ACTIVITIES CREATED IN COLLABORATION WITH NASA SCIENTISTS AND ENGINEERS.

HERE'S TO A UNIVERSE OF ASTRONAUTS, SCIENTISTS, THINKERS AND TRAILBLAZERS.

let's go!

love, littleBits™

WARNING

- This product contains small magnets. Swallowed magnets can stick together across intestines causing serious infections and death. Seek immediate medical attention if magnets are swallowed or inhaled.
- Most modules are small parts. DO NOT allow children under 3 years old to play with or near this product.
- NEVER connect any modules or circuits to any AC electrical outlet.
- Do not touch or hold any moving parts of modules while they are operating.
- Keep conductive materials (such as aluminum foil, staples, paper clips, etc.) away from the circuit and the connector terminals.
- Always turn off circuits when not in use or when left unattended.
- Never use modules in or near any liquid.
- Never use in any extreme environments such as extreme hot or cold, high humidity, dust or sand.
- Modules are subject to damage by static electricity. Handle with care.
- Some modules may become warm to the touch when used in certain circuit designs. This is normal. Rearrange modules or discontinue using if they become excessively hot.
- Discontinue use of any modules that malfunction, become damaged or broken.

VERY IMPORTANT NOTE

- Several projects in this kit involve the use of a box cutter and/or a hot glue gun. These tools should be used ONLY under direct adult supervision and ONLY by children capable of using them safely.

INSTRUCTIONS

We recommend using littleBits brand 9-volt batteries, but standard alkaline or standard rechargeable batteries may also be used. Properly discard and replace exhausted batteries. Do not connect the two battery terminals to any conducting material.

CARE AND CLEANING

Clean modules ONLY by wiping with a dry cloth. If necessary, isopropyl alcohol on a cloth may be used sparingly.

DO NOT use any other cleaning products on modules. Congratulations for reading this fine print. Your dedication and persistence will serve you well.

FC RADIO AND TELEVISION INTERFERENCE

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

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

Changes and Modifications not expressly approved by the manufacturer or registrant of this equipment can void your authority to operate this equipment under Federal Communications Commissions rules.

GOT A QUESTION?

Visit littleBits.cc/faq for troubleshooting and additional support.

www.littleBits.cc

littleBits Electronics, Inc.
60 E. 11th Street, Fifth Floor
NY, NY 10003
(917) 464-4577

You are a proud owner of the **Space Kit v1**.
Over 1,000,000 combinations?! Are you serious?
Yep, www.littleBits.cc/mathmagic

Information in this activity booklet was created in collaboration with the NASA Goddard Space Flight Center and the AURA program.
Made in Dongguan City, China

LITTLEBITS™ BASICS

You always need a blue and a green;
pink and orange are optional, in between.

1

CIRCUITS IN SECONDS

littleBits makes an expanding library of modular electronics that snap together with magnets.

NEED HELP?

For troubleshooting and additional support, visit **littleBits.cc/faq**

2

COLOR CODED

Modules are grouped into four different categories, which are color coded:

POWER is needed in every circuit and the start of all your creations.

INPUT modules accept input from you and the environment and send signals to the modules that follow.

OUTPUT modules DO something–light, buzz, move...

WIRE modules expand your reach and change direction–great for helping to incorporate modules into your projects.

3

ORDER IS IMPORTANT

Power Modules always come first and **Input Modules** only affect the **Output Modules** that come after them.

4

MAGNET MAGIC

littleBits modules snap together with magnets. The magnets are always right, you can't put modules together the wrong way.

5

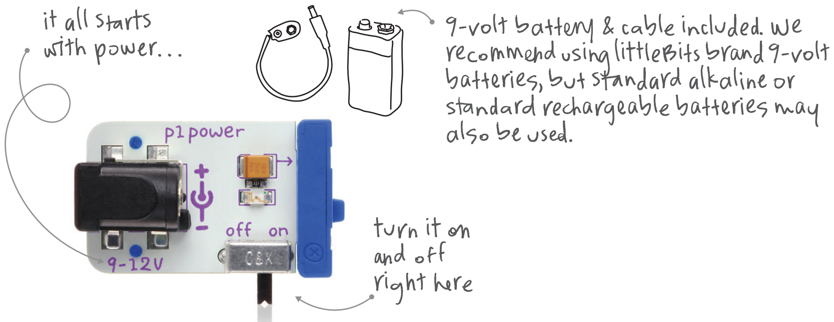
littleBits + anything

The modules are just the beginning. Combine them with craft materials, building sets, and other toys to electrify your life. We'll show you how!

no soldering
no programming
no wiring

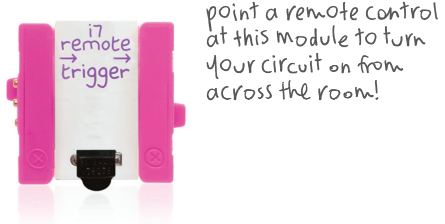
KNOW YOUR BITS™ MODULES

This is the Space Kit, Version 1
Learn more and shop for individual modules at littleBits.cc/Bits



POWER p1

This power module lets you use a 9-volt battery to supply electricity to your other modules. Snap in the battery & cable (both included) and flip the switch to turn it on.

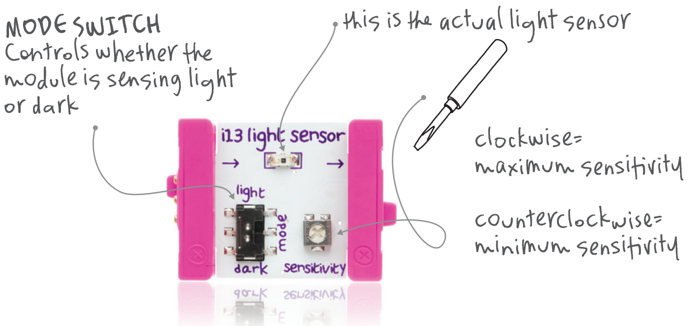


REMOTE TRIGGER i7

The remote trigger lets you use a common remote control with your modules. Make your littleBits circuit and point your remote control at the remote trigger's sensor. Then, press any button on your remote control to activate the module. It will work with almost any button on a remote that uses infrared light to send signals.

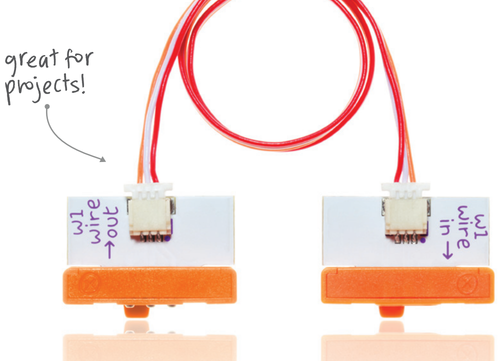
MICROPHONE i21

The microphone module translates sound into the electronic language of littleBits. You can use it to turn sounds into light or motion, or use it with the speaker module like a small megaphone! Make sure the switch is set to "sound" when you're using it with the speaker, and "other" for all your other modules.



LIGHT SENSOR i13

The light sensor measures how much light is shining on it. It has two modes: "light" and "dark." In "light" mode, the more light the sensor receives, the higher the signal it sends out. In "dark" mode, it's just the opposite – the signal increases as light decreases.

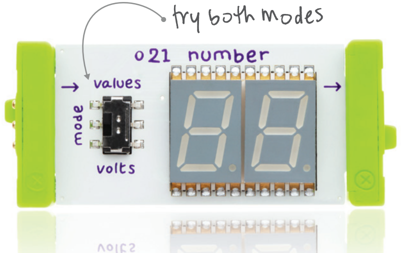


WIRE w1

The wire is just what it sounds like – it allows you to physically separate your modules, turn corners and build your circuit in any direction. Try it whenever you need to break up your chain, like when you need to put a sensor on the top of your rover! You'll find many situations where you'll want a wire.

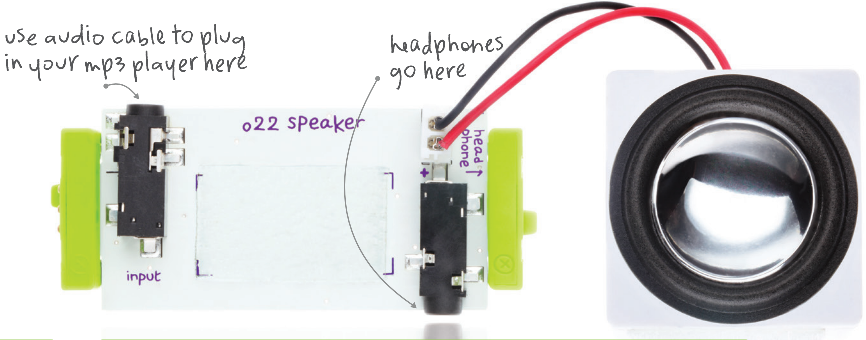
IR LED o7

The IR LED (or infrared light-emitting diode) module sends out light with longer wavelengths than visible light, similar to the light in your remote control. It's invisible to the eye, but many digital cameras can see it! Try using it to activate the light sensor or remote trigger.



