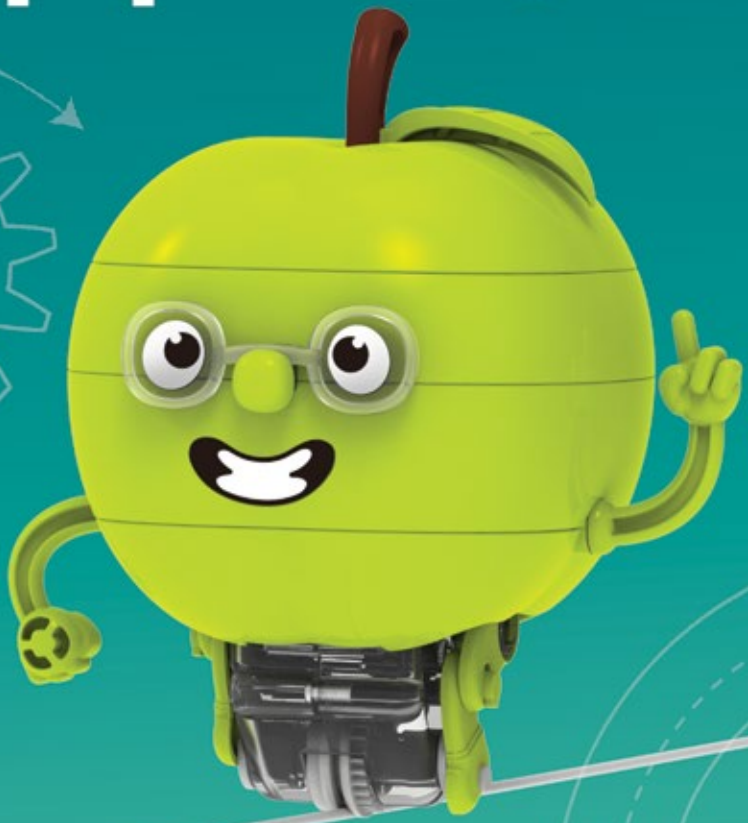
EXPERIMENT MANUAL

Newton's Apple

Tightrope-Walking Gyrobot



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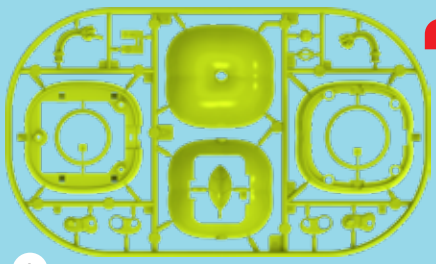
KIT CONTENTS

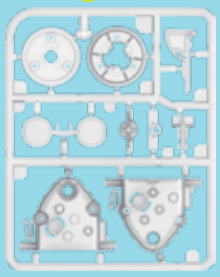
Do you have any questions, or are you missing any parts?
Our tech support team will be glad to help you!
US: support@thamesandkosmos.com or 1-800-587-2872
UK: support@thamesandkosmos.co.uk or 01580 713000

What's inside in your experiment kit:



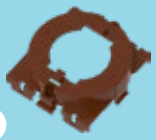
A

! The outside of the green plastic frame will be used during the experiments. Do not cut the outside of the frame and do not throw the frame away.



B

P1



P2

P3

P4

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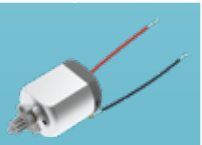

P26

P27

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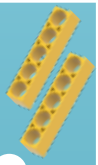
P29



P30

P31

P32

P33

P34

YOU WILL ALSO NEED:

2 x AAA batteries (1.5 volt, type LR03), small Phillips-head screwdriver (PH00, PH0, or PH1 recommended), scissors or diagonal cutters, marker, tape

Wow! **So many parts!**

TABLE OF CONTENTS

TIPS

YOU WILL FIND ADDITIONAL INFO IN THE CHECK IT OUT SECTIONS ON THE INSIDE BACK COVER AND BACK COVER.

Important!
1. Separate the two types of screws (P17 and P18) before starting so that you can tell them apart. P17 is used on the battery box cover.
2. Do not remove the parts from the frames until they are needed so that you can locate the numbered parts during assembly. The part numbers are written on the plastic frames.

Checklist:

✓	No.	Description	Quantity	Part No.
○	A	Green plastic frame (A1–A16)	1	7083-W10-A1G
○	B	Clear plastic frame (B1-B9)	1	7083-W10-B1
○	P1	Battery box	1	7083-W10-C1T
○	P2	Apple base	1	7083-W85-C
○	P3	Battery box cover	1	7083-W10-C3T
○	P4	Motor cover	1	7083-W10-C4T
○	P5	Apple stem	1	7083-W10-C5T
○	P6	Double gear	2	7083-W10-D3S
○	P7	Extended double gear	1	7083-W10-D2S
○	P8	Crown gear	1	7083-W10-D7S
○	P9	Wheel, left	1	7083-W10-D10S
○	P10	Wheel, right	1	7083-W10-D8S
○	P11	Outer safety gear	1	7083-W10-D1S
○	P12	Inner safety gear	1	7083-W10-D9S
○	P13	Brake pad	1	7083-W10-D11S
○	P14	Pedal shaft, right	1	7083-W10-D6S
○	P15	Pedal shaft, left	1	7083-W10-D5S
○	P16	Metal washer	2	M10#7083-1

✓	No.	Description	Quantity	Part No.
○	P17	Half-threaded screw	1	M24-12
○	P18	Fully-threaded screw	6	M20-44
○	P19	Metal rod	4	M10#7396
○	P20	Positive battery plate	2	M30#7336-7
○	P21	Negative battery plate	2	M30#7336-8
○	P22	Positive switch terminal	1	M30#7083
○	P23	Negative switch terminal	1	M30#7083-1
○	P24	Loose red wire	1	E30#7083
○	P25	Loose black wire	1	E30#7083-1
○	P26	Motor assembly	1	7083-W85-A
○	P27	Tube	1	7083-W85-B
○	P28	String	1	R39-W85-200
○	P29	Peg	4	7344-W10-C2D
○	P30	Five-hole rod	2	7413-W10-K2Y
○	P31	Three-hole rod	1	7413-W10-R1R
○	P32	Anchor pin lever	1	7061-W10-B1Y
○	P33	Sticker sheet	1	R20#7083
○	P34	Cardboard track	1	K16#7083

SAFETY INFORMATION

WARNING! Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Strangulation hazard — long cord may become wrapped around the neck.

