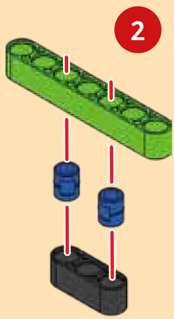
EXPERIMENT 3

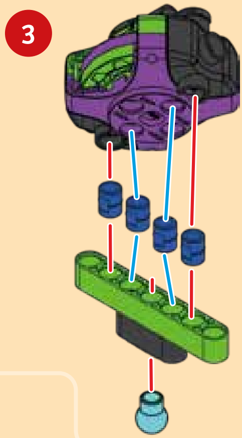
Gyroscopic forces

YOU WILL NEED







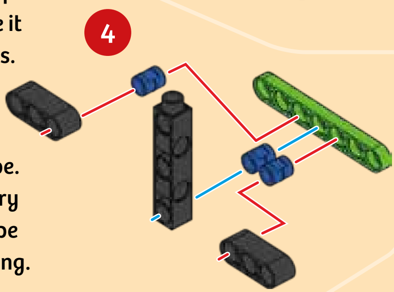


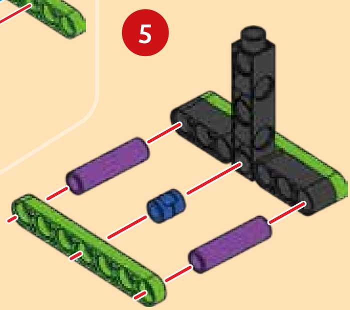
HERE'S HOW

1 to 6 Assemble the model.

7 First, without starting the rotor inside the gyroscope spinning, try to balance it on the stand a few times.

8 Insert one of the rip cords into the slot in the side of the gyroscope. Pull the rip cord. Now try to balance the gyroscope while the rotor is spinning. What do you observe?





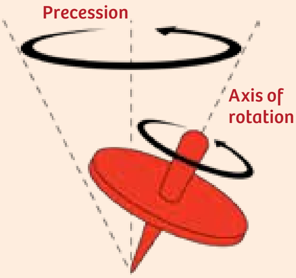
WHAT'S HAPPENING?

A top spins so fast that as soon as its weight becomes unbalanced and it starts to fall to one side, the imbalance has spun around to the other side. As long as it is spinning fast enough, it's like the top is falling to all sides evenly and therefore it stays balanced.

CHECK IT OUT

Precession

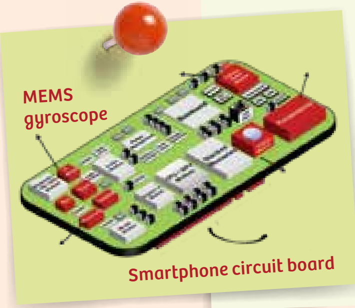
You saw in the previous experiments that the gyroscopic effect keeps the spinning gyroscope from falling over. However, the gyroscope will react to external forces applied to it by changing the direction of its axis of rotation. This change in the orientation of the rotational axis is called **precession.** Even as the rotor is spinning around the axis of rotation, the axis of rotation itself is rotating around a second axis.



Electronic Gyroscopes

How does your phone know to change its screen's orientation when the phone is turned on its side? How do cameras and video game controllers detect shaking? They use gyroscopes!

Gyroscopes are used in phones and other electronic devices to detect movement in three dimensions. The gyroscopes in smartphones are much smaller than the gyroscope in this kit.



Smartphone circuit board

These microchip gyroscopes are small enough to fit on the phone's printed circuit board along with all the other sensors and electronics. Microchip gyroscopes are called **MEMS (micro electro mechanical systems) gyroscopes.**

A Brief History of Gyroscopes

Although tops have been around for hundreds of years, the gyroscope is a more recent invention.

The first known instrument that was similar to a gyroscope was made by John Serson in 1743. It was used as a way to locate the horizon in foggy conditions at sea.

The first gyroscope was made by Johann Bohnenberger in 1817, who called his invention the "machine."

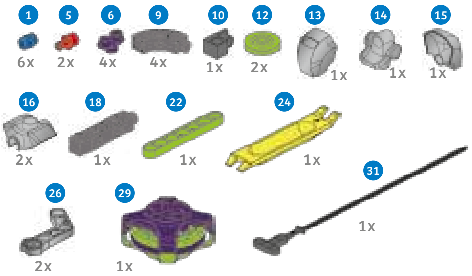
It was Léon Foucault who gave the gyroscope its name. He used a gyroscope to demonstrate the rotation of Earth, which is why gyroscope's root words are the Greek words *skopeein* for "to see" and *gyros* for "rotation."

With the use of electric motors gyroscopes were able to spin almost indefinitely. This allowed them to be used in important navigational instruments such as heading indicators and gyro-compasses.

EXPERIMENT 4

The spinning robot

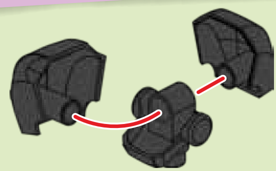
YOU WILL NEED



Determining location with gyroscopes

Image a robot in a factory assembly line needs to turn its arm to pick up a part, and to do so, the robot needs to know exactly where in space its arm is located. A gyroscopic sensor helps the robot do this. The sensor works based on the principle of how gyroscopes respond to forces (pushes and pulls). This experiment demonstrates how this works in principle.

1



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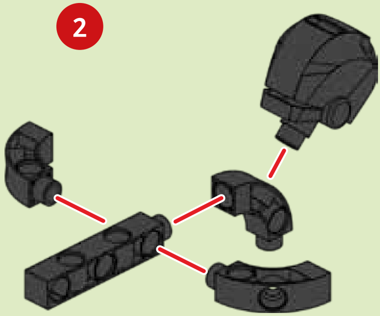

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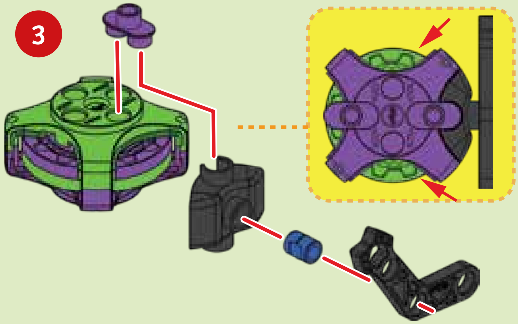

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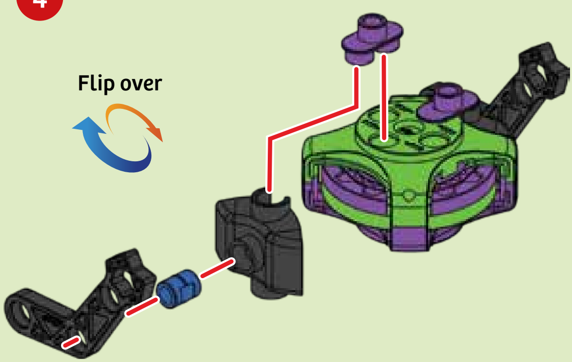

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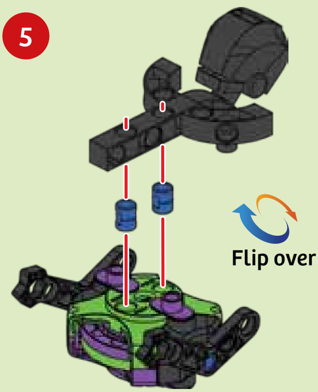


CONTINUED ON NEXT PAGE

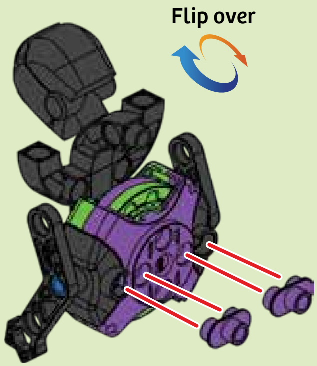
EXPERIMENT 4

HERE'S HOW

1 to 8 Assemble the model.

9 Pull the rip cord so that the rotor disk in the gyroscope turns clockwise. Does the rest of the model rotate clockwise or counterclockwise? Repeat this with the wheel turning counterclockwise.

6



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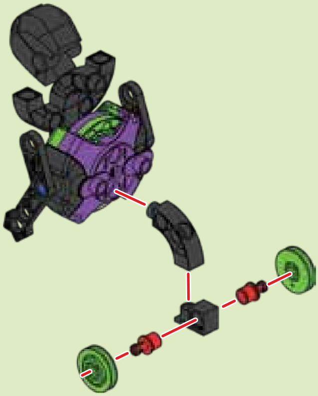


8

WHAT'S HAPPENING?