NUMBER o21

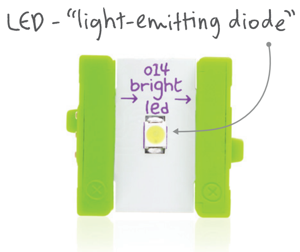
The number module gives you a look into how your modules work: it displays information about the signal it's receiving from your other modules. It has two modes: in "value" mode, it displays a number from 0 to 99 based on the input. In "volts" mode, it displays the actual voltage it is receiving, from 0.0 to 5.0 volts.



SPEAKER o22

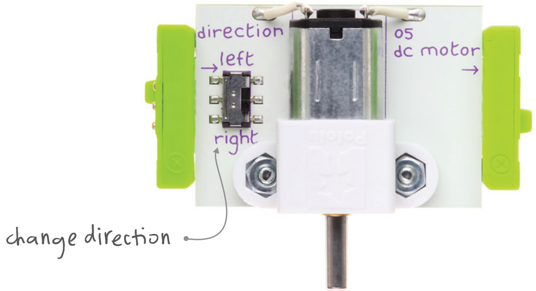
The speaker amplifies sound from modules like the microphone or other sources like mp3 players. It also features a headphone output for personal listening. The speaker is connected with 3M™ Dual Lock™ so it can be removed from its circuit board. To reattach, hold module and press together firmly.

do something you've never done before.



BRIGHT LED o14

The bright LED is a small module that puts out a big light. Just like our other LED modules, it's a great way to shed some light on your creations. Choose the bright LED when you want a lot of bright white light.



DC MOTOR o5

The DC (or "direct current") motor rotates a shaft when you send it an *on* signal. It has a switch to set the direction of rotation. Try attaching various things to make robotic space arms, orbiting satellites, and rovers.

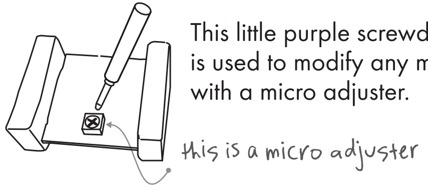
MOTORMATE™ a10

The motorMate works with the DC motor. This makes it easy to attach wheels, paper, cardboard, and lots of other materials to the motor. Simply slide it on the "D" shape on the shaft. A LEGO™ axle also fits in the end.

AUDIO CABLE a16

This cable is for connecting your microphone or speaker module to an audio source, like an mp3 player or smartphone.

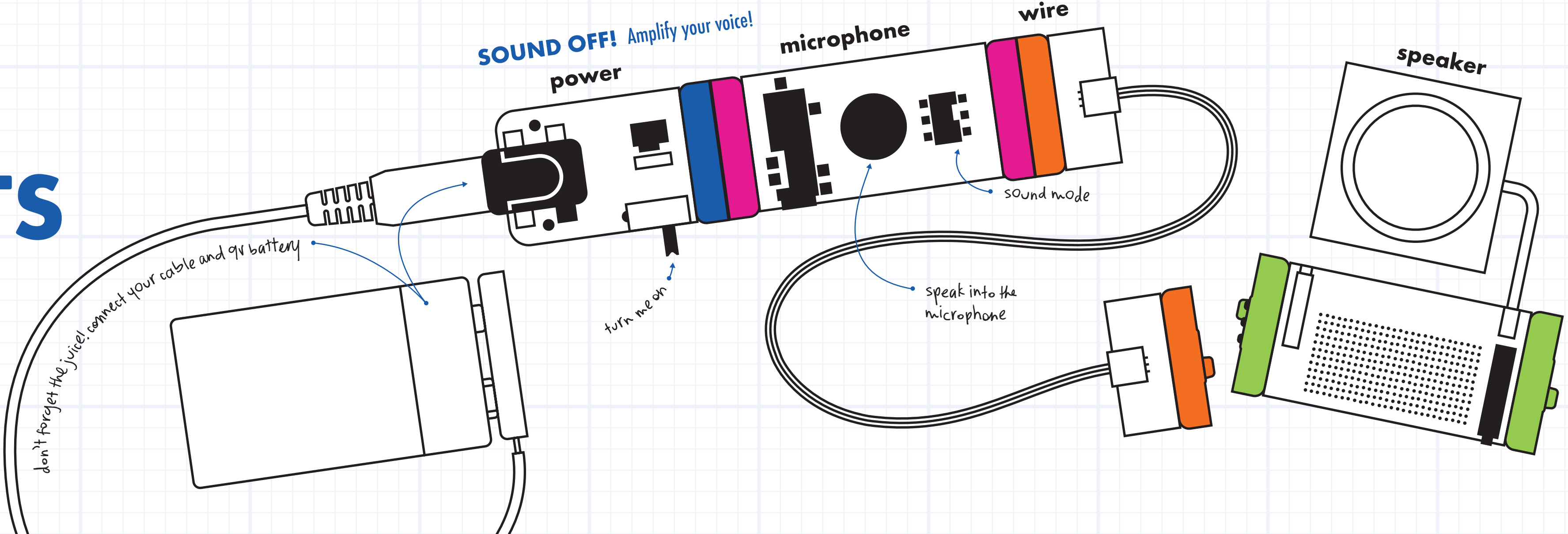
SCREWDRIVER a4



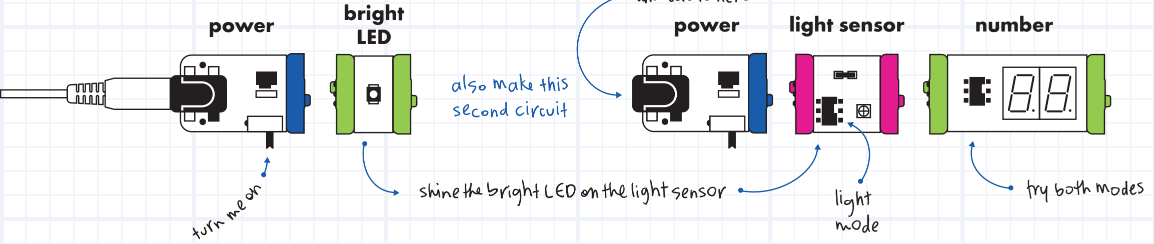
This little purple screwdriver is used to modify any module with a micro adjuster.

TRY THESE CIRCUITS

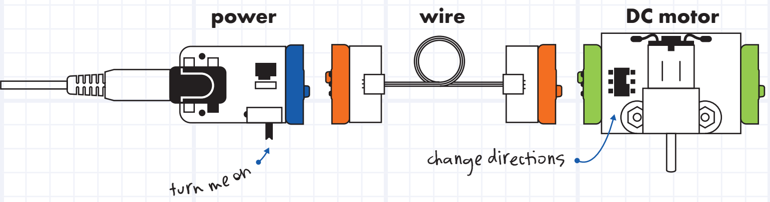
Get started with these, but don't let us hold you back – every module fits with every other module – feel free to experiment.