WARNING: This toy is only intended for use by children over the age of 8 years, due to accessible electronic components. Instructions for parents or care givers are included and shall be followed. Keep packaging and instructions as they contain important information. Store the experiment material, particularly the battery-powered motor and assembled model out of the reach of small children.

WARNING! This kit contains sharp points for functional reasons. Do not injure yourself!

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.

Safety for Experiments with Batteries

- → To operate the models, you will need two AAA batteries (1.5-volt, type LR03), which could not be included in the kit due to their limited shelf life.
- → An adult should insert and change the batteries. For instructions on how to insert and change the battery, see step 25.
- → Avoid a short circuit of the batteries. A short circuit can cause the wires to overheat and the batteries to explode.
- → Different types of batteries or new and used batteries are not to be mixed.
- → Do not mix old and new batteries.
- → Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel-cadmium) batteries.
- → The battery is to be inserted with the correct polarity (+ and -). Press them gently into the battery compartment. See page 9, step 25.
- → Always close the battery compartment with the lid.
- → Non-rechargeable batteries are not to be recharged. They could explode!
- → Rechargeable batteries are only to be charged under adult supervision.
- → Rechargeable batteries are to be removed from the toy before being charged.
- → Exhausted batteries are to be removed from the toy.
- → The supply terminals are not to be short-circuited.
- → Dispose of used batteries in accordance with environmental provisions, not in the household trash.
- → Be sure not to bring batteries into contact with coins, keys, or other metal objects.
- → Avoid deforming the batteries.
- → Have an adult check the model before use to make sure it is assembled properly. Always operate the motorized model under adult supervision. After you are done experimenting, remove the batteries from the battery compartment.
- → The wires are not to be inserted into socket outlets.
- → Warning! Do not manipulate the protective device in the battery compartment (PTC). This could cause overheating of cords, eruption of batteries and excessive heating.
- → The toy is not to be connected to more than the recommended number of power supplies, this means only use the included battery box. Do not use any power supply other than the aforementioned battery, also no adapters.

IMPORTANT INFORMATION

Dear Parents and Adults,

With this science kit, your child can build an apple-shaped, tightrope-walking, gyroscopic robot while learning the physics behind how it works. Stand by to assist your child with any challenging steps, during assembly or while experimenting.

Putting Newton's Apple together can be tricky, especially steps 1–11 where you're building the switch and motor circuit (see below). Please read the tips below before beginning and make sure you follow them. Also, scan the QR code here to view helpful assembly and troubleshooting videos.

We hope you and your child have a lot of fun experimenting with your Newton's Apple Tightrope-Walking Gyrobot!

Scan this QR code to view helpful assembly and troubleshooting videos.

THE RIGHT TOOL

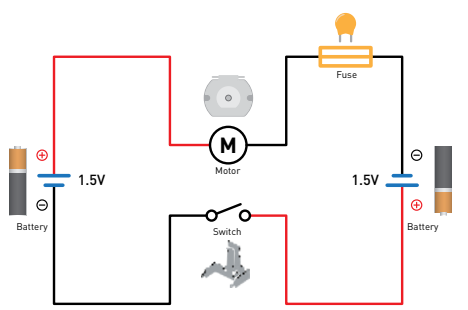
- You must carefully cut the plastic parts out their frames with diagonal cutting pliers (diagonal cutters) or scissors.
- Remove the parts from the frames only when they are needed.
- Do not push, pull, or bend the wires that are attached to the motor. They might break off.

Before building and experimenting, read the instructions with your child and discuss the safety instructions together.

Experiments encourage and challenge children. Stand by to assist your child with any challenging steps of assembly or usage. If your child is working on a table, give them something to work on top of to prevent damage to the furniture.

IMPORTANT!

WHEN BUILDING THE MOTOR AND SWITCH CIRCUIT, MAKE SURE THE METAL ENDS OF THE WIRES STAY IN CONTACT WITH THE METAL TABS OF THE SWITCH TERMINALS AND BATTERY PLATES. ELECTRICITY WILL ONLY FLOW IF THERE IS A COMPLETE CIRCUIT WITH NO GAPS.

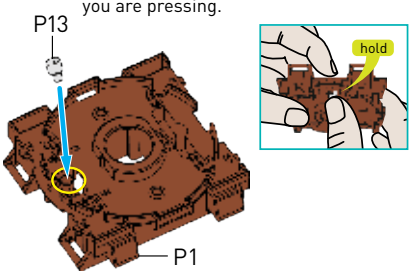


Circuit diagram for Newton's Apple Gyrobot

NEWTON'S APPLE ASSEMBLY

1

Press in the brake pad (P13) while carefully holding P1 underneath where you are pressing.