When the rotor disk rotates clockwise, the body rotates clockwise. Then when the rotor disk rotates counterclockwise, the body also rotates counterclockwise. When the disk spins, the model is experiencing what is called a **torque**. Torque is a force that causes something to rotate. When you turn a bolt using a wrench, you are applying a torque. This is why the model spins in the direction that the disk is spinning.

So, how is the factory robot able to use a gyroscope to find its arm's position? It does this by measuring the amount of torque that a gyroscope inside the arm experiences when it turns and using the torque measurements to calculate the distance and direction the arm moved.

Momentum

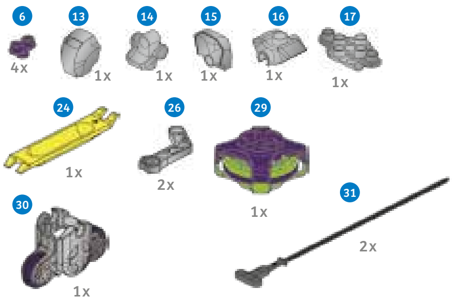
Why does a figure skater spin faster when they move their arm closer to their body? How does the Earth behave like a top?

In the following experiments you will learn about another property of gyroscopes and flywheels called momentum.

EXPERIMENT 5

Balancing robot

YOU WILL NEED



Forces of resistance

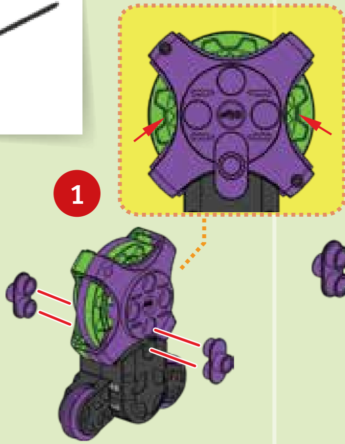
If you roll a ball on the ground and it does not bump into anything, why does it stop rolling? The reason the ball stops rolling is because of **friction.** Friction is a force that resists motion by converting that motion into heat. If you rub your hands together you will feel them heat up due to friction. If there was no friction and the ball could roll forever, would it ever stop rolling?

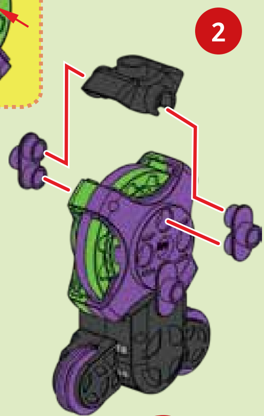
HERE'S HOW

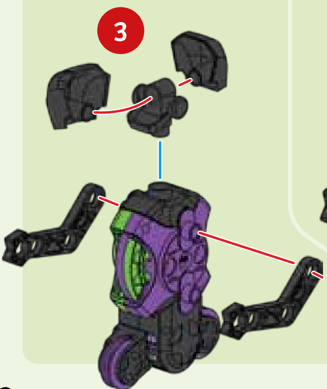
1 to 4 Assemble the model.

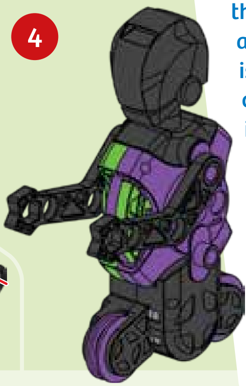
5 Insert one rip cord into the slot in the flywheel engine. Pull the rip cord and place the model down on a flat smooth surface. See how far the model travels.

6 Now insert rip cords into both the gyroscope and flywheel engine. Pull both rip cords at once (or start with the gyroscope) and place the model down. How does the distance it travels this time compare to before?









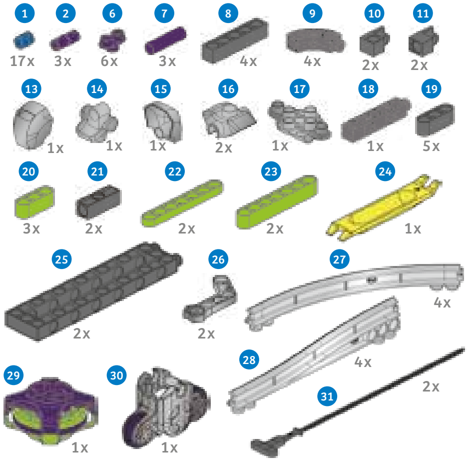
WHAT'S HAPPENING?

From your previous experiments you saw that a gyroscope resists changes in its axis of rotation. This resistance to change is due to a property of all materials called **inertia.** You feel the effects of inertia when a car stops suddenly and your body continues moving forward, pressing into your seatbelt. Inertia was formulated by Newton in his first law of motion, often called the law of inertia. It states that an object at rest stays at rest, while an object in motion stays in motion unless it is acted upon by a force.

EXPERIMENT 6

Rip-cord gyrobot and track

YOU WILL NEED



Note: This model is intended to be used with the track included in the kit. Instructions for track assembly start on the next page.

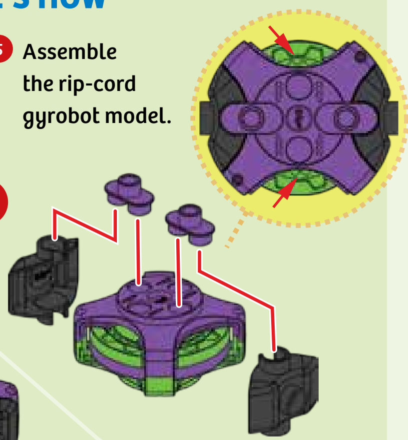
Objects in motion

If a large truck is traveling very fast it would take a large force to bring it to a stop. Is that due to the inertia of the truck? The inertia of an object is only related to its mass. Since the object is moving, this requires another important concept from physics called **momentum.**

HERE'S HOW

1 to 5 Assemble the rip-cord gyrobot model.

1



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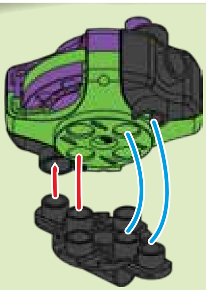

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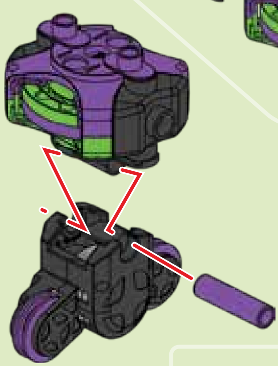

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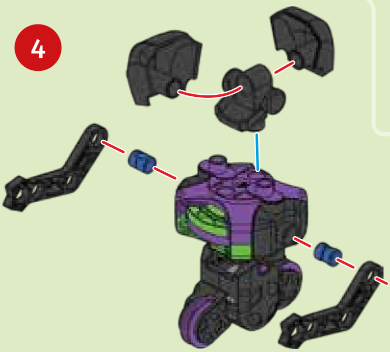
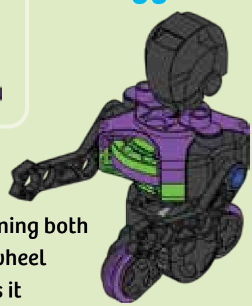


5 Rip-cord gyrobot



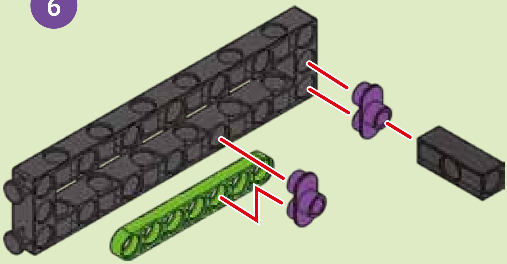
Test this model by spinning both the gyroscope and flywheel with the rip cords. Does it balance and move forward?

CONTINUED ON NEXT PAGE

Launch chute assembly

6 to 12 Now assemble the launch chute. This structure acts as a chute to help you quickly load the rip-cord gyrobot onto the track, so it's easier to get the gyrobot perfectly positioned and running on the track before its gyroscope rotor or flywheel run down too much.