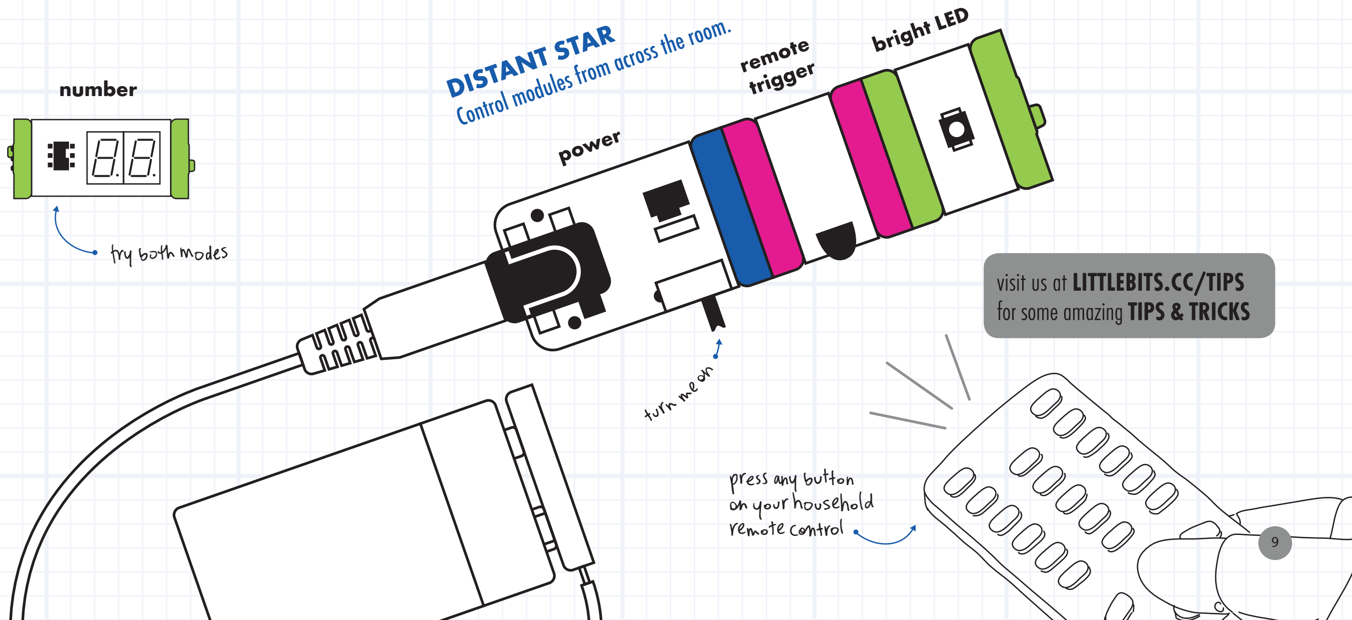
LIGHT READER Learn how to measure light.



INTRO TO DC MOTOR Get to know the motor.



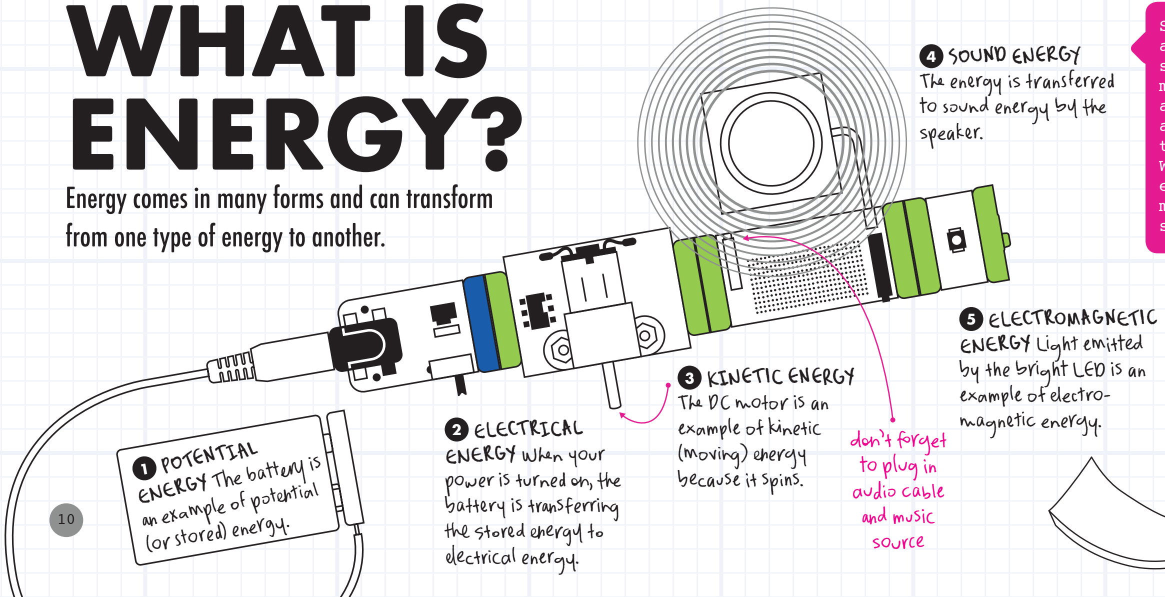
DISTANT STAR Control modules from across the room.



visit us at **LITTLEBITS.CC/TIPS** for some amazing **TIPS & TRICKS**

WHAT IS ENERGY?

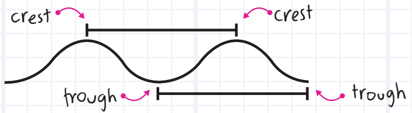
Energy comes in many forms and can transform from one type of energy to another.

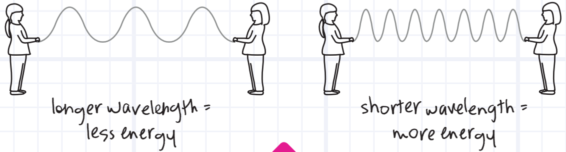


Sound waves are both potential and kinetic energy. When the speaker moves, it compresses air molecules nearby, giving that air potential energy. When the air expands, potential energy is transformed into kinetic energy. Waves created by compressing and expanding matter – such as air molecules – are called compression waves.

SCIENCE IN ACTION
try the Wave Generator Project p.13

WAVELENGTH The distance from crest to crest or trough to trough of a wave.





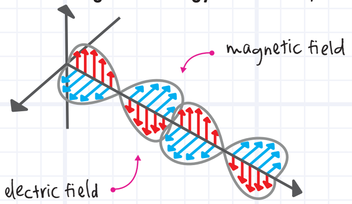
An electromagnetic wave can also be described in terms of its energy – in units of measure called electron volts (eV). Moving along the spectrum from long to short wavelengths, energy increases as the wavelength shortens. Consider a jump rope with its ends being pulled up and down. More energy is needed to make the rope have more waves.

ELECTROMAGNETIC ENERGY

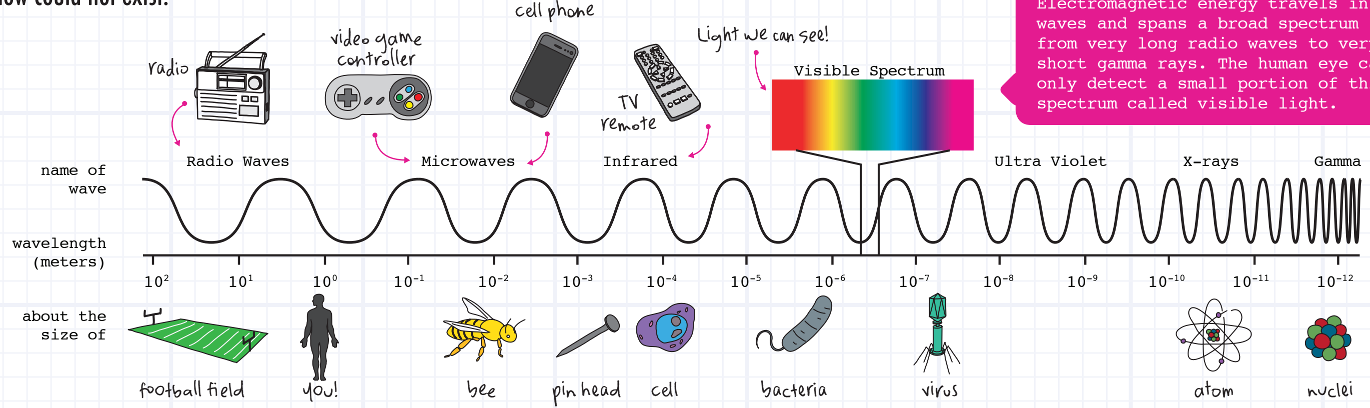
Light is also energy that travels in waves. You cannot see these waves like you can see ocean waves, but you can see their energy as visible light.

SCIENCE IN ACTION
try the Energy Meter Project p.14

When you tune your radio, watch TV, send a text message, or pop popcorn in a microwave oven, you are using electromagnetic energy. Without it, the world you know could not exist.



ELECTROMAGNETIC WAVE
Electricity can be static, like the energy that can make your hair stand on end. Magnetism can also be static, as it is in a refrigerator magnet. A changing magnetic field will create a changing electric field and vice-versa, the two are linked. These changing fields form electromagnetic waves.

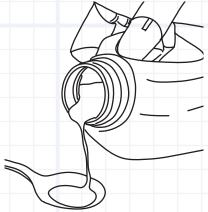


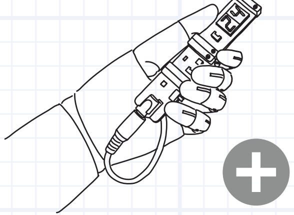
ELECTROMAGNETIC SPECTRUM
Electromagnetic energy travels in waves and spans a broad spectrum from very long radio waves to very short gamma rays. The human eye can only detect a small portion of this spectrum called visible light.

