

EXPERIMENT MANUAL

Gravity Bugs™

Free-Climbing MicroBot

It's Climb Time!
Let's start climbing!



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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!

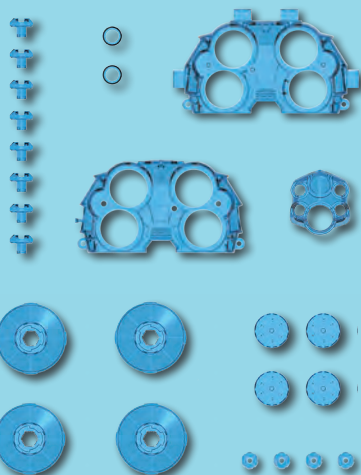
USA: support@thamesandkosmos.com
or 1-800-587-2872

UK: support@thamesandkosmos.co.uk
or 01580 713000

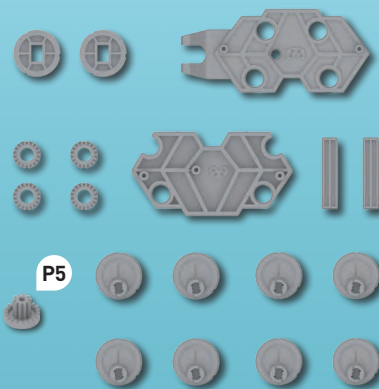
Parts in your experiment kit:



C



A



B



P2



P1



P4



P3



P6



P7



P8

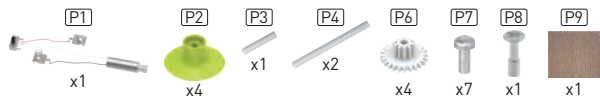
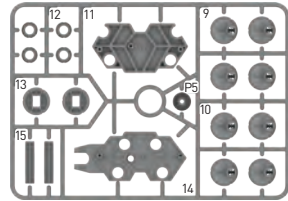
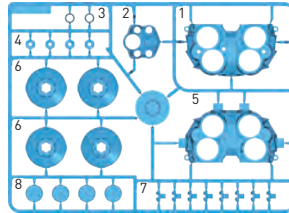
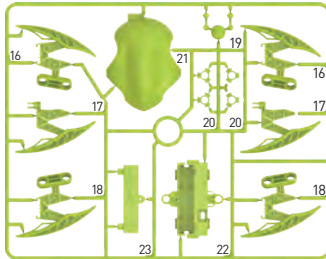


P9

Wow!
So many parts!

KIT CONTENTS

What you will find in the box:



Checklist:

✓ No.	Description	Quantity	Part No.
○ A	Blue plastic frame [Parts 1–8]	1	724229
○ B	Gray plastic frame [Parts 9–15, P5]	1	724231
○ C	Green plastic frame [Parts 16–23]	1	724230
○ P1	Motor and switch circuit	1	724232
○ P2	Suction cup	4	724228
○ P3	Short metal rod	1	724226
○ P4	Long metal rod	2	724227
○ P6	White gear	4	724223
○ P7	Fully threaded screw	7	724224
○ P8	Half-threaded screw	1	724225
○ P9	Sandpaper	1	725626

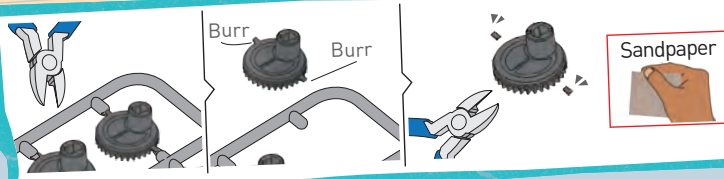
YOU WILL ALSO NEED:

1 x AAA battery (1.5 volt, type LR03), small Phillips-head screwdriver (PH00, PH0, or PH1 recommended), scissors or diagonal cutters, olive oil or other cooking oil, window or other smooth climbing surface

Important!

1. Separate the two types of screws (P7 and P8) before starting so that you can tell them apart. P8 is used on 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.

IMPORTANT!
YOU MUST REMOVE ALL BURRS (EXCESS MATERIAL) FROM THE PARTS AFTER CUTTING THEM OUT OF THE FRAMES. USE **DIAGONAL CUTTERS** AND **SANDPAPER**.



Ready?
Let's get building!

SAFETY INFORMATION



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

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 one AAA battery (1.5-volt, type LR03), which could not be included in the kit due to its limited shelf life.
- An adult should insert and change the battery. For instructions on how to insert and change the battery, see step 30.
- Avoid a short circuit of the battery. A short circuit can cause the wires to overheat and the battery 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 (step 30). Press it gently into the battery compartment.
- Always close 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 battery from the battery compartment.



A WORD TO PARENTS AND ADULTS

Children want to be amazed, understand how things work, and create with their hands!

With this science kit, your child can build a robot that walks up a window, while learning the physics behind how it works. Stand by to assist your child with any challenging aspects of assembly or usage.

Putting the Gravity Bug together can be tricky. This is an experiment kit, and you may need to experiment to get your Gravity Bug to climb a window. It's normal if you find you need to take it apart and try it again. 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 Gravity Bug!

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



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.