6



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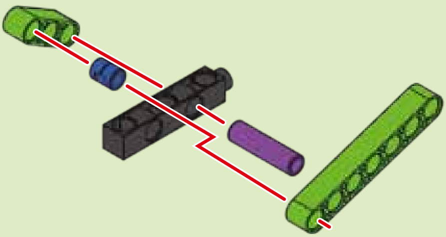

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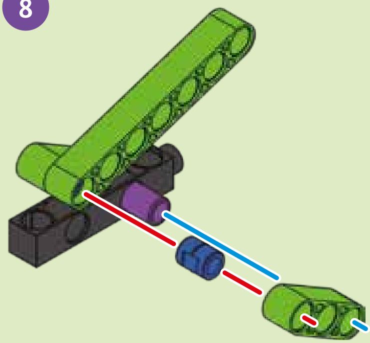

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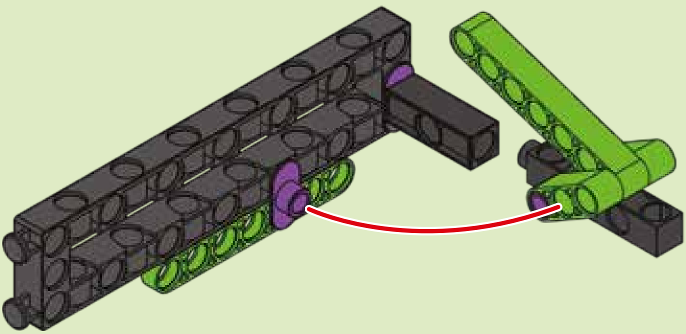

EXPERIMENT 7

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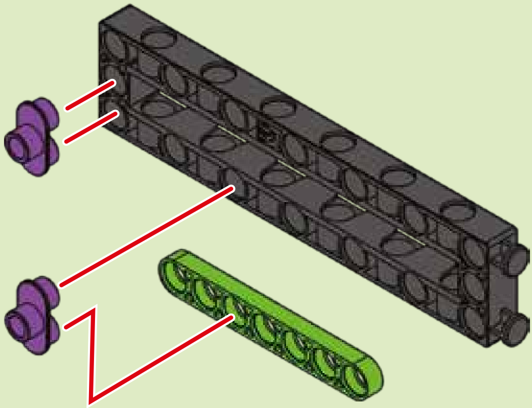

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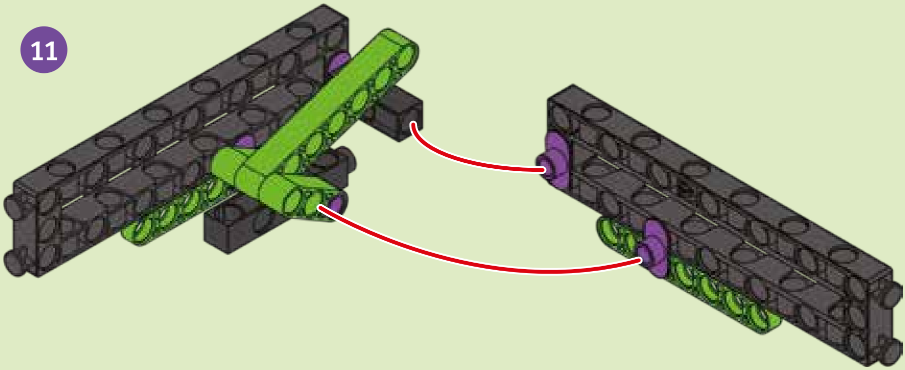

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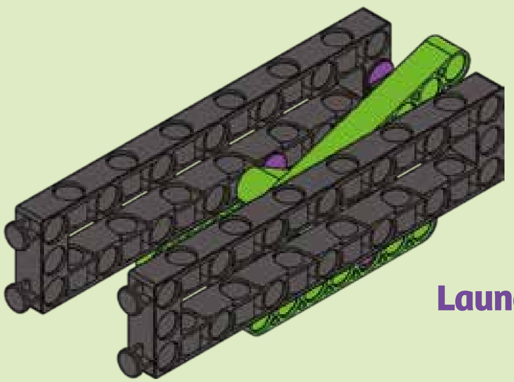

Launch chute

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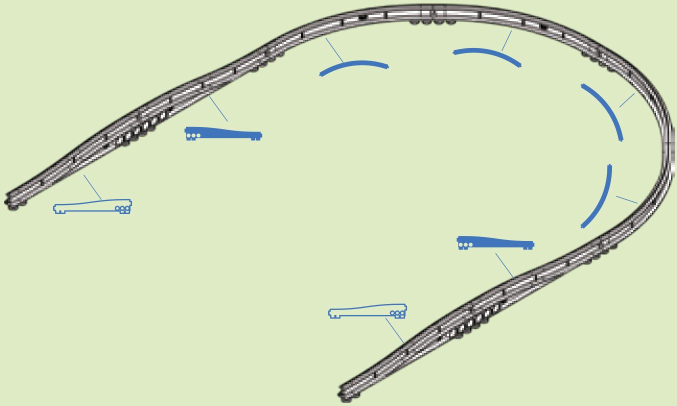
EXPERIMENT 7

“U-turn” track assembly

13 to 18 Now assemble the track. Follow the instructions here to build the “U-turn” track design. There are nine other track configuration suggestions on pages 18–20.

13



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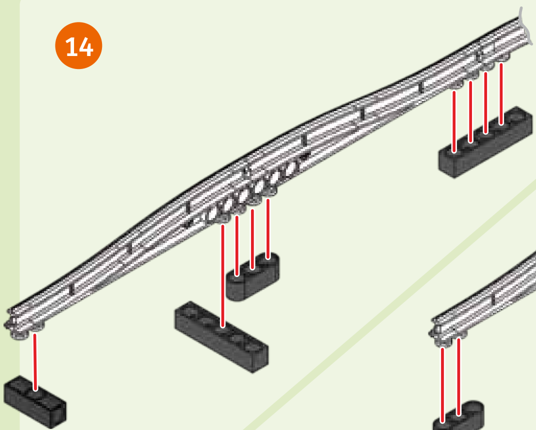

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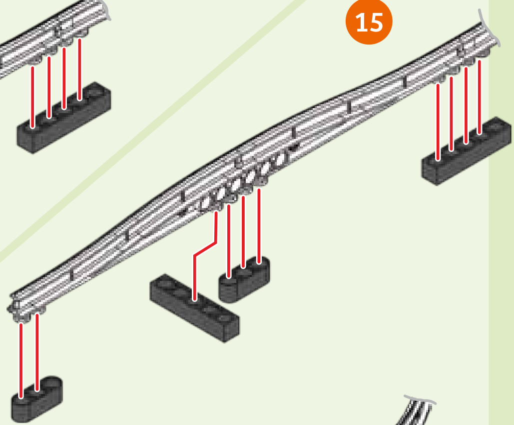

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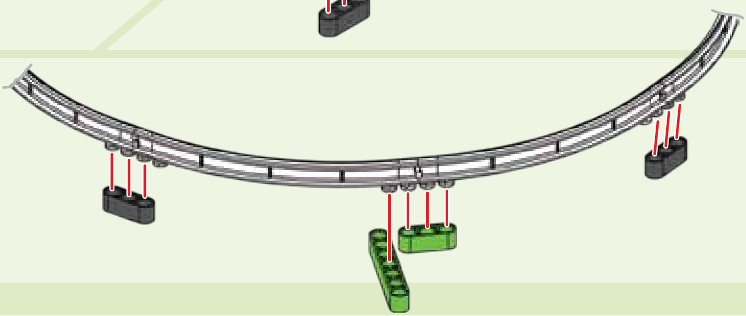
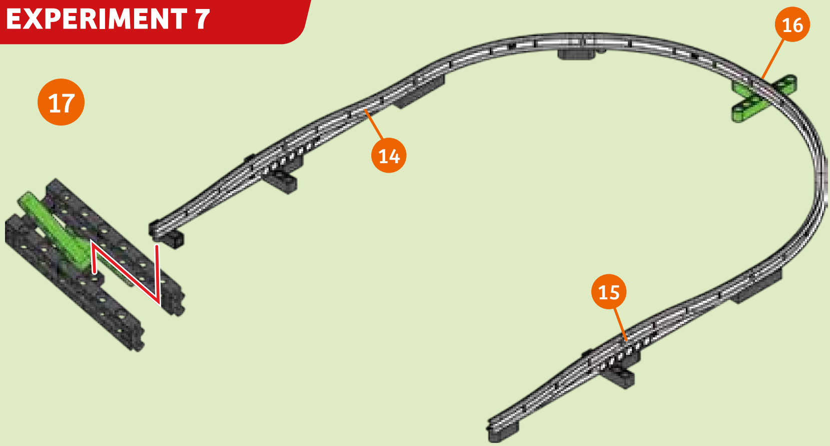
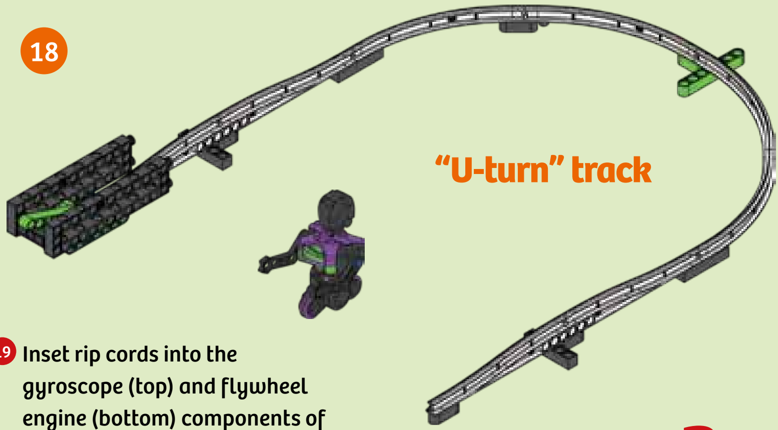