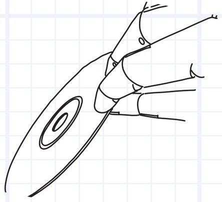
PROJECTS

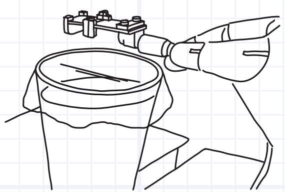
Enhanced instructions plus tons more projects online, **littleBits.cc/space**

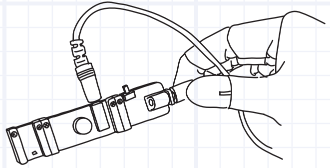
DOWNLOAD ACTIVITIES ONLINE AT
WWW.LITTLEBITS.CC/SPACE

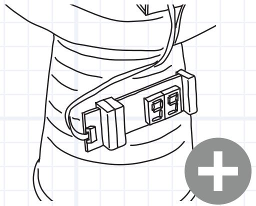


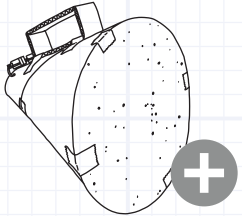


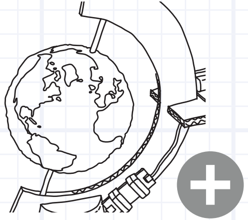


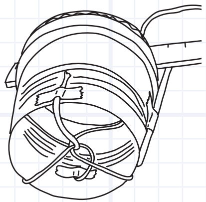


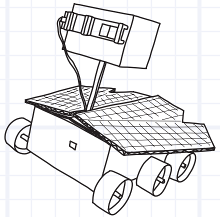








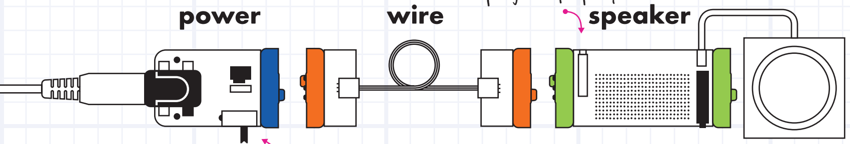




PROJECT 1: An introduction to speakers and mechanical waves.

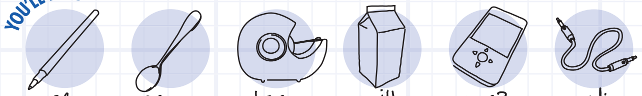
WAVE GENERATOR

1 Start with this circuit.

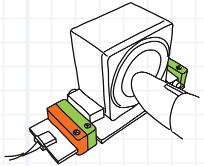


TIME: 15 mins
DIFFICULTY: ●●○○○

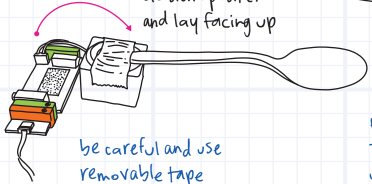
YOU'LL NEED



2 Play song on mp3 player and gently touch speaker cone.

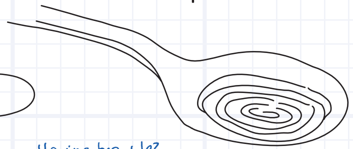


3 Attach spoon to speaker with tape.



4 Pour milk into spoon, then play some songs.

5 Turn up your volume and check out the cool wave patterns!



Having trouble? Try different songs until you see some waves.

Describe how different music causes different reactions in the liquid.

....

....

....

....

....

....

....

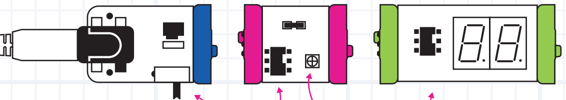
....

WHY'D IT DO THAT?
refer back to What is Energy on p.10

PROJECT 2: Discover sources of light energy around you.

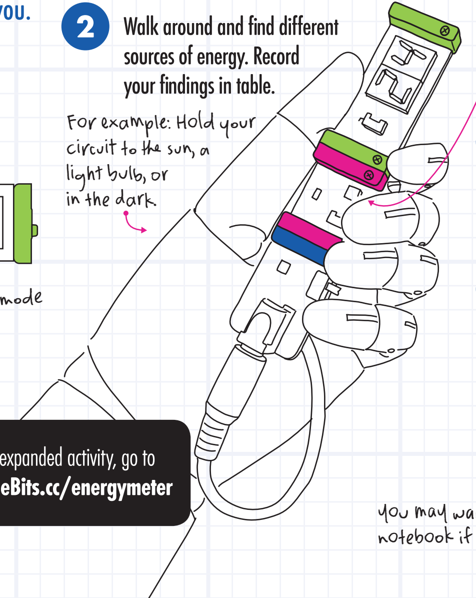
ENERGY METER

1 Start with this circuit.



2 Walk around and find different sources of energy. Record your findings in table.

For example: Hold your circuit to the sun, a light bulb, or in the dark.



if you are having trouble seeing the numbers change, adjust sensitivity with screwdriver

3 Move the sensor closer or farther from the energy source. Record your observations in table.

4 Can you see any energy coming from a TV remote control? What happens if you point it at the energy meter and press a button?

(hint: most remotes have IR LEDs)

you may want to start your own scientific notebook if you find you need more room

TIME: 15 mins
DIFFICULTY: ●○○○○

YOU'LL NEED

pen

For expanded activity, go to **littleBits.cc/energymeter**

What sources of energy can you find?

1. .... 3. ....
2. .... 4. ....

Describe what happens when you move the sensor closer to or farther from the energy source.

....

What happens if you point a household remote at the light sensor?

....

WHY'D IT DO THAT?
refer back to Electromagnetic Energy on p.11

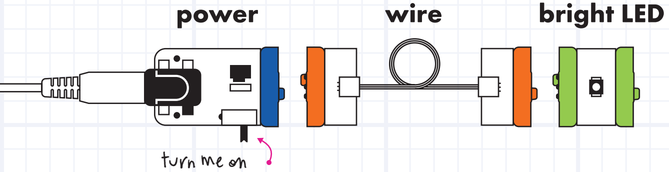
Digital cameras create images by measuring light energy. This is similar to how NASA satellite images are created by measuring energy reflecting off the Earth's surface.

NASA images by Reto Stöckli, based on data from NASA and NOAA

PROJECT 3: Explore light waves you can see.

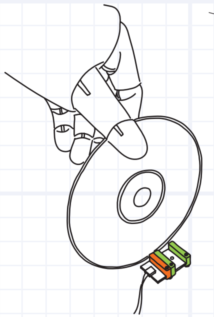
MAKE A SPECTRUM

1 Make this circuit.



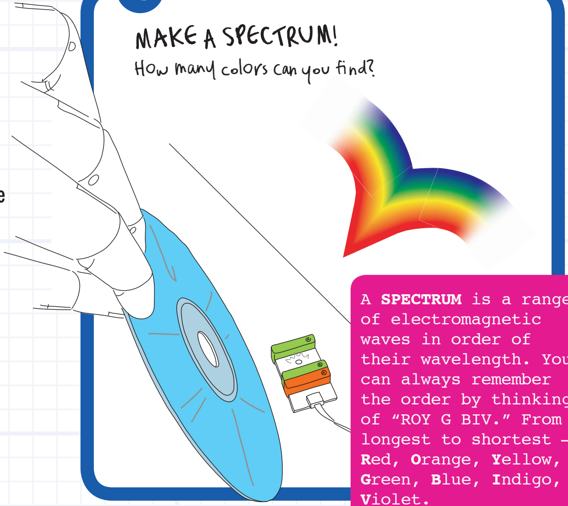
2 Find a dark place and set the reflective side of the CD opposite a white wall or piece of paper.

3 Place a bright LED in between the CD and the wall (or paper).



TIME: 15 mins
DIFFICULTY: ●○○○○

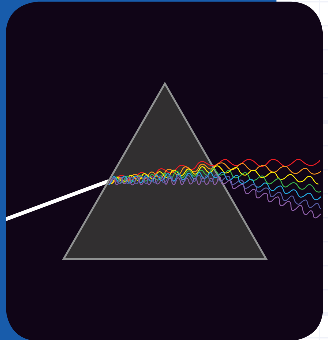
4



A **SPECTRUM** is a range of electromagnetic waves in order of their wavelength. You can always remember the order by thinking of "ROY G BIV." From longest to shortest – **R**ed, **O**range, **Y**ellow, **G**reen, **B**lue, **I**ndigo, **V**iolet.

As white light bends, each color in the spectrum bends at a slightly different angle because their wavelengths are different sizes. Shorter wavelengths will bend more and longer wavelengths will bend less.

Why does a CD behave like a prism? They both act as "diffraction grating." The grooves on a CD diffract light into several beams like you saw in this experiment!