Particular care must be taken when cutting out the plastic parts, as sharp points can be created. These can be removed with the help of a diagonal cutter and the included sandpaper. If possible, provide your child with diagonal cutters and supervise them.

Do not let the robot model climb so high up a vertical surface that it goes out of reach. Prevent the robot from falling onto people or objects that might be damaged by it.



So much fun!

IMPORTANT TIPS

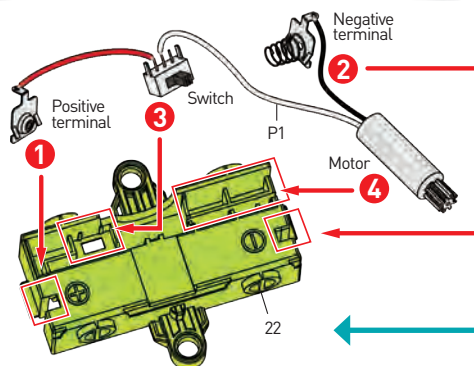
- You must carefully cut the plastic parts out their frames with diagonal cutting pliers (diagonal cutters) or scissors.
- Remove the parts from the frames only when they are needed.
- Remove excess material (burrs) from the parts before assembling them. Normal scissors do not cut as precisely as diagonal cutters, so you may have to smooth some of the rough edges down with sandpaper.
- Do not push or pull on the motor wires. They might break off.



STEPS 1 – 4

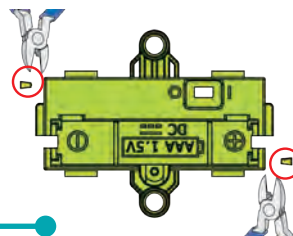


Follow steps 1 – 4 to assemble the battery compartment in the order shown!



Carefully remove all of the excess material (burrs) before assembling.

First cut off the burrs using diagonal cutters or scissors.



Then, use sandpaper to remove any remaining burrs.

Sandpaper



1



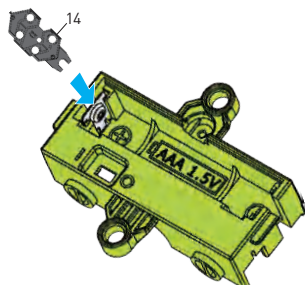
Insert the positive terminal, which is attached to the red wire, into the slot next to the \oplus symbol.



Make sure the round protrusion on the terminal is facing the inside of the battery compartment.

2

Use one of the prongs of part 14 as a tool to push the positive terminal all the way into the slot.



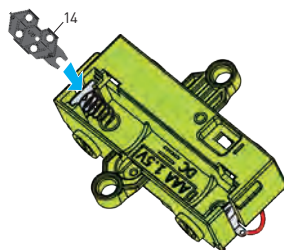
3

Insert the negative terminal, which is attached to the black wire, into the slot next to the \ominus symbol.



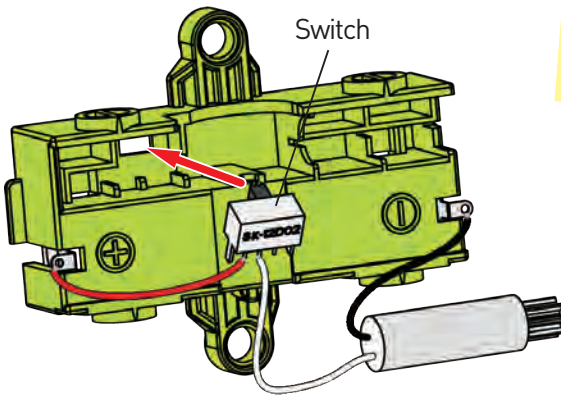
4

Use one of the prongs of part 14 as a tool to push the negative terminal all the way into the slot.



STEPS 5 – 7

- 5** Insert the switch into the hole.

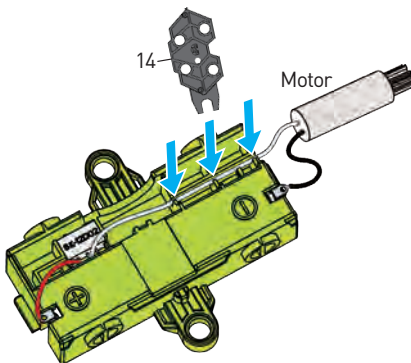


Don't feel like reading? You can find a step-by-step assembly video here.

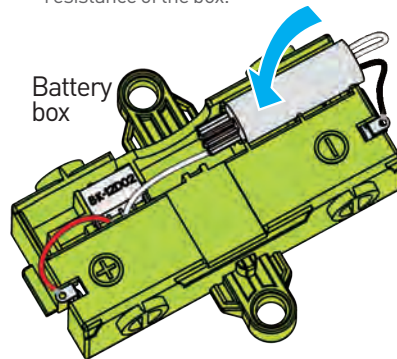


- !** Make sure the wires are not twisted here. The red wire should be on the side of the positive terminal and the white wire should be on the side of the negative terminal.

- 6** Insert the white wire into the channel in the battery box. Use part 14 to push the wire all the way down, so that it fits snugly in the channel.



- 7** Place the motor into the motor compartment above the white wire. Slide the motor toward the center of the battery box until it meets the resistance of the box.



- !** Make sure the wires lie flat under the motor. After this step, the motor gear should spin freely, without touching the white wire.