EXPERIMENT 7





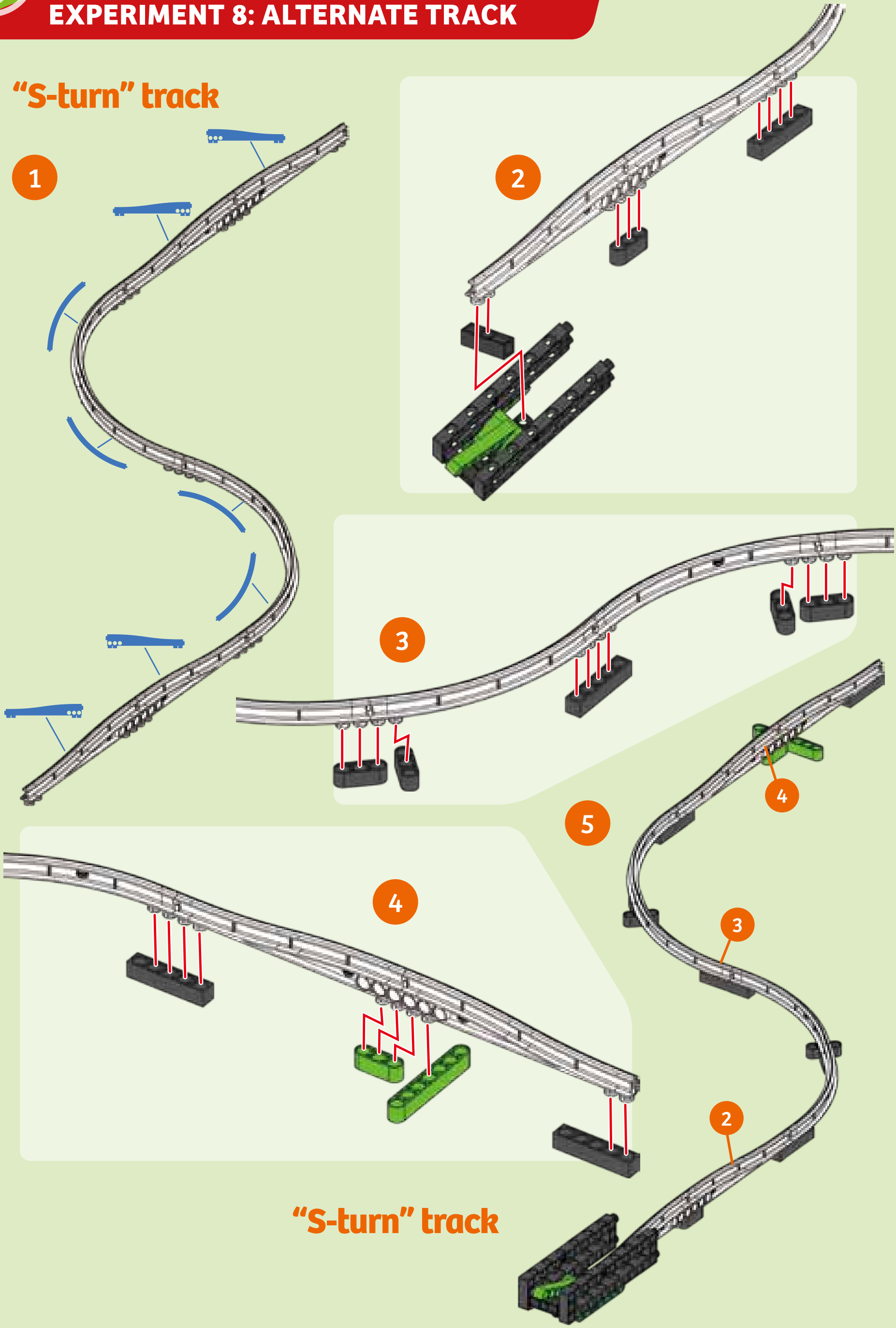
19 Inset rip cords into the gyroscope (top) and flywheel engine (bottom) components of the rip-cord gyrobot model.

20 Hold the model by the underside of the gyroscope. Place the gyrobot on the track in the launch chute, making sure that the wheels are centered on the ridge of the track. Pull the rip cords at the same time (or start with the gyroscope rip cord) and immediately release the gyrobot. How is the gyrobot able to move up an incline without assistance?

WHAT'S HAPPENING?

The gyroscope keeps the gyrobot from falling off the track and the flywheel engine transfers power to the wheels to move the model forward along the track. You added energy to the system with your pull of the rip cords. The energy is then used to spin the gyroscope and flywheel, which keep spinning due to their momentum. Momentum is a measure of an object's mass multiplied by its velocity (which is its speed in a specific direction). Momentum keeps the gyrobot model moving along the track. Read more about momentum on the next Check It Out page.

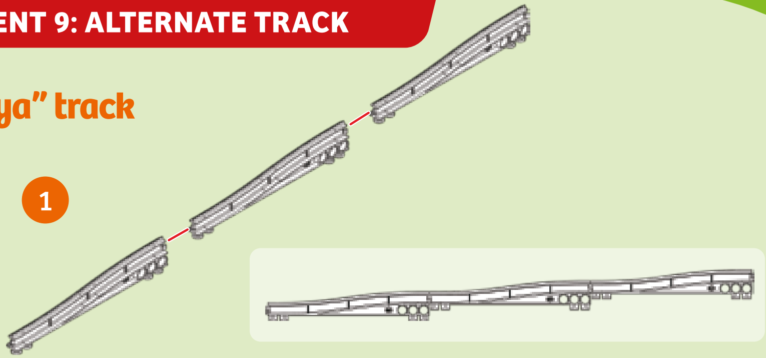
"S-turn" track



EXPERIMENT 9: ALTERNATE TRACK

“Himalaya” track

1



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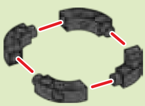

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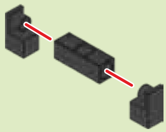

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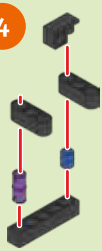

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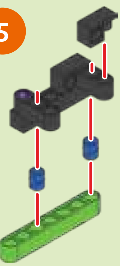

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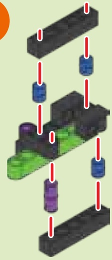

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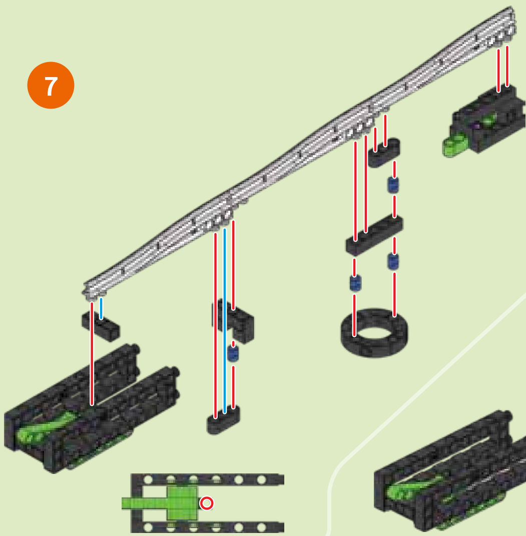