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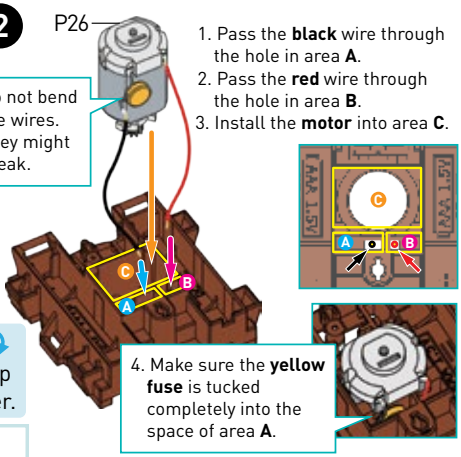
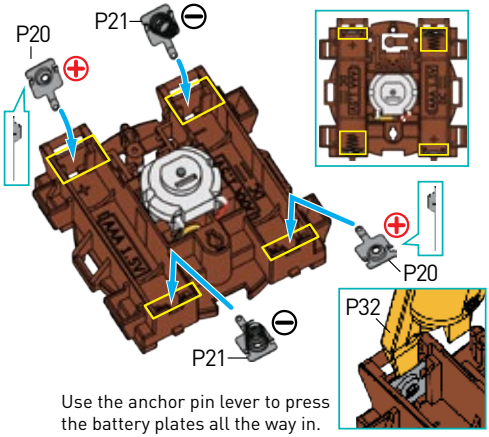


1. Pass the **black** wire through the hole in area **A**.
2. Pass the **red** wire through the hole in area **B**.
3. Install the **motor** into area **C**.
4. Make sure the **yellow fuse** is tucked completely into the space of area **A**.

3

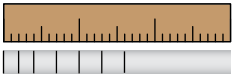
Insert the positive and negative battery plates into the battery box, paying close attention to the positive and negative symbols.



Use the anchor pin lever to press the battery plates all the way in.

4

Actual size



Mark the tube as shown against the ruler to the right, then cut the tube with scissors. You need a total of six tube segments:

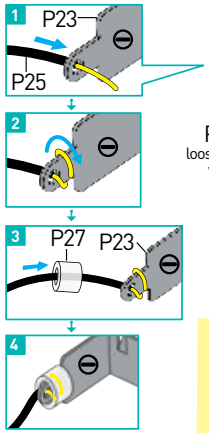
2mm x 2

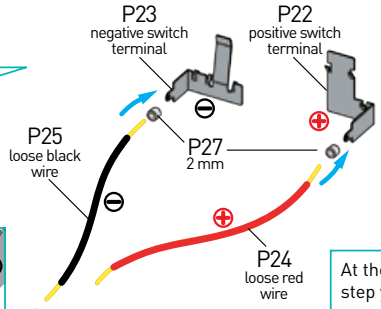
3mm x 4

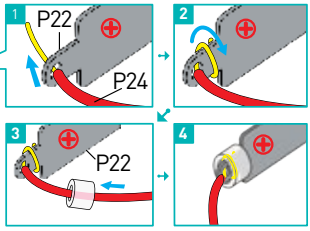
5

Make sure to connect the **loose wires** (P24 and P25) to the switch terminals.

1. For each switch terminal, feed the end of the correct wire through the small hole.
   - **loose red** wire > **positive** switch terminal
   - **loose black** wire > **negative** switch terminal
2. Wrap the metal end of the wire around the tab.
3. Place a 2-mm segment of tube onto the wire.
4. Push the tube segment all the way onto the tab so that it covers the end of the wire and secures it to the terminal.

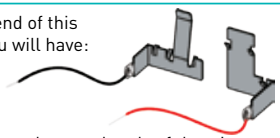






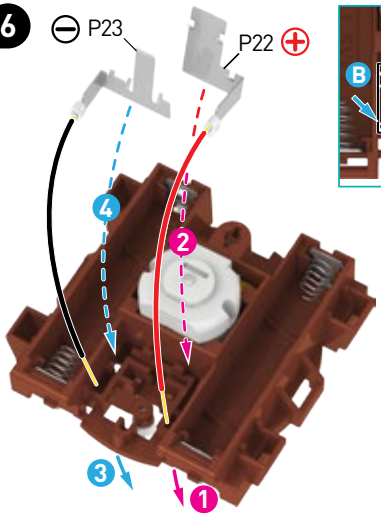
Scan the QR code to watch a video of step 5.

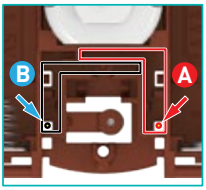
At the end of this step you will have:



Make sure the metal ends of the wires are in contact with the metal tabs of the terminals.

6

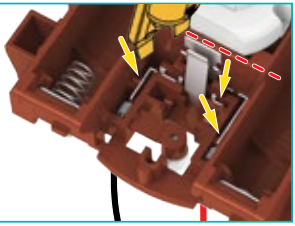




Follow steps 1 – 4 in order.

1. Feed the **red** wire through hole **A**.
2. Insert the **positive switch terminal** all the way into the L-shaped groove.
3. Feed the **black** wire through hole **B**.
4. Insert the **negative switch terminal** all the way into the L-shaped groove.

Use the anchor pin lever to push the positive and negative switch terminals all the way into the L-shaped grooves.