A

A capital letter indicates the completion of a subassembly. You are now finished with the battery box. Set it aside for now.

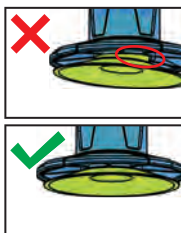
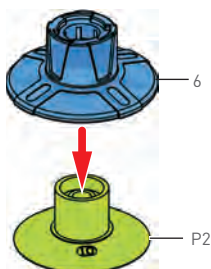
STEPS 8 – 12

8

Repeat four times.

x4

! Make sure there is an even gap all around the suction cup.



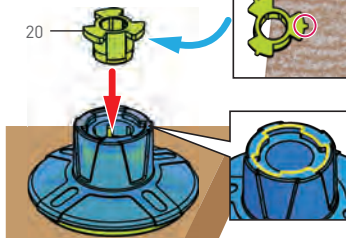
9

Place on a tabletop and press down until it clicks.



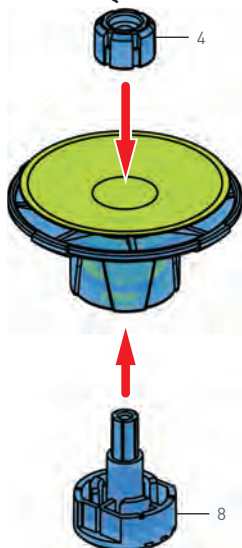
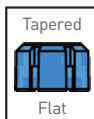
Use sandpaper to thoroughly remove the burrs on part 20.

x4



10

x4



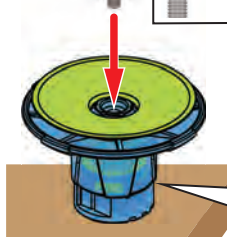
11

Place on a table top. Then screw together.

x4



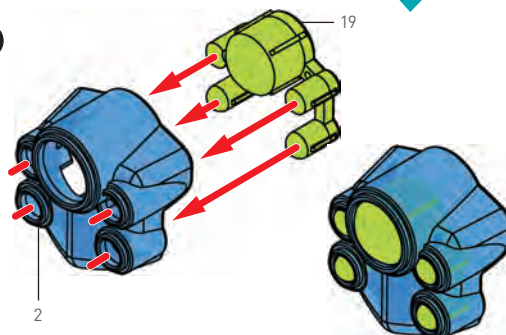
Use the fully threaded screws.



1. Make sure there is no gap between the blue parts.
2. Tighten the screw.



12

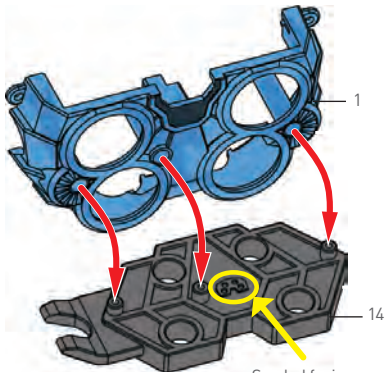


B

C

STEPS 13 – 16

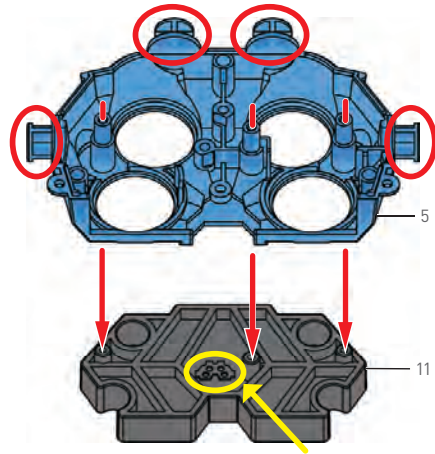
- 13** Note the orientation. Line up the trapezoidal notch on part 1 with the matching notch on part 14.



Part 14 is used as a tool for aligning the gears.

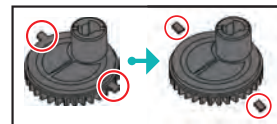
**D**

- 14** Note the orientation. Line up the trapezoidal notch on part 5 with the matching notch on part 11.

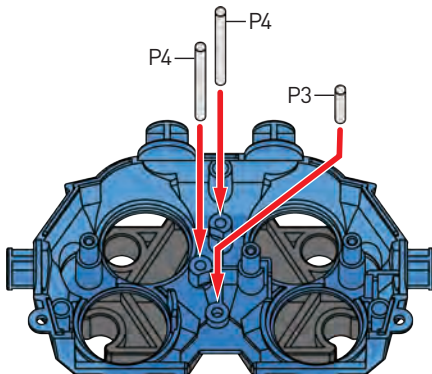


Part 11 is used as a tool for aligning the gears.

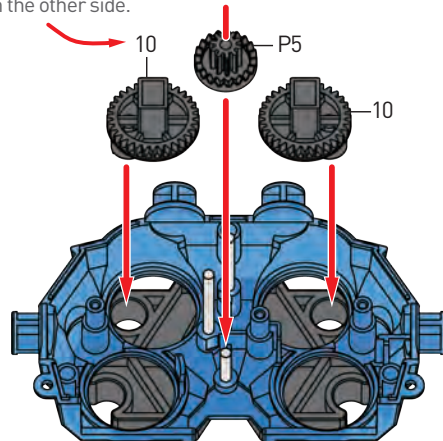
! Use sandpaper to thoroughly remove the burrs from all gear pieces.