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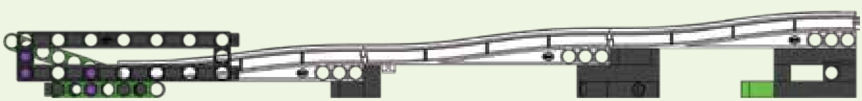
“Himalaya” track



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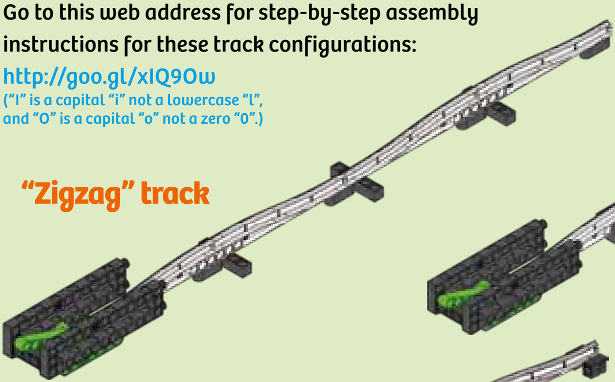
EXPERIMENTS 10–16: MORE TRACK IDEAS

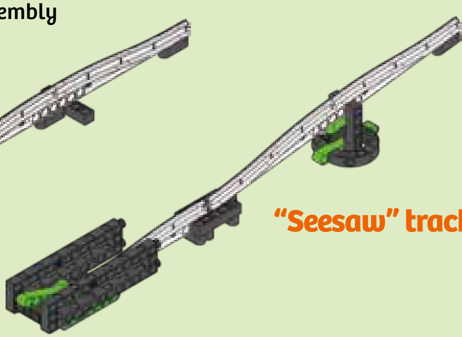
Go to this web address for step-by-step assembly instructions for these track configurations:

http://goo.gl/xIQ9Ow

("I" is a capital "i" not a lowercase "l", and "O" is a capital "o" not a zero "0".)



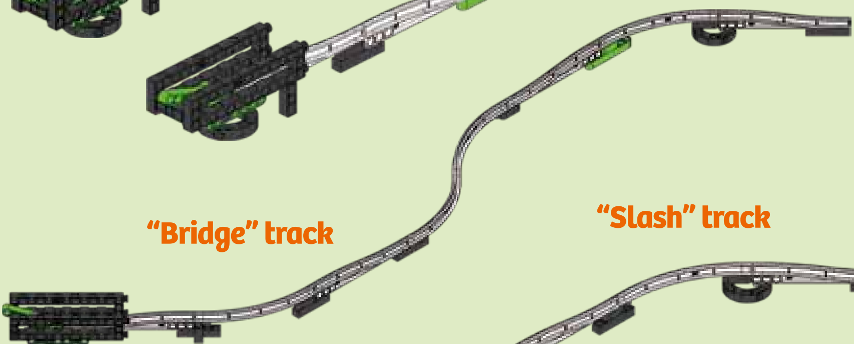
"Zigzag" track



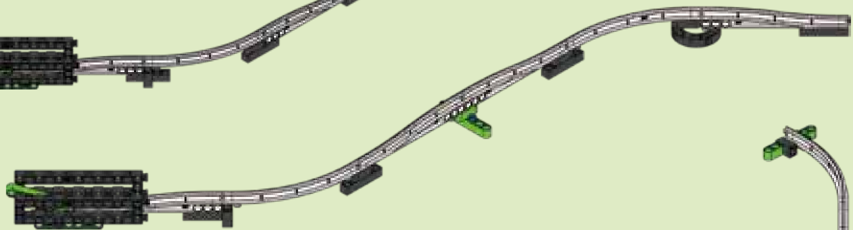
"Seesaw" track

"Waterfall" track

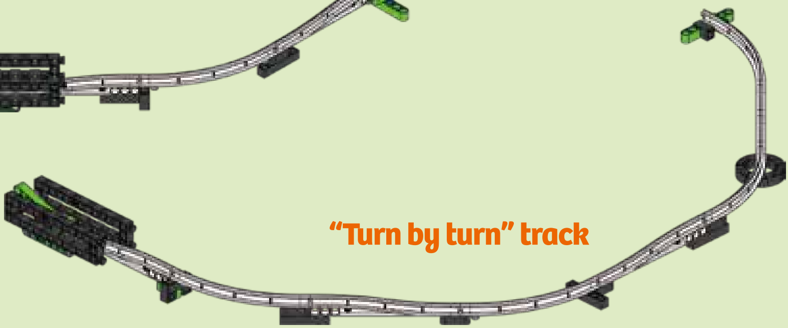
"Half pipe" track



"Bridge" track



"Slash" track



"Turn by turn" track

CHECK IT OUT

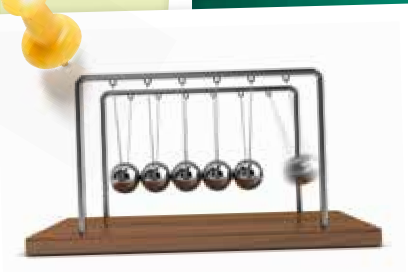
Conservation of Momentum

The **momentum** of an object is directly related to the amount of mass of the object and how fast the object is moving in a specific direction, or its velocity. The faster and heavier the object, the more momentum it has. When an object is moving in a straight line it has what is called **linear momentum.**

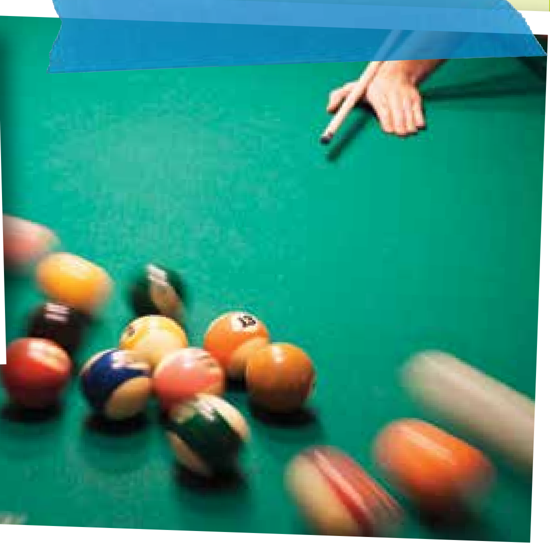
The momentum of an object is conserved. This means that the amount of momentum in a closed system — a system in which no energy is lost or converted — always stays the same. For example, when two billiard balls collide, momentum is transfered from one of the balls to the other in the form of a change in their velocities, but the total amount of momentum of the two balls stays the same. However, it is not a perfectly closed system, so some momentum is lost to the friction between the balls and the table and the balls and the air, and even to the sound waves released when they hit.

Gyroscopes in nature

Have you ever wondered how a fly can buzz around a room and instantly change direction many times without losing control of itself? Flies have an organ called a haltere that acts like a gyroscope allowing the insects to detect their rotation during flight.



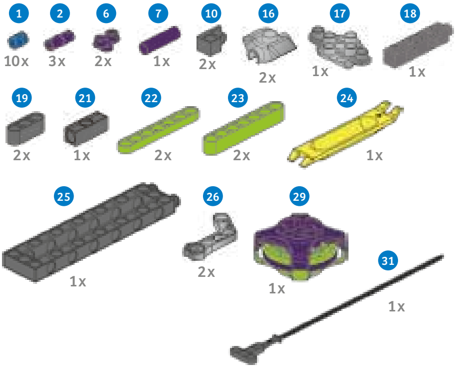
Momentum is transferred between the balls in a Newton's cradle.