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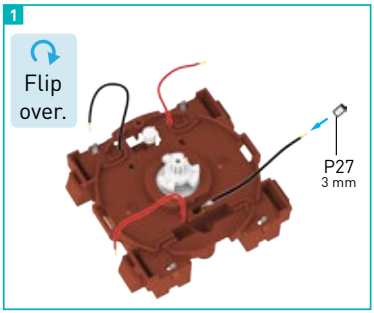
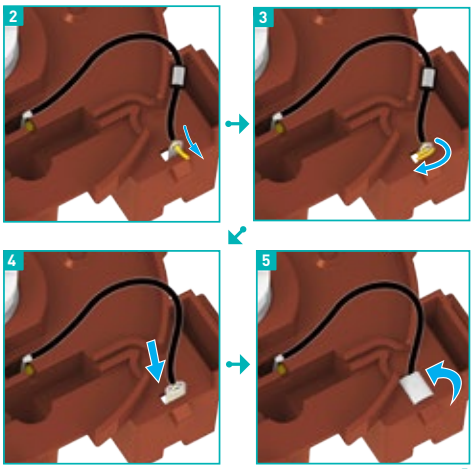




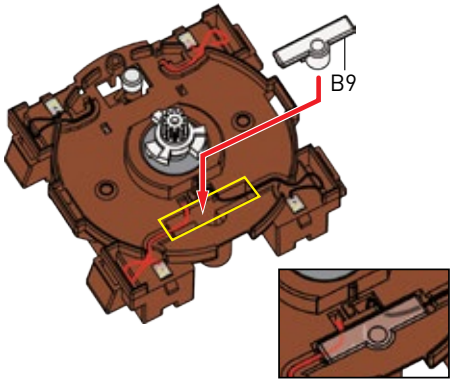
1. Place a 3-mm segment of tube onto the wire.
2. Feed the metal end of the wire through the small hole in the battery plate.
3. Wrap the metal end of the wire around the tab.
4. Push the tube segment all the way onto the tab so that it covers the end of the wire and secures it to the terminal.
5. Use your thumb or the anchor pin lever to bend the tab inward.
6. Repeat for all four wires.

Scan the QR code to watch a video of step 7.

8

Push all of the wires into the grooves, and tuck in the loops.

9 Place B9 on top of the red and black wires as shown.

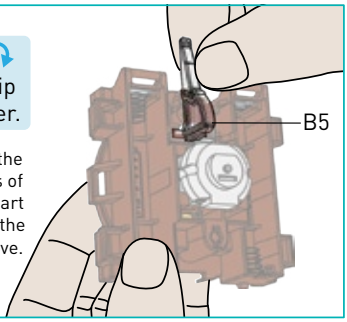


10 Double check that all wires are pushed into the grooves and tucked out of the way.

11

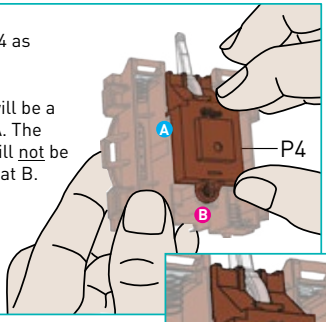
1 Flip over.

Put the pegs of B5 part into the groove.

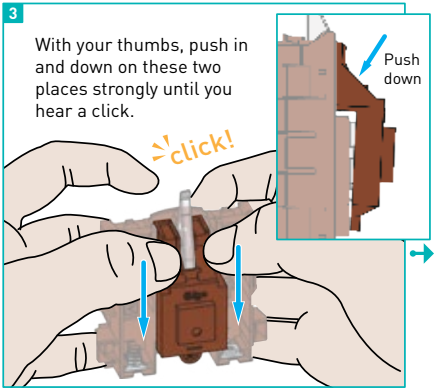


2 Place P4 as shown.

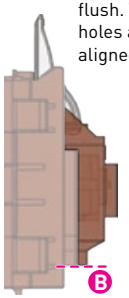
There will be a gap at A. The holes will not be aligned at B.



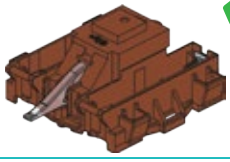
3 With your thumbs, push in and down on these two places strongly until you hear a click.



4 Make sure that everything is flush. The holes are now aligned at B.

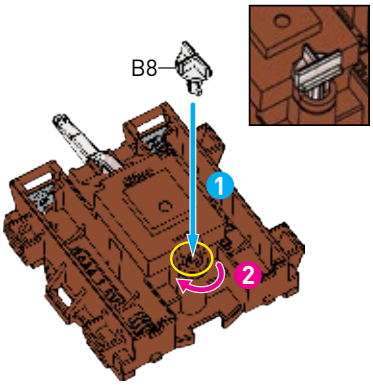


At the end of this step you will have:

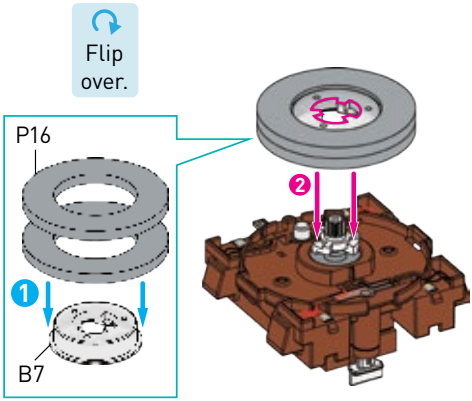


Scan the QR code to watch a video of step 11.

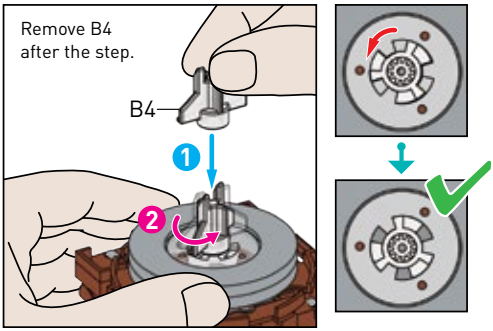
12 Insert B8, then turn it 90 degrees to lock the motor cover (P4).