**16**

- 15** **!** It is helpful to assemble the gearbox on a tabletop.



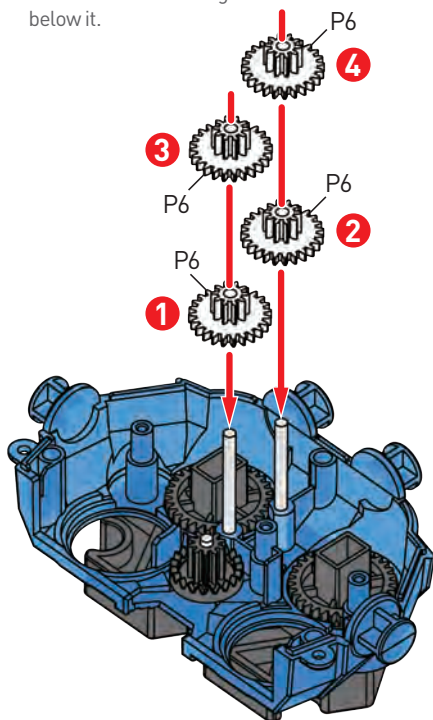
- !** Many gears look alike. Part 10 has a circular column on one side and a rectangular column on the other side.



STEPS 17 – 19

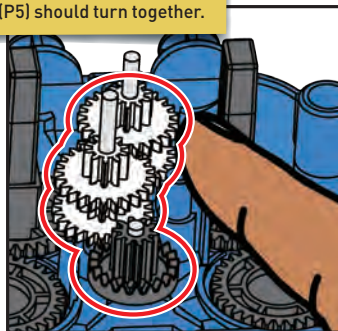
- 17** Place the white gears (P6) on the long metal rods in the order shown.

! Make sure the outside teeth of each P6 gear mesh with the inside teeth of the gear below it.

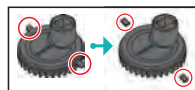


Check the gears:

Gently move the gears with your finger. All four white gears and the gray gear (P5) should turn together.

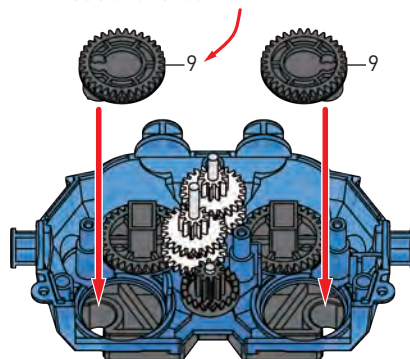


- 18** Place two part 9 gears as shown. Use sandpaper to thoroughly remove any burrs from the gears.

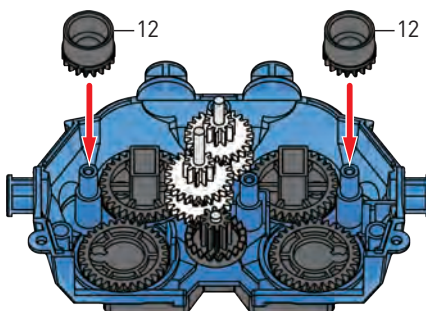


Sandpaper

! Many gears look alike. Part 9 has a circular column.



- 19** Place two part 12 gears, with the teeth facing down, on the blue pegs as shown.



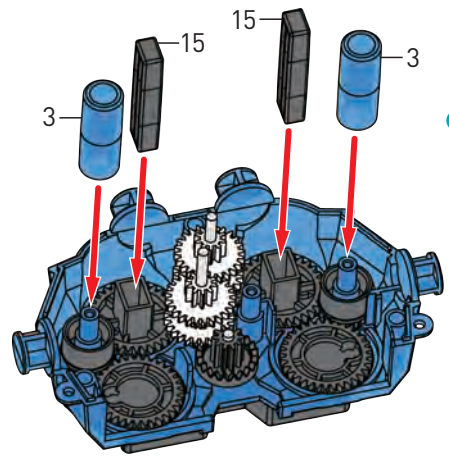
Check the gears:

The teeth of part 12 should mesh with the teeth of parts 9 and 10, but the gears will not turn, because they are locked in place by the alignment tool (part 11).