EXPERIMENT 17

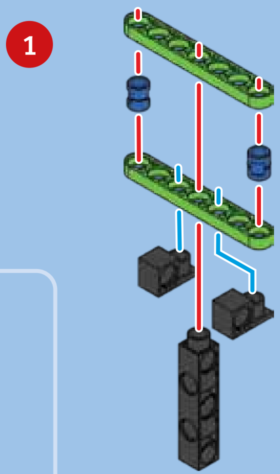
Breakdancer

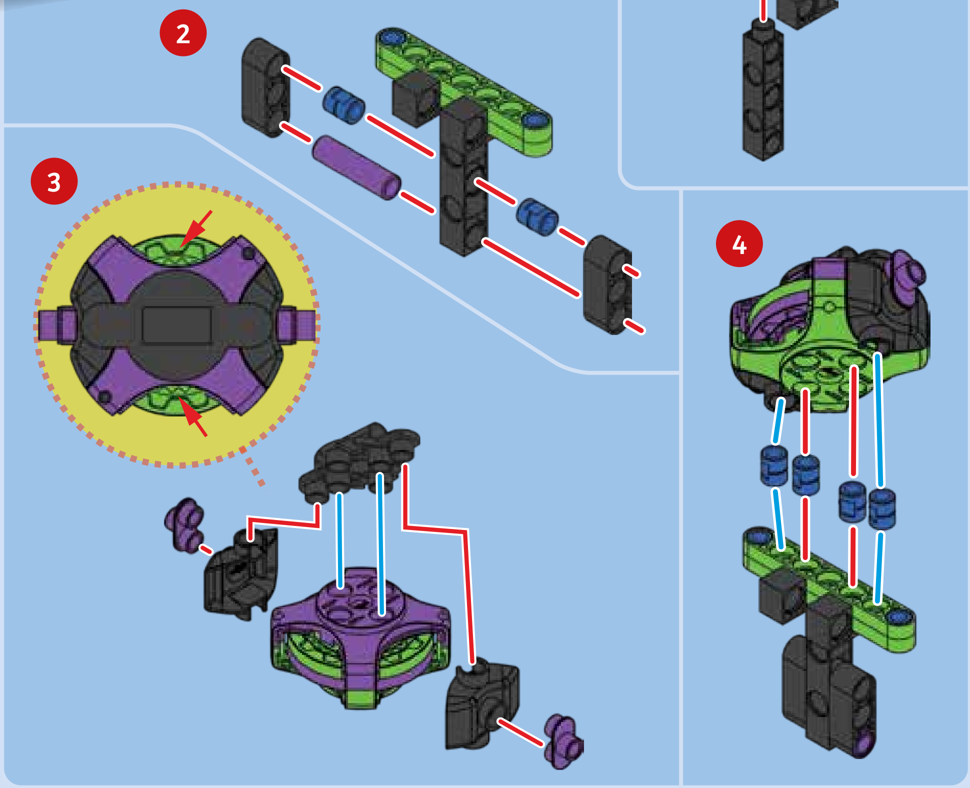
YOU WILL NEED



Spinning around

How about when an object is spinning — does it have momentum? Yes! However, when an object is spinning the momentum is called **angular momentum** and the physics becomes more complex.





EXPERIMENT 17

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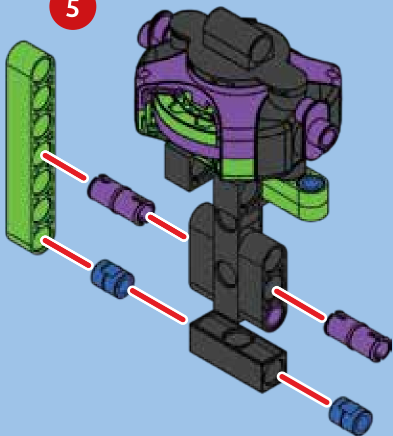

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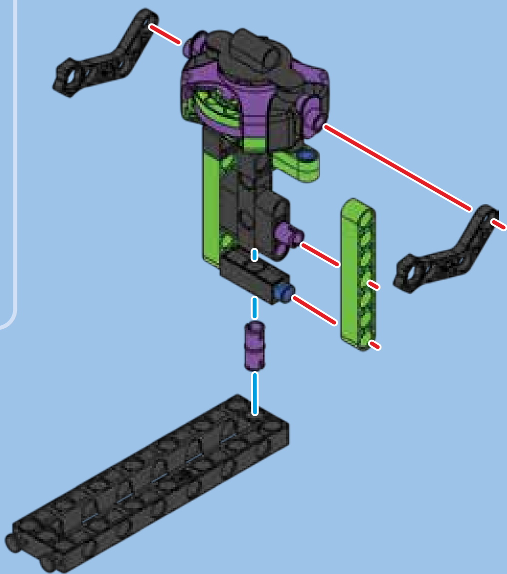


7

HERE'S HOW

1 to 7 Assemble the model.

8 Insert the rip cord into the slot in the gyroscope. Hold the base of the model and pull the rip cord. What do you observe?

WHAT'S HAPPENING?

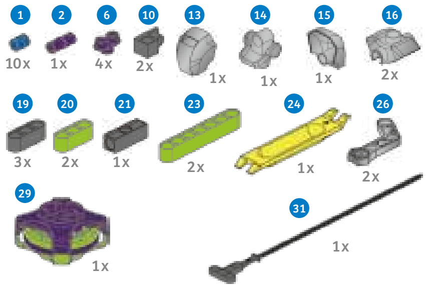
The gyroscope stays spinning due to conservation of its angular momentum. But as it spins, the gyroscope's momentum is transferred to other parts of the model, which is what causes the model to move. The gyroscope eventually stops spinning.

Just like linear momentum, angular momentum is a product of an object's mass and speed. But when calculating angular momentum, the speed of the object's rotation around its axis as well as how the mass is distributed relative to its axis of rotation must be considered. These factors have important effects as you will discover in the next experiment.

EXPERIMENT 18

Headspinning breakdancer

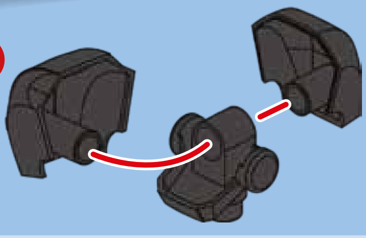
YOU WILL NEED



Conserving angular momentum

If you have ever seen figure skaters spin around with their arms outstretched and then bring their arms in close to their bodies, you will see that when they bring their arms close to their bodies, they start spinning faster. Why do you think that happens?

1



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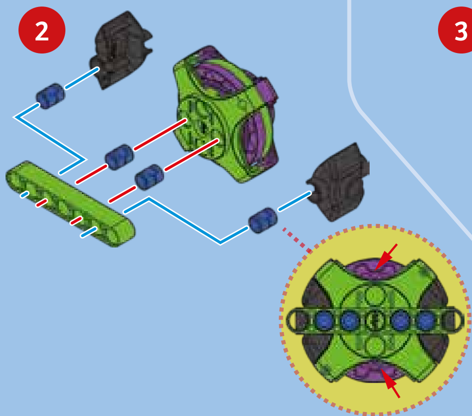

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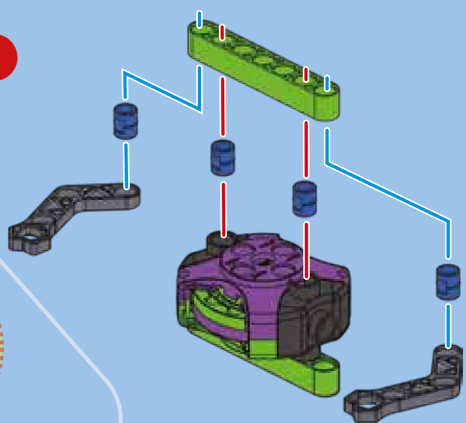

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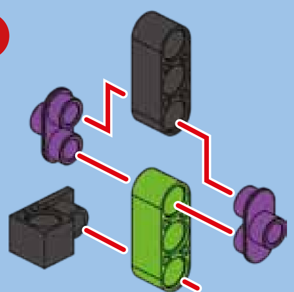

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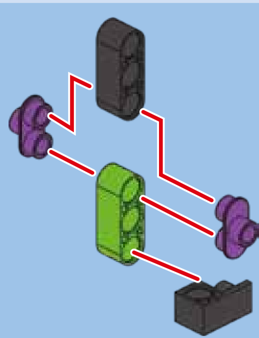
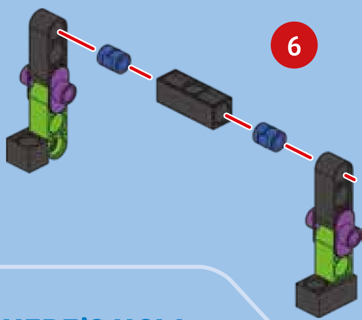
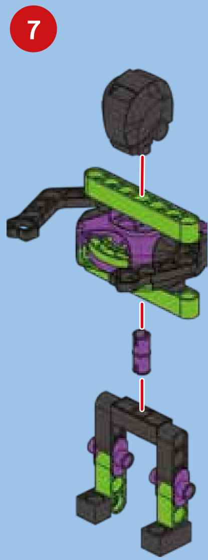
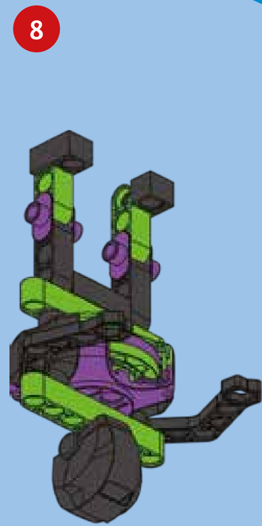


EXPERIMENT 18







HERE'S HOW

1 to 8 Assemble the model.