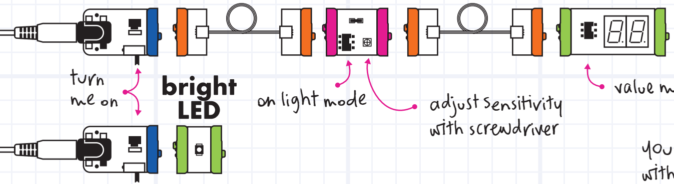


WHY'D IT DO THAT?
refer back to Electromagnetic Energy on p.11

PROJECT 4: Learn how satellites detect particles in the atmosphere.

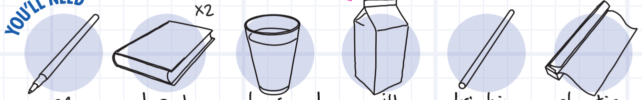
MEASURING THE ATMOSPHERE

1 Make these two circuits.

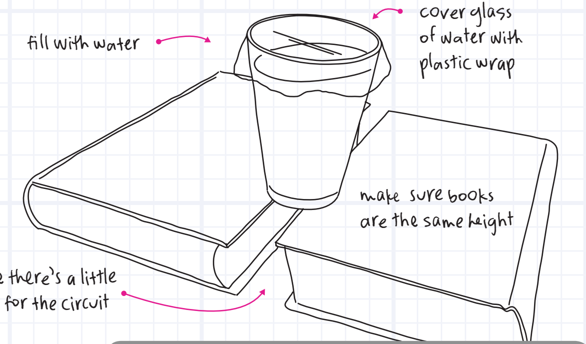


TIME: 30 mins
DIFFICULTY: ●●○○○

YOU'LL NEED

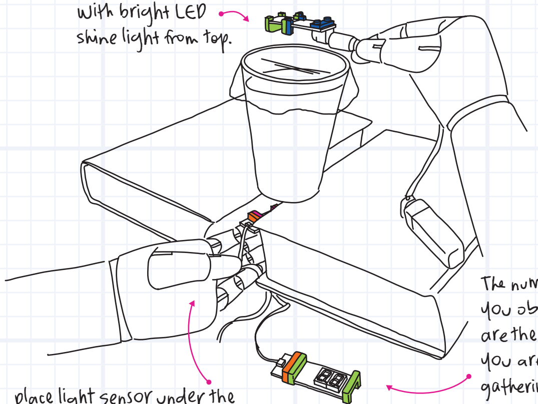


2 Place glass of water over the space between two books.

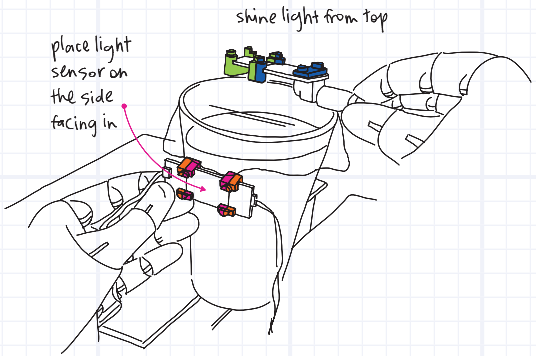



```
This project is similar to how satellite
instruments measure the atmosphere.
Since aerosols and gases scatter light
differently, NASA instruments can determine
the composition of the atmosphere by
measuring how light is scattered.
```

3 Orient your circuits above and below the glass. Measure the amount of energy passing through the bottom of the glass. Record your data.



4 Measure the amount of energy coming through the side of the glass. Record your data in table.

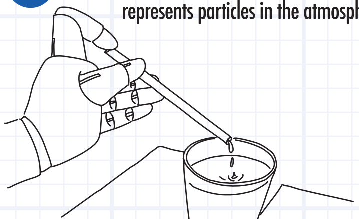


Why not try some other liquids as well? Orange Juice? Soda?

5 What do you think will happen to the number if you add a drop of milk to the water? Record your hypothesis. Now conduct an experiment to find out if you were right.

Scientists use what they know to make a guess about what may happen. This is called a "hypothesis."

6 Add 1 drop of milk and stir. The milk represents particles in the atmosphere.



7 Continue adding milk and record your observations. Repeat steps 3 and 4 and record your data.

Hypothesis:

....

Data Table

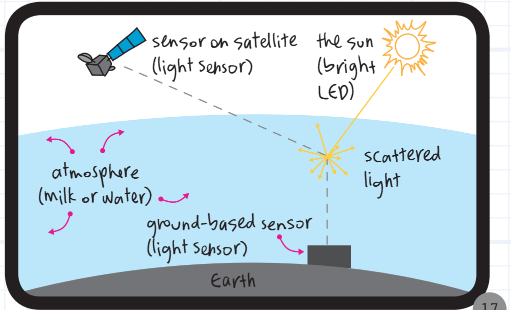
	Bottom	Side
Water		
1 drop milk		
2 drops milk		
3 drops milk		
4 drops milk		

Was your hypothesis correct?

....

Measuring from bottom: With water, the reading will be high because light is traveling downward. With milk, the reading will be lower because light is scattered.

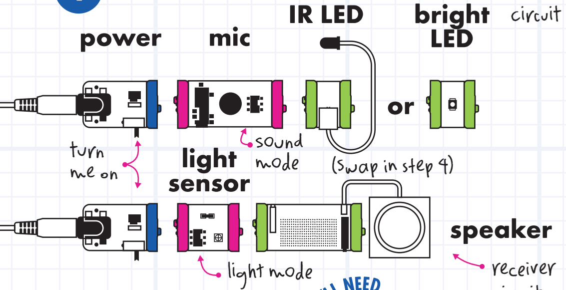
Measuring from side: With water, the reading will be low because light is traveling downward. With milk, the reading will be higher because the light is scattered.



PROJECT 5: Learn how to wirelessly transmit music using a digital signal.

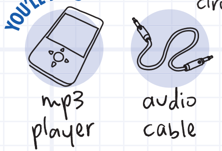
DATA COMMUNICATION

1 Make these two circuits.

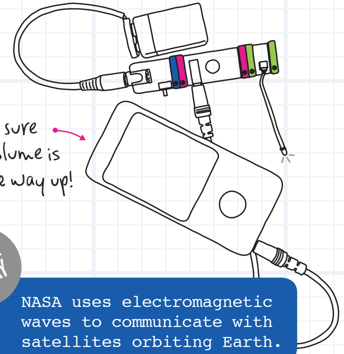


TIME: 30 mins
DIFFICULTY: ●●○○○

YOU'LL NEED



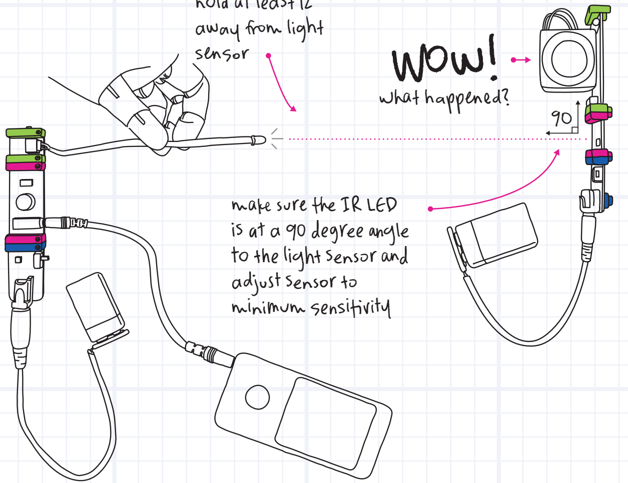
2 Plug audio cable into microphone module and an mp3 player and play your favorite song.



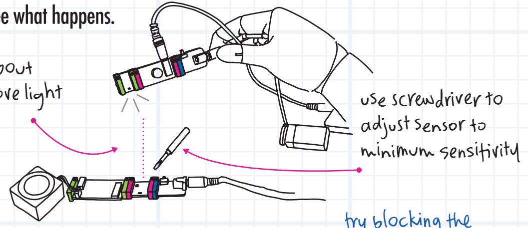
NASA TODAY

NASA uses electromagnetic waves to communicate with satellites orbiting Earth.

3 Place both circuits on a flat surface, like below.



4 Now swap out the IR LED for the bright LED and see what happens.



5 Put different materials between the light source and sensor. What happens?

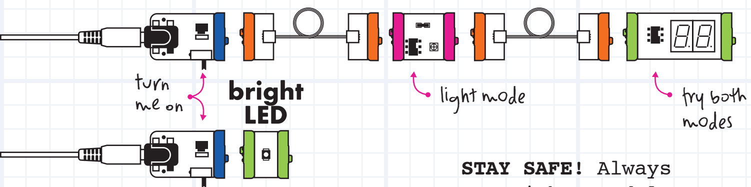
try blocking the light sensor with your hand or a piece of paper!