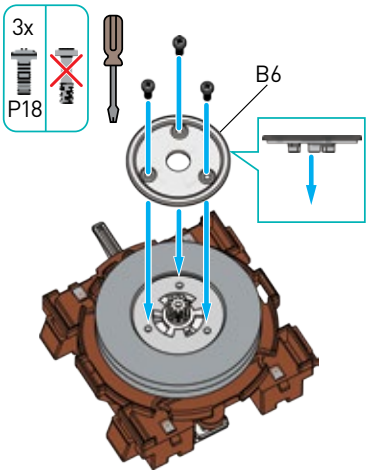
13 1. Place the two metal washers (P16) on B7.
2. Place them onto the assembly as shown.



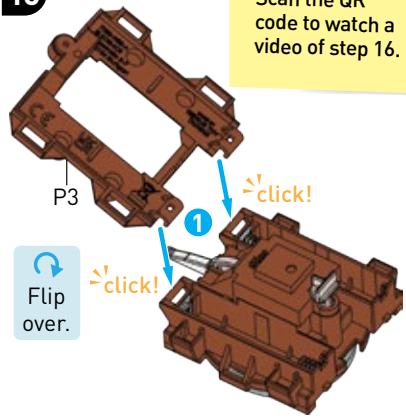
14 Use B4 to rotate the gear counterclockwise while holding the metal washers steady with your hand.

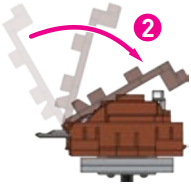


15 1. Place B6 with the flat side on top and the screw holes lined up.
2. Use a screwdriver to fasten the three screws.

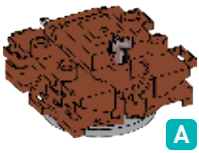


16 Scan the QR code to watch a video of step 16.



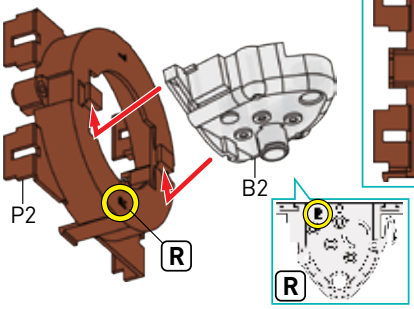


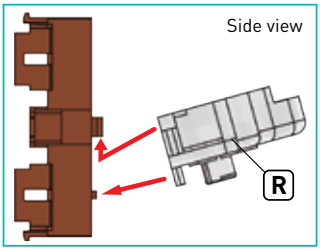
You will use a screw to secure the battery cover in step 25.

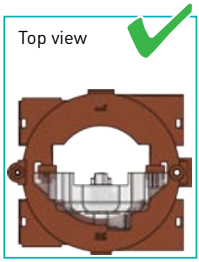


This is subassembly A. You can put it to the side for now.

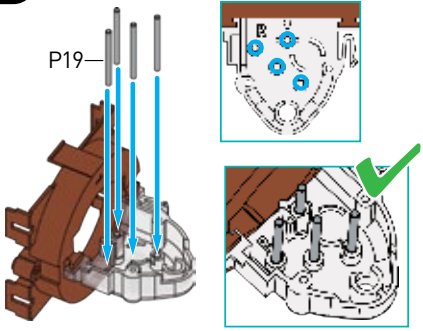
17 Assemble the right side first. Insert B2 at an angle, then push it toward the center.



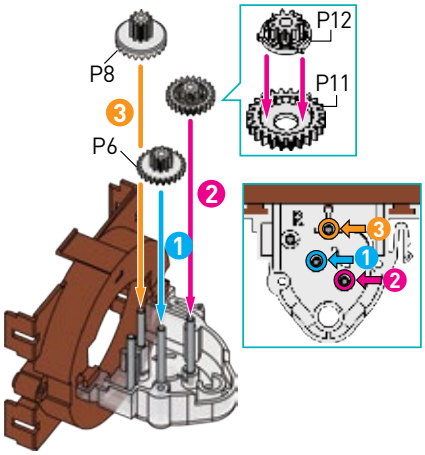




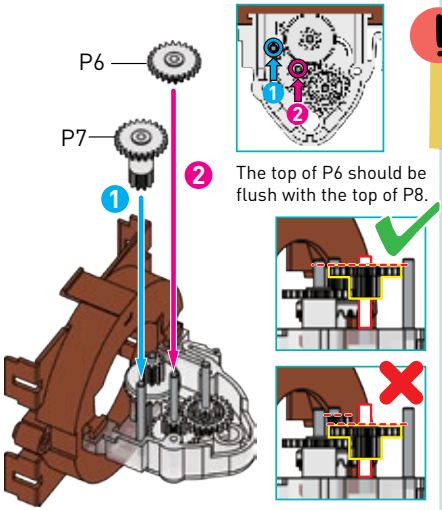
18 Insert the four metal rods.



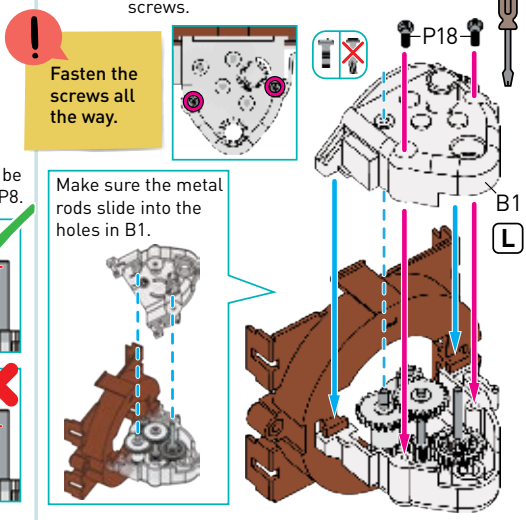
19 Follow the steps in order to assemble the gears.