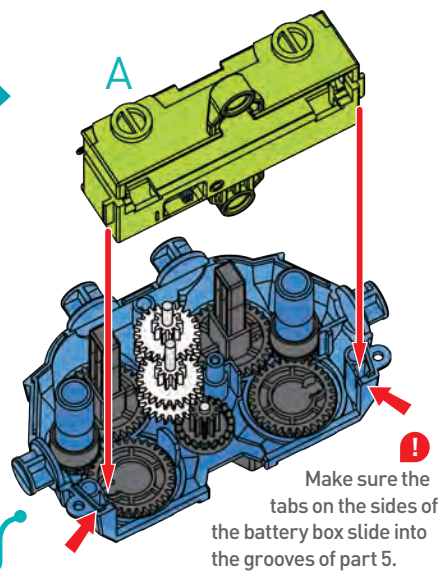


STEPS 20 – 22

20 Place parts 3 and 15 as shown.

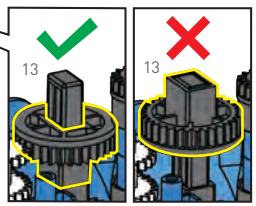
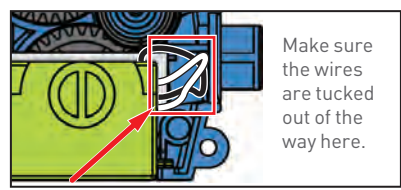
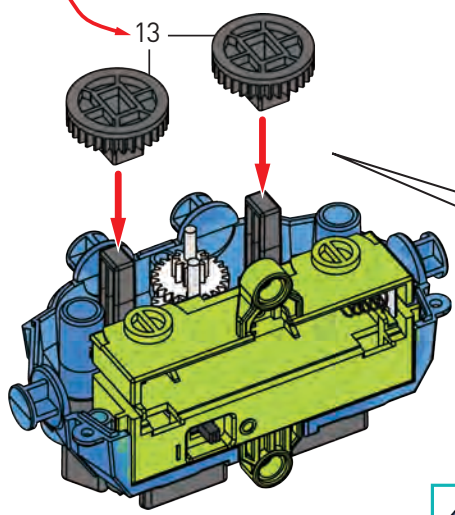


21 Insert the battery box into the body frame. The battery compartment should face outward, and be oriented toward the top.



22 Place two part 13 gears as shown.

! Many gears look alike. Part 13 has a rectangular column and a rectangular hole.



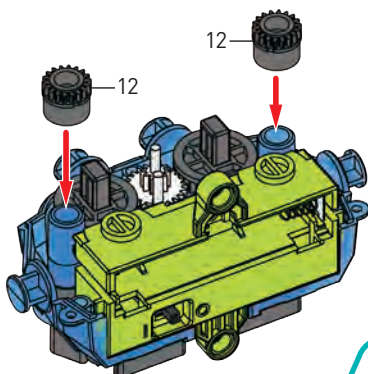
! Make sure the rectangular column of part 13 is pointed down when you place the part.

Check the gears:
The teeth of part 13 parts should mesh with the teeth of the highest white gear. The gears will not turn at this point because they are locked in place.

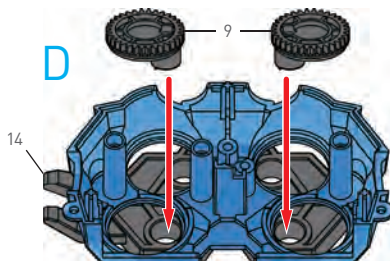


STEPS 23 – 27

- 23** Place two part 12 gears, with the teeth facing up, on the blue pegs as shown.

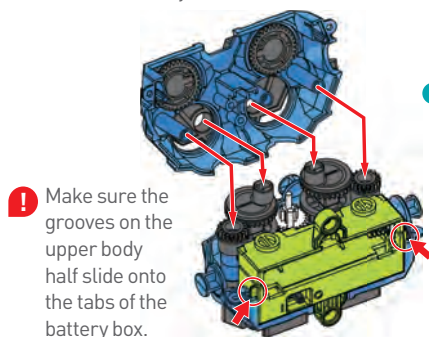


- 25** Place two part 9 gears as shown into subassembly D. Remove any burrs with sandpaper.



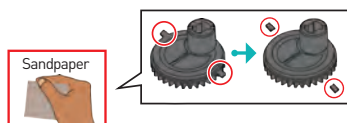
! Press the gears firmly into place.

- 26** Carefully place the upper body half onto the lower body half.

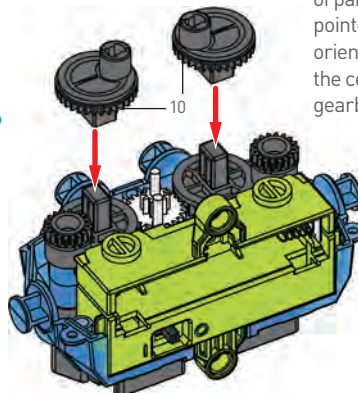


! Make sure the grooves on the upper body half slide onto the tabs of the battery box.

- 24** Place two part 10 gears as shown. Remove any burrs with sandpaper.

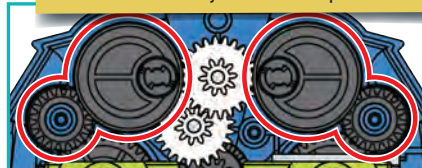


! Make sure the circular columns of part 10 are pointed up and oriented toward the center of the gearbox.

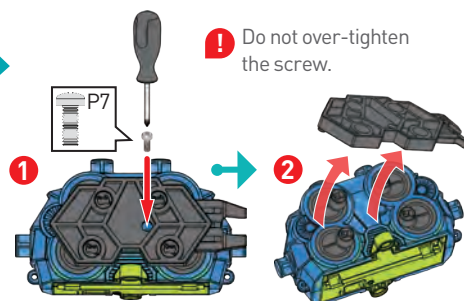


Check the gears:

The teeth of part 10 should mesh with the teeth of part 12. The gears will not turn at this point because they are locked in place.