How does it work?
Your digitized music is converted into a series of light wave pulses. The pulses are decoded by the light sensor and converted into sound waves by the speaker.

PROJECT 6: Learn the science behind satellites and make your own parabolic reflector.

SATELLITE DISH

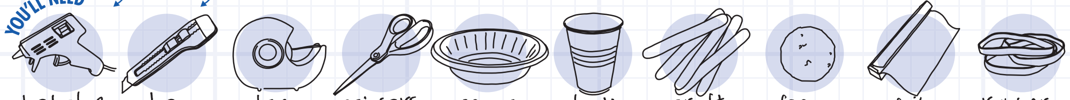
1 Make these two circuits.



STAY SAFE! Always use with an adult.

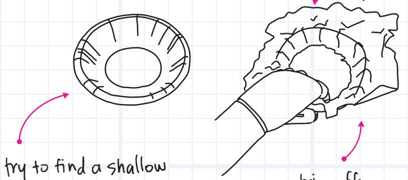
TIME: 60 mins
DIFFICULTY: ●●●○○

YOU'LL NEED

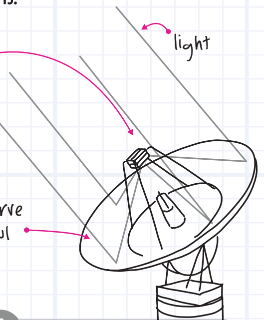


hot glue, box cutter, tape, scissors, paper bowl, plastic cup, craft stick, foam ball, foil, rubber-band

2 Find a paper or plastic bowl and cover it with foil.

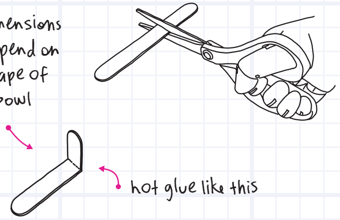


3 To optimize the amount of light that is reflected into your sensor, you'll need to calculate where the focus point is.

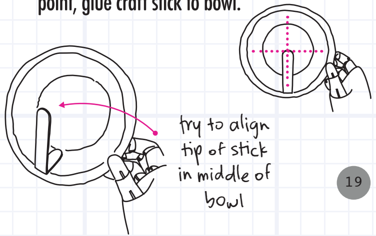


To learn how to calculate the focus distance, go here: **littleBits.cc/satellitedish**

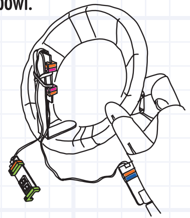
4 Use craft stick to make a sensor arm.



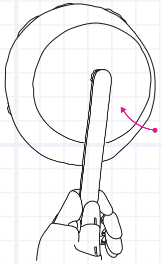
5 Once you have found the ideal focus point, glue craft stick to bowl.



6 Rubberband light sensor to tip of arm. It should face into bowl.



7 Create a mounting stick.

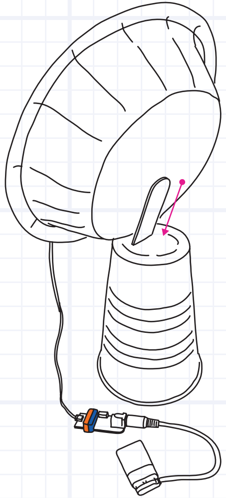


glue craft stick to back of the bowl

8 Cut slit in bottom of cup.

sharp! be careful!

9 Stick satellite dish into cup through the slit.

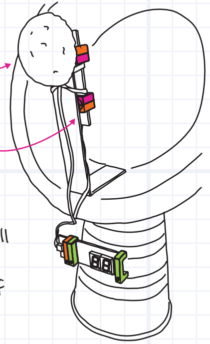


10 Use tape and place number module on front of cup.

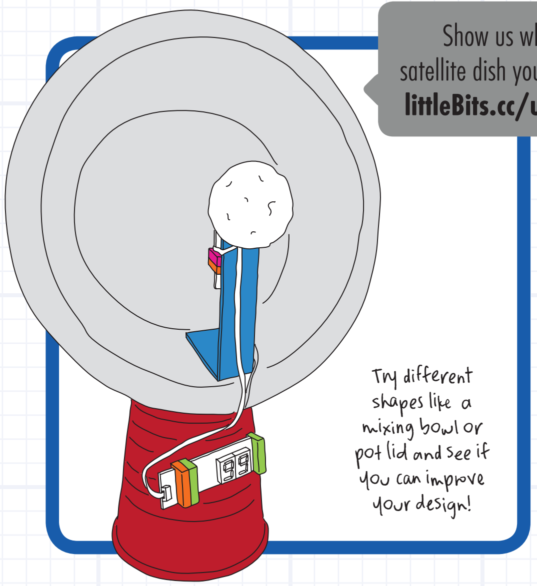
cut foam ball in half

adjust sensitivity of the light sensor with screwdriver

Decorate by adding foam ball at tip of stick on other side of light sensor.



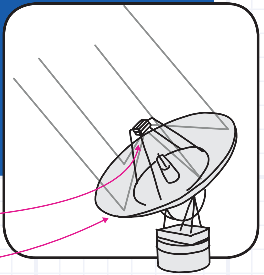
11 Shine bright LED into your dish... what happens to the number reading?



Try different shapes like a mixing bowl or pot lid and see if you can improve your design!

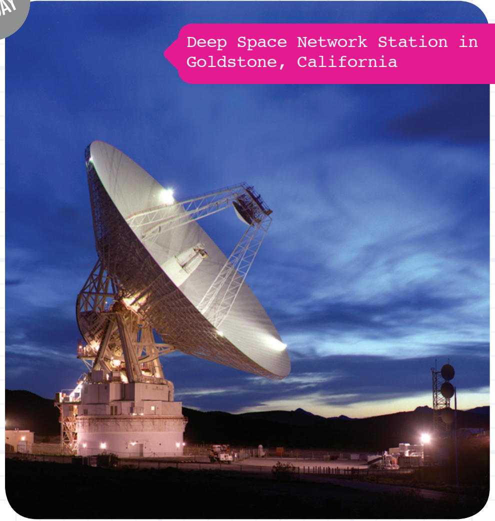
Show us what satellite dish you made!
littleBits.cc/upload

Unique curved surfaces, such as parabolas, have a point called the **FOCUS**, where all of the energy entering the shape is 'reflected' from the parabolic curve and intersects at the focus. In your satellite dish model, the light sensor is your focus that receives energy from the bright LED and measures it in the number module.



this focus is collecting data just like your light sensor,
and this is just like the bowl in your model

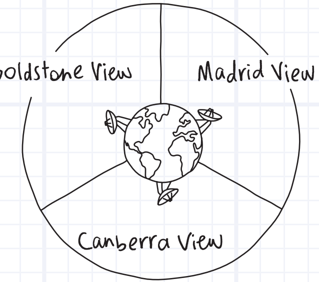
NASA TODAY



Deep Space Network Station in Goldstone, California

THE DEEP SPACE NETWORK (DSN) is a worldwide network of antennas developed by NASA to communicate with robotic spacecraft exploring our solar system and beyond. Sensors on board this spacecraft gather and transmit data about distant planets, moons, asteroids, comets, stars, and galaxies.

Receiving data from this spacecraft is very challenging because of the extreme distances between the spacecraft and Earth. Signals must travel millions or even billions of kilometers between Earth and a spacecraft in deep space. The spacecraft's communications equipment – designed to be small and lightweight – transmits at very low power, typically about the same as a refrigerator light bulb. Receiving antennas on Earth must have large collectors (antenna dishes) with precisely shaped surfaces and they must accurately point towards the spacecraft.

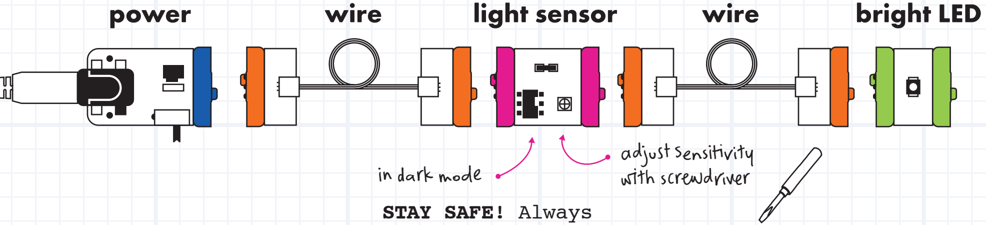


The DSN has three ground stations located approximately 120 degrees apart on Earth (120 + 120 + 120 = 360). This is to ensure that as the Earth rotates, at least one station is able to capture and transmit signals to any deep space mission without any gaps in coverage.