9 Place the arms of the breakdancer stretched out as far away from the center of its body as possible.

10 Hold the model upside down by the top surface of the gyroscope. Insert one of the rip cords into the slot in the side of the gyroscope. Pull the rip cord and place the breakdancer down on the tabletop standing on its head.

11 Repeat the previous step, but this time move the arms of the breakdancer as close as possible to the center of its body. What differences do you observe in the way the model moves?

WHAT'S HAPPENING?

The breakdancer model and the ice skater spin faster when their arms are close to their bodies.

This can be explained by the conservation of angular momentum. As described in the previous experiment, angular momentum is the product of how fast something is spinning and how its mass is distributed around its axis of rotation. The measure of how an object's mass is distributed around its axis is called its **moment of inertia**.

Since angular momentum is conserved, when the moment of inertia is changed — for example, by moving an object's mass in toward its axis of rotation — the other factor in calculating angular momentum must change too: the speed of rotation. So, in order to keep angular momentum constant, if the moment of inertia changes, the speed of rotation must change too!

You can try this out yourself if you have a rotating desk chair. Sit in the chair with your arms out straight to the sides. Have a friend or family member give you a push to start you turning. Immediately pull your arms in close to your body. You will speed up! Put your arms out again, and you will slow down.

CHECK IT OUT

Galileo Galilei, Isaac Newton, and Inertia

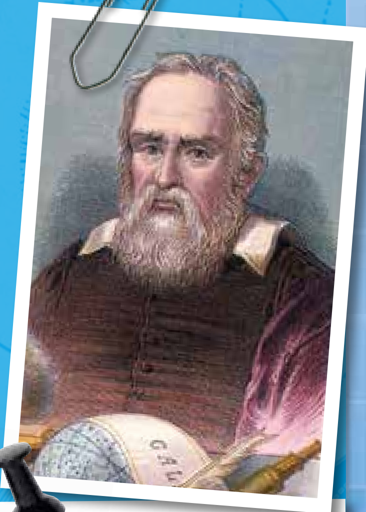
People once believed that a continuously applied force (a push or pull) was required to keep an object in motion, even with no other forces resisting its motion. We now know that an object in motion will stay in motion unless forces act on it to stop its motion. For example, an object will stop moving because of friction with its environment, like the ground it's moving on or the air or water it's moving through.

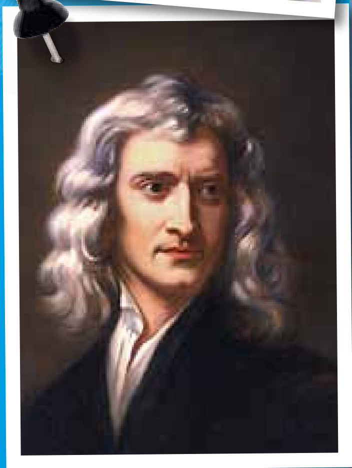
In an experiment to understand inertia, Galileo rolled marbles down two inclined planes (ramps) that were positioned in a "V" shape. He found that when he rolled a marble down one incline, the height that the marble would reach on the second incline was about the same as the height from which the marble was released on the first incline, only just a little lower.

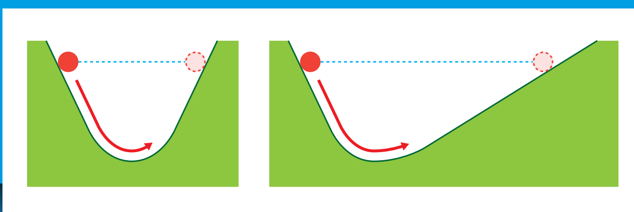
Even when Galileo made the inclined planes as smooth as possible, he found that the marble never rose as high on the second plane. He reasoned that there must be something acting on the marble preventing it from reaching the same height. He had discovered friction.

Galileo reasoned that if the second inclined plane was horizontal and there was no friction, then the marble would roll forever.

Sir Isaac Newton added to the work of Galileo by stating that the idea of inertia applies to all objects. He also found that the amount of inertia an object has depends on its mass: A more massive object will be harder to move while a less massive object will be easier to move.







The marble rolls to almost the same height on the second incline, but friction keeps it from getting all the way up to the original height.

Flywheels

From your experiments with gyroscopes, you have seen that they can hold a lot of energy. The energy is used to move the models in which the gyroscopes are installed. The energy is stored in the heavy spinning rotor disk inside the gyroscope. This spinning disk is also called a flywheel and it has other applications in addition to gyroscopes.

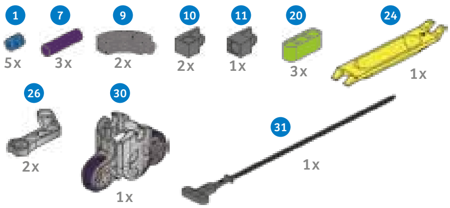
A flywheel is a heavy disk that is used to store rotational energy. The energy can then be used to drive machines. This kit contains a device with a flywheel that drives a pair of wheels: the flywheel engine. In the following experiments, you can use the flywheel engine to power vehicle models.

A flywheel in a pumping station in the Neatherlands.

EXPERIMENT 19

Motorcycle

YOU WILL NEED



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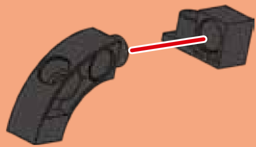

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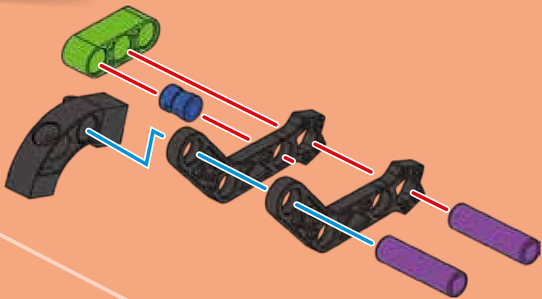

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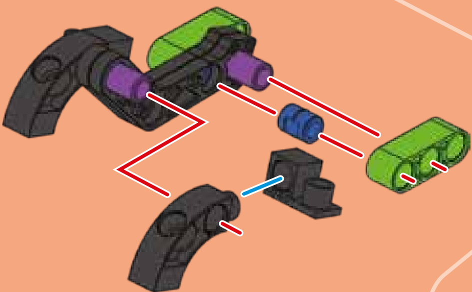

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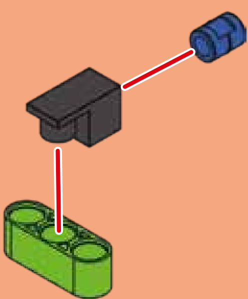

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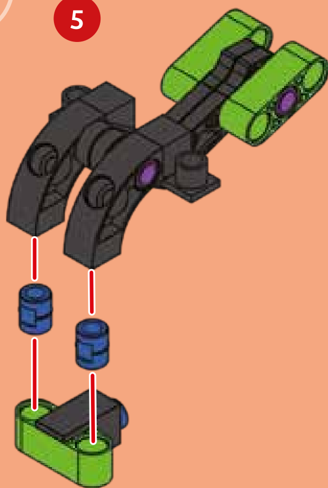
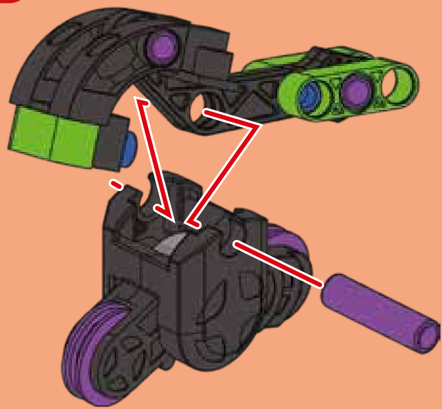


EXPERIMENT 19

6



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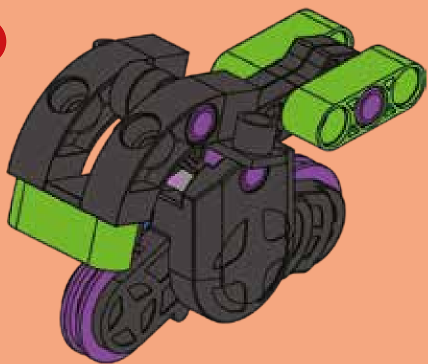


HERE'S HOW

1 to 7 Assemble the model.