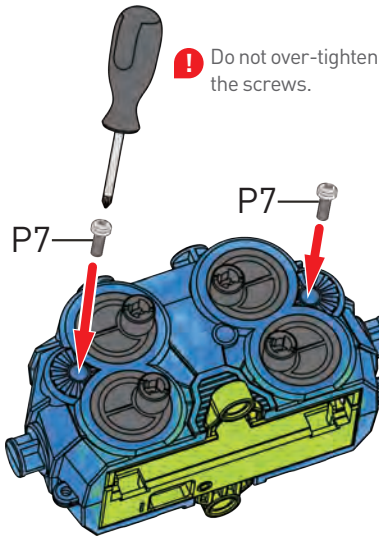
- 27** Insert one fully threaded screw through the hole in part 14, then tighten the screw. Next, remove part 14.



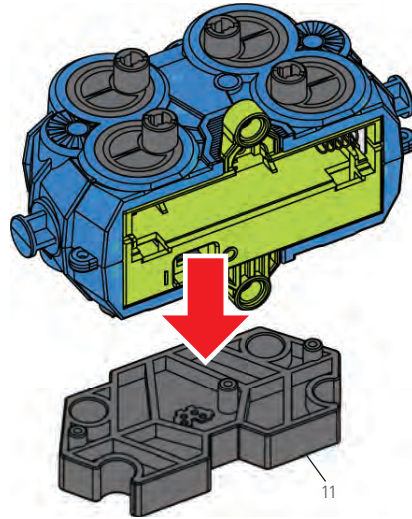
! Do not over-tighten the screw.

STEPS 28 – 31

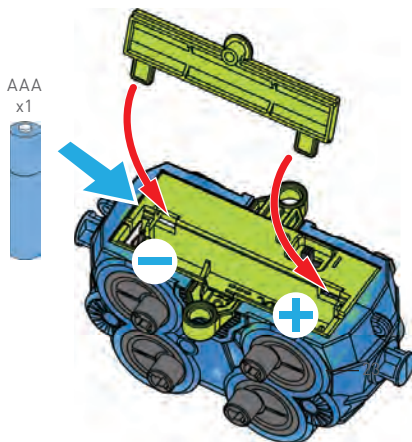
- 28** Insert two more fully threaded screws into the body as shown and tighten.



- 29** Remove the second alignment tool (part 11).



- 30** Insert a AAA battery with the correct polarity. To cover, slide the tabs of part 23 into the slots in the battery compartment.



Note the \oplus and \ominus polarity markings on the battery compartment.

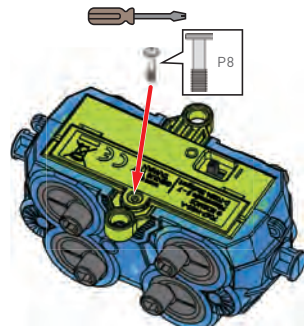
Turn it on!

Turn on the switch to make sure the gears turn. The four gray circular columns on each side of the body should now be moving in unison.

If the columns don't turn smoothly, something is misaligned in the gearbox. Don't stress! Take it apart, then try to figure it out as you rebuild it. This is part of the fun of engineering!

Make sure you've removed all of the burrs from the gears.

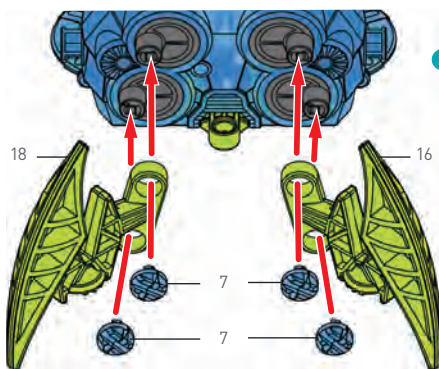
- 31** Use the half-threaded screw (P8) to secure the cover to the battery compartment.



STEPS 32-34

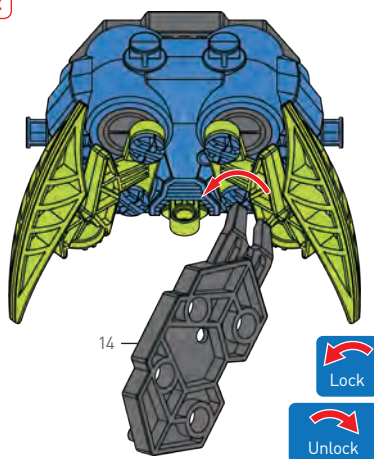
- 32** Attach two legs to each side of the body as shown. Each leg requires two locking bolts, so you will need a total of eight locking bolts.

x2

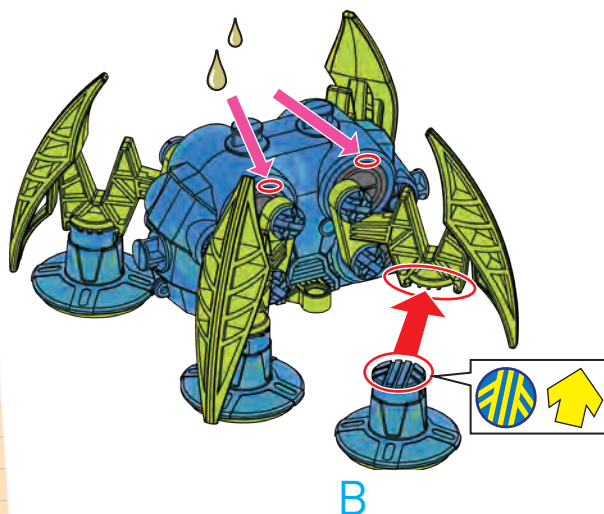
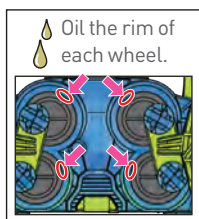