PROJECT 7: Learn about astronomy and project the night sky in your room.

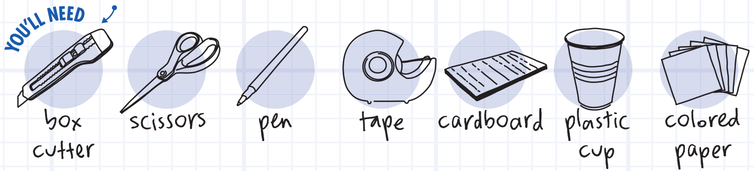
STAR CHART

1 Start with this circuit.

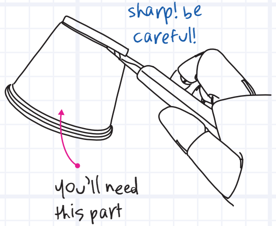


STAY SAFE! Always use with an adult.

TIME: 60 min
DIFFICULTY: ●●●○○

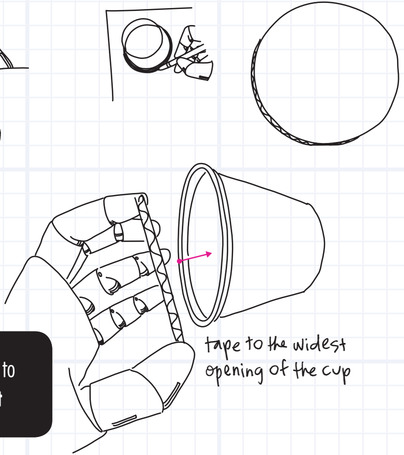


2 Cut the bottom off of a plastic cup.

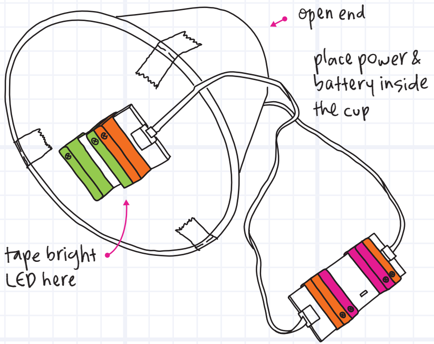


For expanded activity, go to **littleBits.cc/starchart**

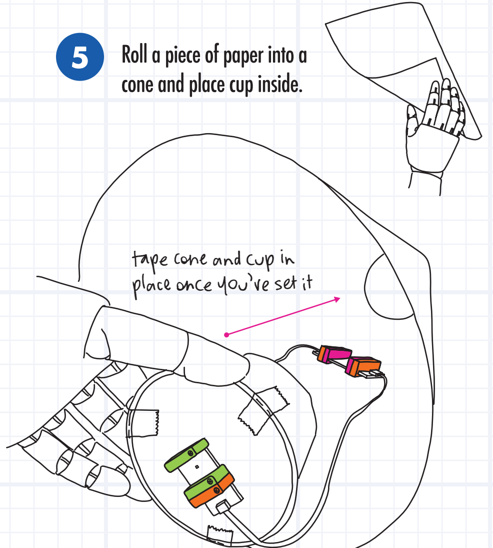
3 Trace wide end of the cup on a piece of cardboard and cut it out.



4 Tape bright LED on top of cardboard circle.

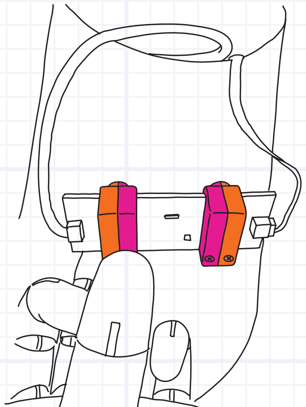


5 Roll a piece of paper into a cone and place cup inside.

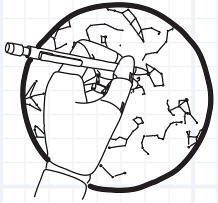


tape cone and cup in place once you've set it

6 Tape light sensor on the outside of the cone.

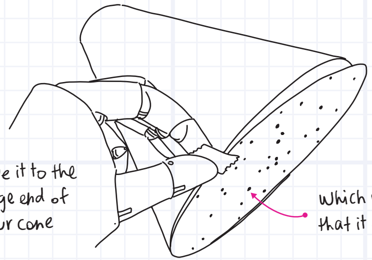


7 Print out a star chart. You can download one at littleBits.cc/starchart



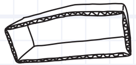
cut chart to size to fit on end of cone

use a pen to poke the holes of the constellations



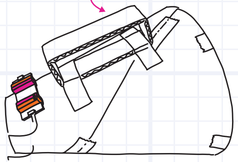
tape it to the large end of your cone

8 Create a handle out of cardboard.



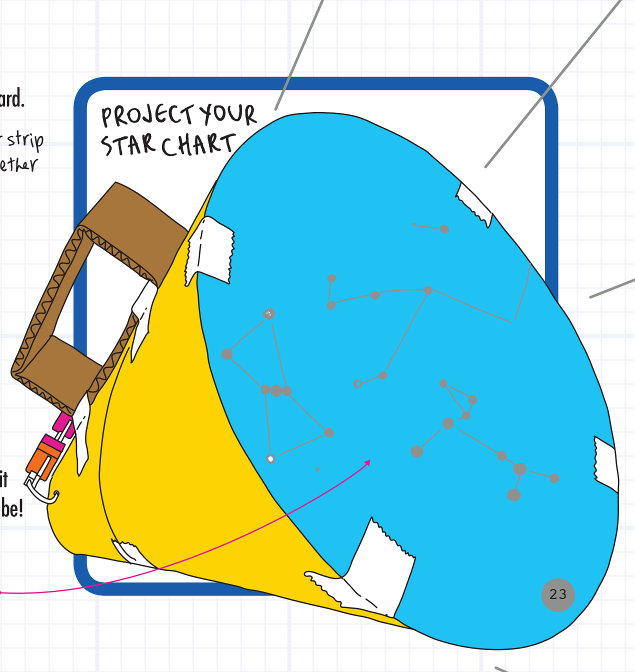
cut a rectangular strip and tape ends together

then tape it to your cone



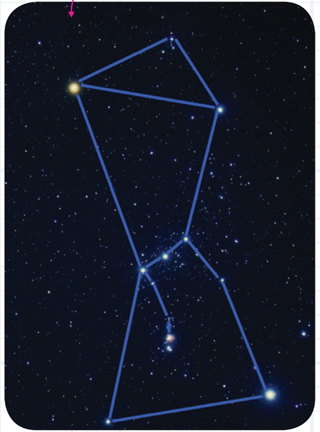
9 Turn off the lights, the darker it gets the brighter the stars will be!

which way will you attach the star chart so that it appears the same as the night sky?

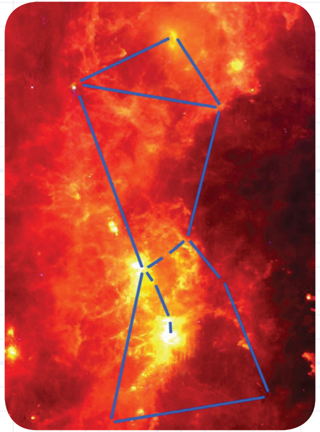


NASA instruments measure energy in the night sky across the electromagnetic spectrum. By looking at the sky in wavelengths beyond the visible spectrum, scientists can see a more complete picture. This helps them study questions like 'how was the universe formed' and 'how is it changing.'

The constellation Orion.
These images show features that cannot be seen in visible light but appear brightly in infrared



Visible light image: Akira Fujii



Infrared image: Infrared Astronomical Satellite

Orion is one of the most widely recognized of all the 89 constellations in the sky. It is also one of the oldest known to humans. The Ancient Egyptians called it Osiris as long ago as 2000 BC!

The brilliant stars that make up this rectangular star pattern seem to be close-by because they are so bright, but in fact they are very far away. Astronomers measure distances using a unit called the light year, which equals about 5.9 trillion miles (9.5 trillion km), or 63,240 times the distance from Earth to the Sun!

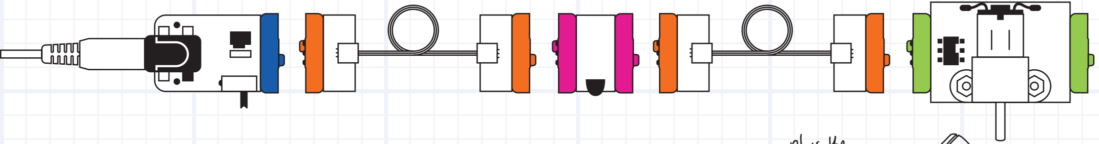
TRY THESE CALCULATIONS!
The bright star in Orion called **Betelgeuse** is located 650 light years from Earth. What is this distance in miles or kilometers?