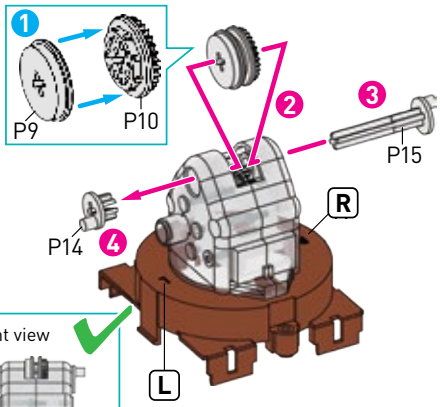
20 Follow the steps in order to assemble the gears.

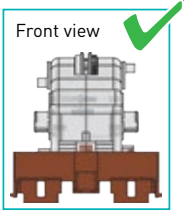


21 Make sure the gears are aligned, then lower B1 onto B2 and secure it with two screws.

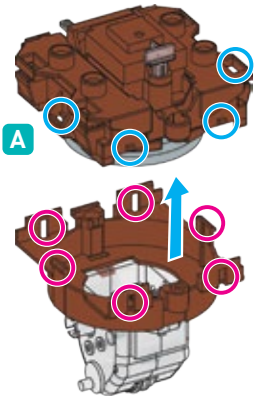


22 Make sure P15 is inserted from the right side. The round pegs on either side of the shaft should be 180° apart.

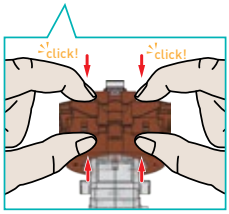




23 Align all six points then press the two sides together until they click.



Scan the QR code to watch a video of step 23.



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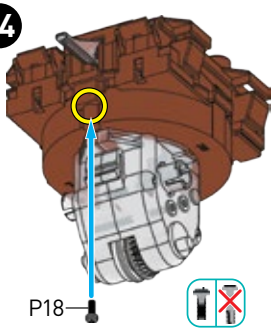
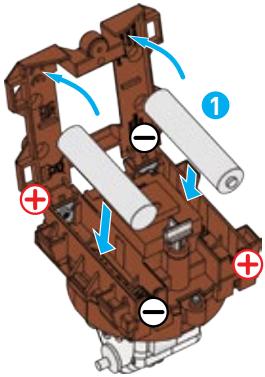
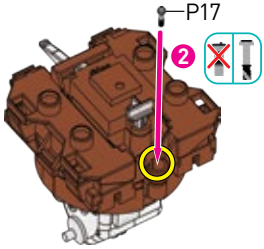


25 Insert two AAA batteries with the correct polarity (+ and -). Then secure lid with P17.

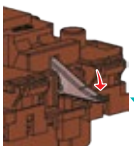




26 Test the motor circuit by moving the switch upwards.

Turn ON.

You should hear the motor turn on.



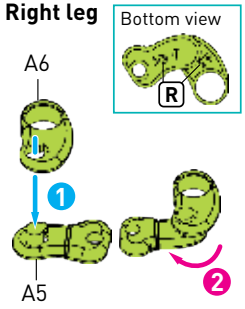
Turn OFF.

Turn the motor off before moving on to the next step.

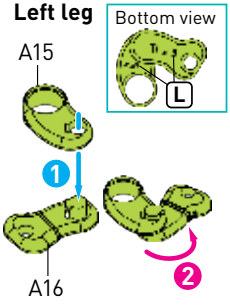
IMPORTANT:
If the motor does not turn on, you will have to go back and check all of the wire connections. Scan the QR code for troubleshooting tips.

27 Place the two pieces of each leg together, then rotate.

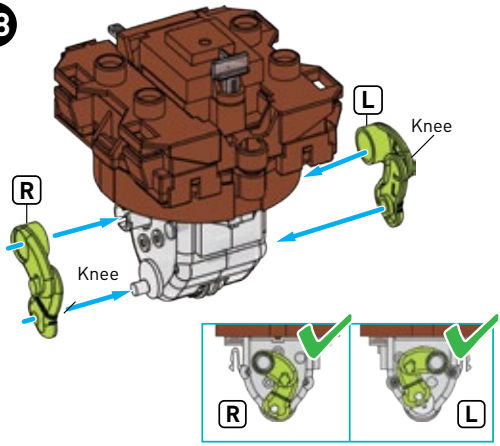
Right leg



Left leg

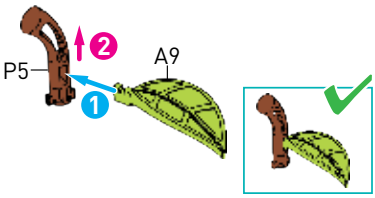


28

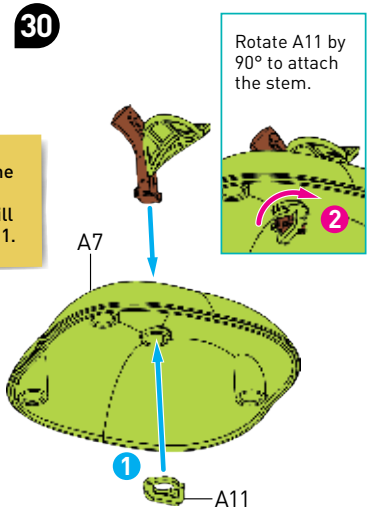


29

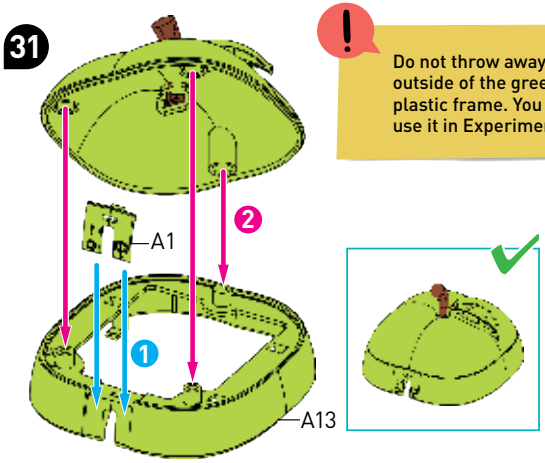
1. Put the leaf (A9) into the stem (P5).
2. Push the leaf upwards to secure it.