- 33** Lock each bolt in place by using one prong of part 14 as a screwdriver. To lock, turn the bolt counterclockwise until it clicks. [Turn the bolt clockwise to unlock.]

x2



- 34** Attach the four suction-cup feet to the legs. Pay attention to the direction of the arrow pattern on the tops of the feet when sliding the feet onto the legs. Add two drops of olive oil (or other cooking oil) to the rim of each gray gear that attaches to the legs

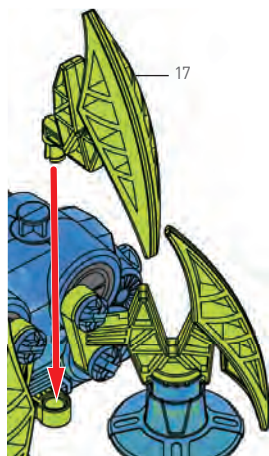


TIP

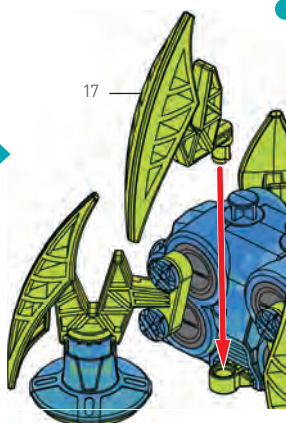
IF YOU SWITCH IT ON NOW, AND THE LEGS DON'T MOVE, TAKE THE MODEL APART AND BUILD IT AGAIN. INSPECT EACH OF THE GRAY GEARS, AND CAREFULLY REMOVE ANY BURRS WITH SANDPAPER.

STEPS 35 – 38

35

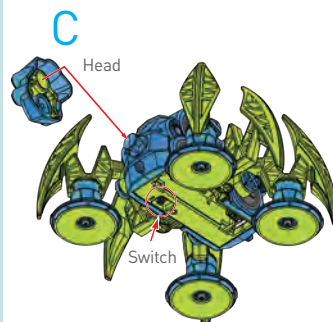


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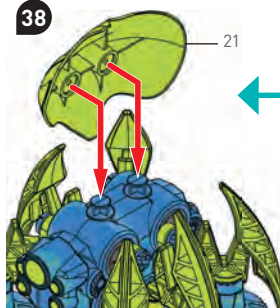


37

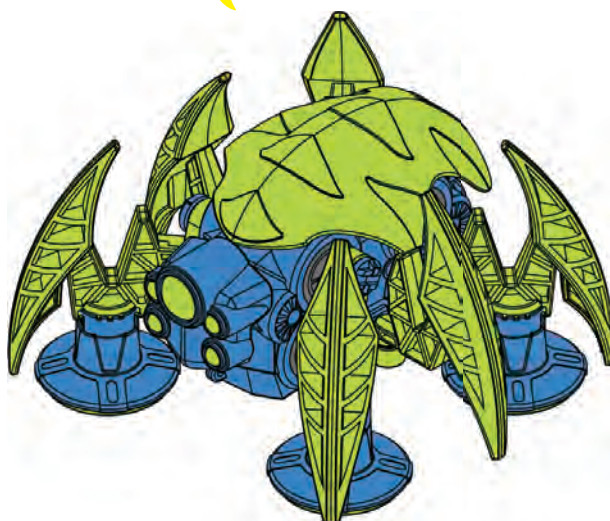
Attach the head on the side closest to the switch.



38



Done!

**TROUBLESHOOTING!**

If you are having trouble getting your Gravity Bug to climb, scan this QR code for help.



OPERATION AND TIPS

Experiment: Climbing a window

First, test out your Gravity Bug on a smooth, horizontal surface, like a tabletop. Turn it on and it should walk forward.

Then, stick it to a smooth, vertical surface like a large glass window. Press the suction cups firmly to the surface. The surface must be extremely smooth.

Make sure the surface is clean and dust-free. Cleaning the suction cups or the surface with water can also improve the robot's grip.

Turn on the switch and watch the robot climb. Keep your hands below the robot at first to catch it in case it falls.

Experiment to see which surfaces your Gravity Bug can climb.

CAUTION! Never hold your Gravity Bug between the moving legs. You fingers can be pinched, causing pain. Instead, it is best to hold your Gravity Bug with one finger on the head and the other finger on the opposite side.