8 Insert the rip cord into the slot in the flywheel engine. Hold the model, pull the rip cord, and place the model on a smooth tabletop. What do you observe?

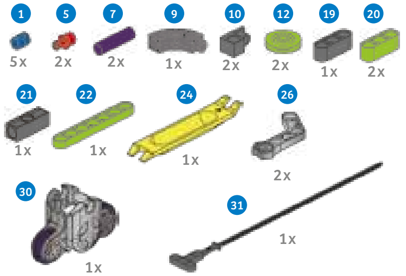
WHAT'S HAPPENING?

The flywheel inside the flywheel engine is connected to one of the engine's wheels. When you pull the rip code, you are adding a lot of rotational energy to the flywheel. By setting the flywheel in motion, you are increasing its angular momentum. The angular momentum is stored in the flywheel and is slowly transferred to the two wheels to drive the model. As the two wheels turn and make the model move forward, the flywheel transfers its rotational energy to the wheels. As the flywheel loses energy, it slows down, eventually stopping.

EXPERIMENT 20

Trike motorcycle

YOU WILL NEED



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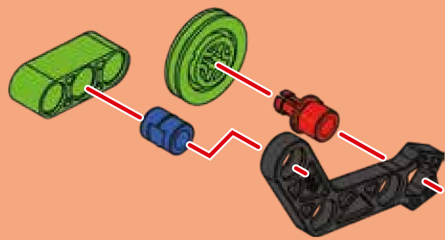

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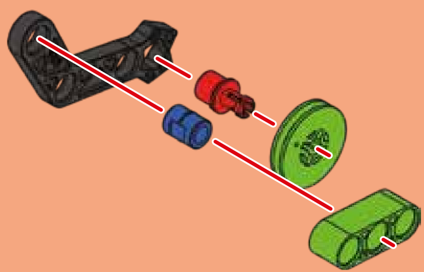

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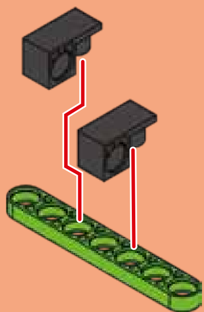

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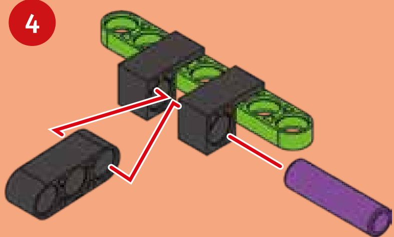

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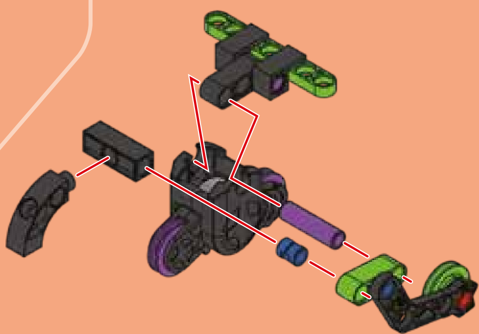
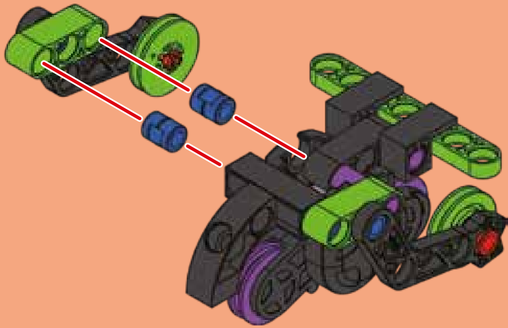


EXPERIMENT 20

6



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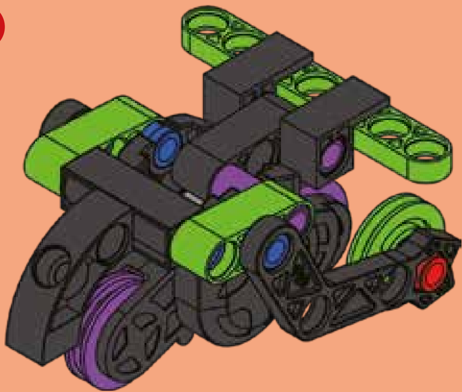


HERE'S HOW

1 to 7 Assemble the model.

8 Insert the rip cord into the slot in the flywheel engine. Hold the model, pull the rip cord, and place the model on a smooth tabletop. What do you observe?

WHAT'S HAPPENING?

The flywheel engine works the same way in this experiment as in the previous experiment. The main difference is that this model has two extra wheels that help stabilize the model so it doesn't fall over as easily. The drawback is that the extra wheels create more friction with the tabletop. More energy from the flywheel engine goes toward overcoming that extra friction, so the model may not travel as far. However, because of the improved stability, the model may be less prone to skidding out, so it may actually drive farther. See for yourself how your model behaves.

CHECK IT OUT

Flywheels in Action

Flywheels are usually large, heavy wheels with a large moment of inertia. They are designed to have a lot of weight around their outer edges. As you learned in the experiment with the headspinning breakdancer, the farther away an object's mass is located from its axis of rotation, the larger its moment of inertia.

A flywheel receives its energy from torque applied to it. The flywheel's rotational speed builds up and thus so does its stored rotational energy. The flywheel can then release its stored energy by transferring torque to other mechanisms as needed.

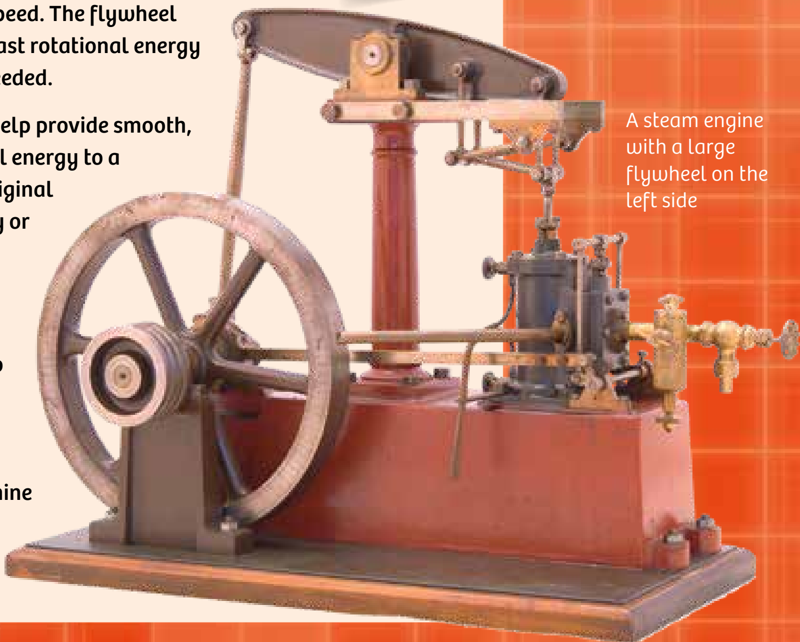
Flywheels can be used in machines to provide a faster rotational motion than the source of the original torque can provide on its own. The original energy source can slowly increase the speed of the flywheel, which will store energy and thus build up rotational speed. The flywheel can then release its fast rotational energy very quickly when needed.

Flywheels can also help provide smooth, continuous rotational energy to a machine when the original energy source is jerky or intermittent.

And of course, flywheels can be used in gyroscopes to balance objects and resist certain forces to help control the orientation of a machine or device.

Did you know?

The gyroscopic effect is also at play when you tilt a bicycle when 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.



A steam engine with a large flywheel on the left side

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