30

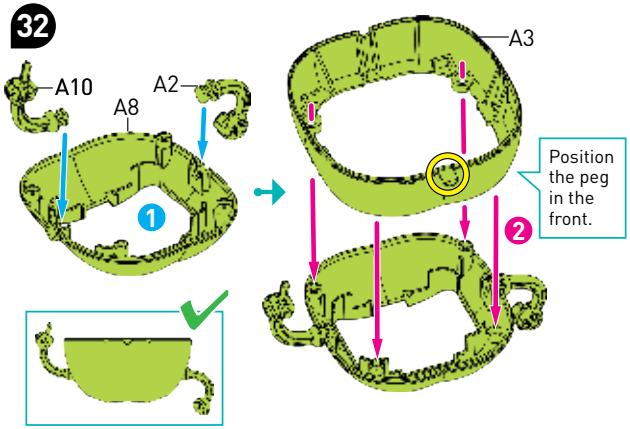


31



Do not throw away the outside of the green plastic frame. You will use it in Experiment 1.

32



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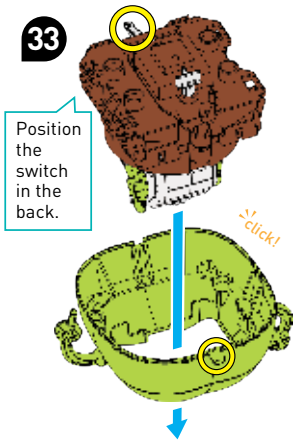
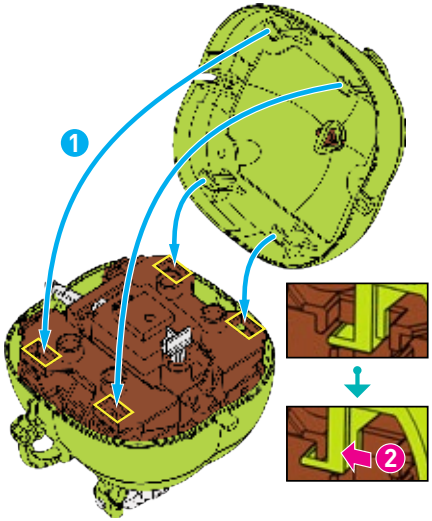


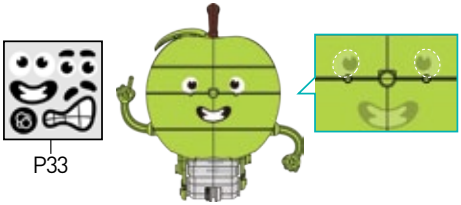
34

1. Place the top of the apple as shown.
2. Slide the top of the apple backward.

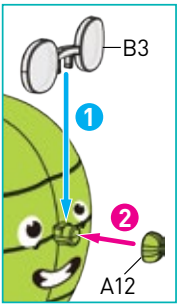


35

Place the stickers and give your apple a face. Make sure to place the eye stickers slightly slightly above the plastic dots.



36



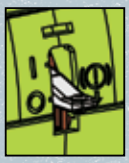
Done!

USING THE GYROBOT

1. The switch has three settings: on, off, and brake.

Turn ON
Pull up strongly on the switch **until it clicks**

Turn OFF
Push down on the switch



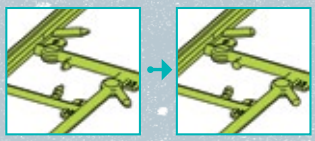
Brake
Press the switch all the way down

2. After turning on the power, hold the model level and wait 20 seconds — to ensure the motor reaches its driving speed — and then place your gyrobot on the track.

3. If you want the motor to stop immediately, press the switch all the way down to engage the brake. The brake pad will wear down over time.

4. If the model becomes less stable after use, make sure the model is still perfectly assembled and none of the parts have come out of alignment.

5. Trim any sharp points on the track before using it.

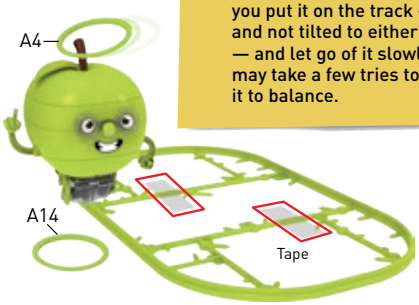


EXPERIMENT 1

You will need:
-Green plastic frame
-*Tape*

Here's how:
1. Tape the inner bars of the green plastic frame down onto a table or the floor. (Do not tape the outer rim of the frame).
2. Turn the motor on, wait 20 seconds, then place the apple onto the outer rim of the frame.
3. Try tossing the rings A4 and A14 onto the apple's stem. How does that change the apple's balance?
4. Can you get the apple to balance on a mug?

Tip: Make sure the model is as upright as possible when you put it on the track — and not tilted to either side — and let go of it slowly. It may take a few tries to get it to balance.