*Watch
me climb!*





CHECK IT OUT

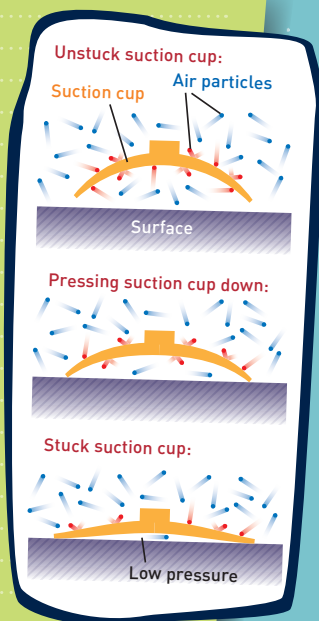


HOW DO Suction Cups WORK?

Suction cups use air pressure to stick to hard, smooth surfaces where a partial **vacuum** can be created. A suction cup has a cup-shaped surface made of a flexible material, like silicone, rubber, or plastic. When this cup is pressed against a hard surface, the air inside the cup, between the cup and the surface, gets pushed out. The regular atmospheric air outside the cup, which contains many more **air particles** per unit volume of space than inside the cup, remains the same. These air particles are constantly flying around through the air and hitting things, making a tiny impact, the sum of which is **air pressure**.



Because there are a lot more air particles per unit volume on the outside of the cup than there are on the inside, the air pressure is higher on the outside. This difference in air pressure is what keeps the suction cup stuck to the surface.

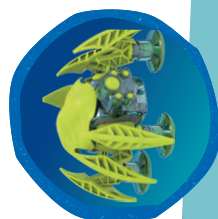


HOW DOES THE GRAVITY BUG Climb?

By pressing its suction-cup feet onto the window, the Gravity Bug creates a **negative pressure** there. This means that the air pressure existing there is lower than the environmental air pressure all around it. This negative pressure ensures the Gravity Bug stays stuck to the smooth surface, as the pressure of the atmosphere outside of the suction cups is pushing them toward the surface, while there is virtually no pressure pushing them away.

It is important that the contact between the suction cup and the climbing surface is free of gaps and as airtight as possible. Gaps caused by dust or dirt cause leaks that allow additional air to enter, destroying the negative pressure. Moistening the suction cups can improve the grip. The thin film of water fills in the small gaps and makes for a better seal.

You can create a negative pressure by gently sucking air from an empty water bottle with your mouth. You feel the negative pressure as soon as your lips are pressed against the bottle opening. The force that you can feel is the reason why the Gravity Bug sticks to vertical surfaces. Again, it is important to ensure that the contact between the bottle and your lips is airtight.





CHECK IT OUT



Octopus with suction cups

Your Gravity Bug isn't the only one who uses suction cups. Some frogs, bats, and bugs also use suction cups to get around. Octopuses too are famous for their suckers. They have two rows of suction cups on each of their eight arms, giving them hundreds in total. With these they can move along smooth surfaces or grab food.

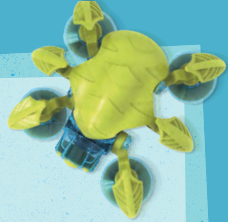
OT ER GR VIT -DEFYIN ANIMAL CLIMBER

YOU HAVE PROBABLY SEEN INSECTS LIKE FLIES AND SPIDERS EFFORTLESSLY CLIMB UP WALLS OR WALK ON THE CEILING. UNLIKE THE GRAVITY BUG, THEY DO NOT USE SUCTION CUPS, BUT RATHER ADHESIVE FORCES. THIS PHYSICAL PHENOMENON OCCURS BETWEEN TWO SURFACES, SUCH AS A PANE OF GLASS AND A FLY'S FOOT. TINY HAIRS ON THE BOTTOMS OF INSECTS' FEET PRODUCE A SUBSTANCE OF SUGARS AND OILS THAT ACTS LIKE GLUE.

GECKOS, SMALL LIZARDS FOUND MAINLY IN WARMER CLIMATES, GET THEIR EXTRAORDINARY CLIMBING ABILITY FROM ELASTIC HAIRS ON THEIR FEET THAT ARE SHAPED LIKE TINY SPATULAS. GECKO FEET HAVE INSPIRED SCIENTISTS AND ENGINEERS TO DESIGN MORE ADVANCED ADHESIVES.

*Let's go
up the walls!*





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Text and Editing: Ted McGuire and Hannah Mintz
Translation and editing: Tanja Sautter
Technical product development: Dr. Petra Müller; Genius Toys Taiwan Co., Ltd

Manual design concept: Atelier Bea Klenk, Berlin
Manual layout: Joanna Mühlbauer and Hannah Mintz
Manual illustrations: Genius Toys Taiwan Co., Ltd
Manual photos: Jaimie Duplass & beror (all adhesive strips, ©fotolia), Vector Memory (gears, ©Shutterstock); Ana Munaretto (octopus); Natalia van D (gecko); Volodymyr Horbovyi (suction cup with hand) all previous © shutterstock
Background graphics U1: Joanna Mühlbauer

Packaging design concept: Peter Schmidt Group, Hamburg
Packaging layout: Joanna Mühlbauer and Dan Frietas
Packaging photos: Genius Toys Taiwan Co., Ltd

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Phone: 800-587-2872; Web: www.thamesandkosmos.com

Distributed in United Kingdom by Thames & Kosmos UK LP, Cranbrook, Kent TN17 3HE
Phone: 01580 713000; Web: www.thamesandkosmos.co.uk

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Printed in Taiwan / Imprimé en Taiwan



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