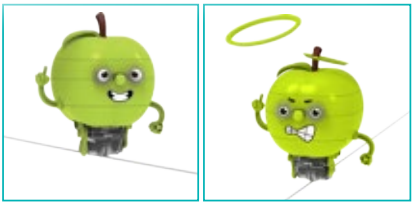


EXPERIMENT 2

WARNING! Do not place the gyrobot high up, where it can fall and break or injure people or animals.

You will need:
-String
-*Two anchor points, like chairs*

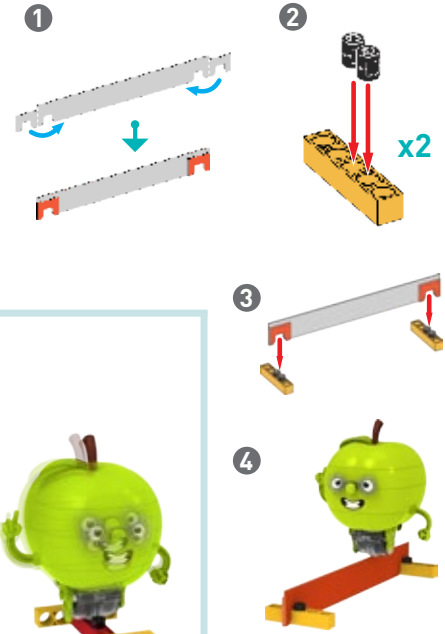
Here's how:
1. Tie the string tightly between two secure anchor points (e.g. two chairs).
2. Turn the motor o.n, wait 20 seconds, then balance the apple on the string.
3. Try tossing the rings onto the stem of the apple while it's moving along the string.



EXPERIMENT 3

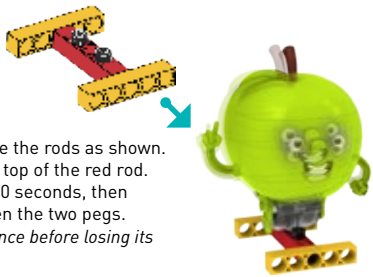
You will need:
-Cardboard track
-Five hole rod x2
-Peg x4

Here's how:
1. Remove the cardboard track (P34) from the frame, then fold the two sides inward.
2. Assemble two track supports as shown.
3. Place the track into the track supports.
4. Turn the motor on, then try to balance the apple on the track.



EXPERIMENT 4

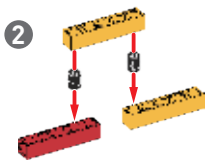
You will need:
-Five-hole rod x2
-Three-hole rod
-Peg x4



Here's how:
1. Use two pegs to assemble the rods as shown. Then add two pegs to the top of the red rod.
2. Turn the motor on, wait 20 seconds, then balance the apple between the two pegs.
How long can the apple dance before losing its balance?

EXPERIMENT 5

You will need:
-Five-hole rod x2
-Three-hole rod
-Peg x2
-Green plastic frame



Here's how:

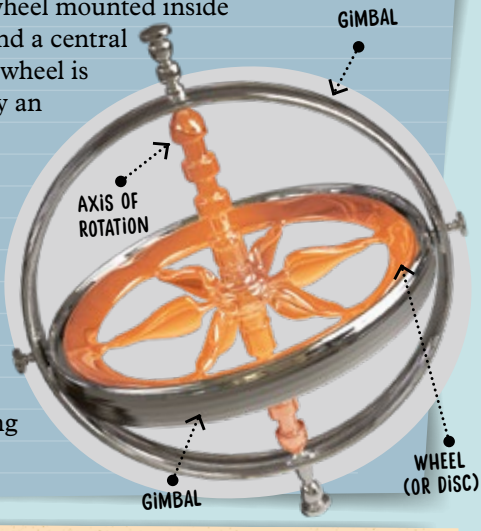
1. Remove the green "apple" shell from the gyrobot.
2. Assemble the rods and pegs into a weight as shown.
3. Attach the weight to the gyrobot in different configurations and test the gyrobot on the green plastic frame. How does the weight affect the gyrobot's balance?

CHECK IT OUT

How does the gyrobot balance?

The gyrobot's secret is a gyroscope, which is a wheel mounted inside of a special frame. The wheel spins rapidly around a central axis of rotation. In the case of your gyrobot, the wheel is made of two heavy washers, which are rotated by an electric motor. The frame is independent of the wheel, so when the wheel rotates, it stays stable.

The spinning gyroscope resists moving out of the vertical plane in which it is spinning. The axis of rotation is horizontal, parallel to the plane of movement. This keeps the model from falling to the side. When the gyrobot is moving along the string, the upward force of the string is enough to balance the downward force of gravity on the apple, which allows it to walk along the string.



GYROSCOPES TODAY

These days, many devices use technology that relies on the same gyroscopic effect that the gyrobot relies on to keep its balance. For example, did you know that gyroscopes are also built into **airplanes**?

In every airplane cockpit there is a gyroscope that is part of a device called an **artificial horizon**: This device shows the pilots a horizontal line that remains the same, even if the aircraft is tilting to make a turn.

The Laws of Gravity

As the story goes, Isaac Newton (1642-1727) was sitting near an apple tree in his mother's garden when a question popped into his mind: Why do apples always fall perpendicularly to the ground? Newton had a eureka moment: Maybe the force that makes an apple fall to the ground is the *same force* that is keeping the moon in orbit around Earth. The force that is responsible for both of those phenomena is the **force of gravity.**

Newton's insight led to the development of his **universal law of gravitation,** which states that all objects in the universe attract each other. The force of gravity, according to Newton, increases with **mass** and decreases with **distance**. Even though Newton's theory was supplanted in the 20th century by Albert Einstein's **general theory of relativity,** which states that objects curve space and time around them, Newton's law is still used when making calculations to launch rockets into space!

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