Betelgeuse is expected to blow up as a supernova sometime in the next million years. Suppose this happened in the year 3000 AD. In what year would someone on Earth see this explosion? Go online to find the answers, littleBits.cc/starchart

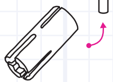
PROJECT 8: Learn about how satellites take photos of the Earth.

SATELLITE ORBIT

1 Make this circuit.



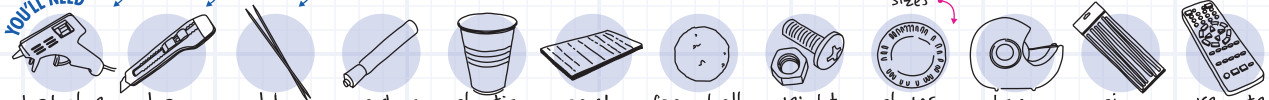
plus the **motorMate**



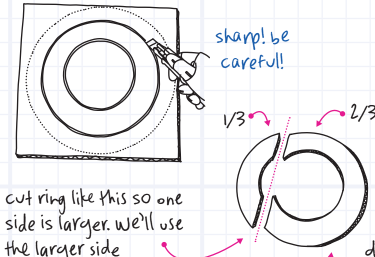
STAY SAFE! Always use with an adult.

TIME: 90 min
DIFFICULTY: ●●●○○

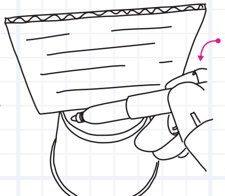
YOU'LL NEED

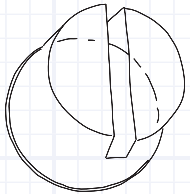


2 Make a ring. Trace a large plate and then a small plate on a piece of cardboard and cut them out.

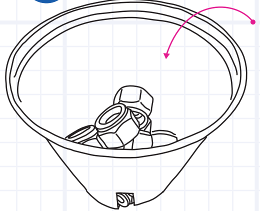


3 Cut a slot in a plastic cup.

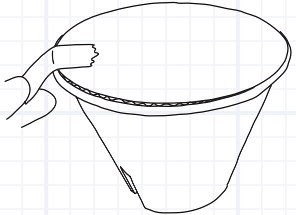




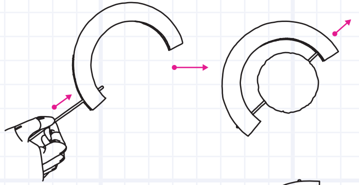
4 Fill the cup with some weight.



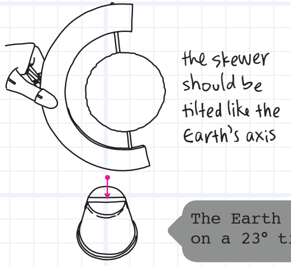
5 Cover cup with circular piece of cardboard and tape it down.



6 Stick skewer through the cardboard curve and the center of the foam ball.

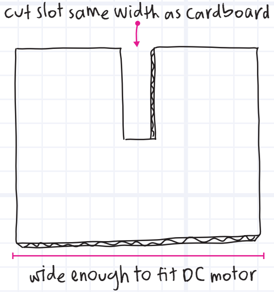


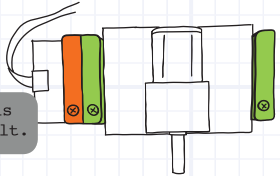
7 Place the cardboard curve in the cup slot in the cup and tape in place.



The Earth is on a 23° tilt.

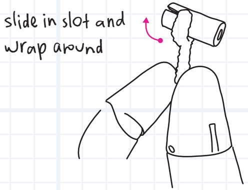
8 Make a cardboard shelf for the DC motor.



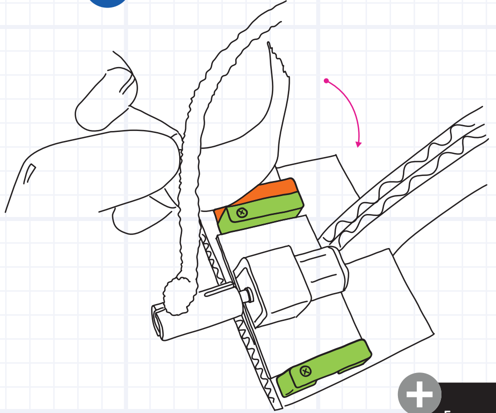


9 Then glue to center of cardboard curve.

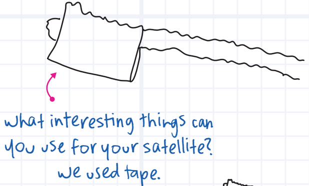
10 Attach pipe cleaner to motorMate and put on the DC motor.



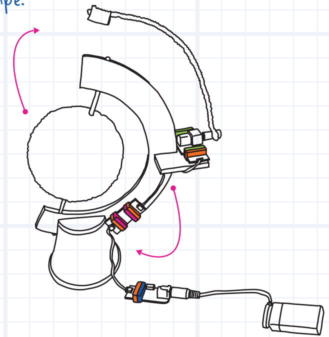
11 Tape the DC motor to the cardboard shelf.



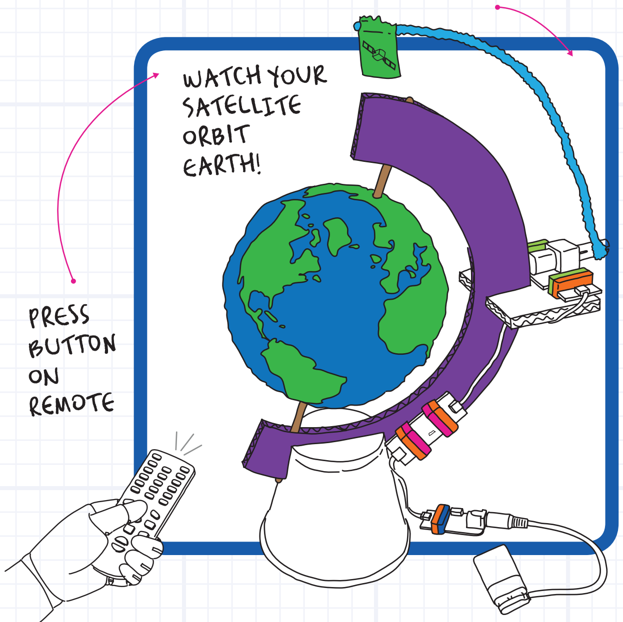
12 Add satellite to end of pipe cleaner.



13 Decorate your model.



For expanded activity, go to **littleBits.cc/orbit**

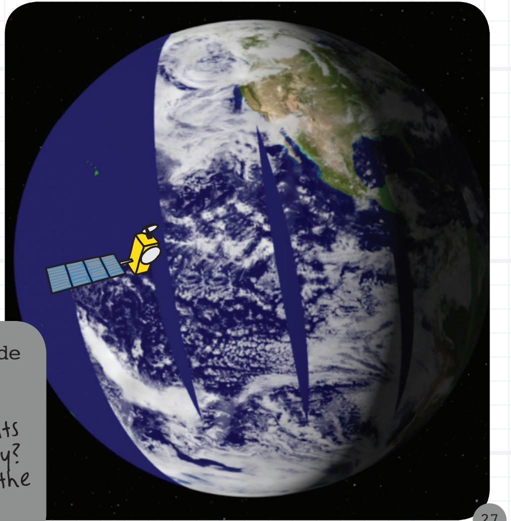


The AURA Satellite

NASA TODAY

Every day, NASA satellites (like AURA pictured to the left) collect global observations of the Earth. The image to the right shows the path of the Aqua satellite. Data is only collected when the satellite is on the sunlit side of the Earth because it measures reflected light from the Sun. With each orbit, the MODIS sensor onboard the satellite can observe a swath of data over 1400 miles (2253 km) wide and can image almost the entire Earth surface everyday.

A satellite at an altitude of 438 miles (705 km) orbits Earth once every 99 minutes. How many orbits does the satellite make in a day? How many times does it cross the equator in one day?

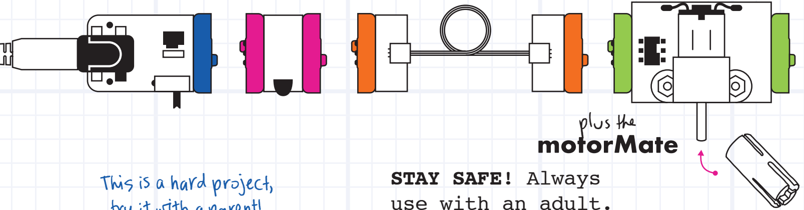


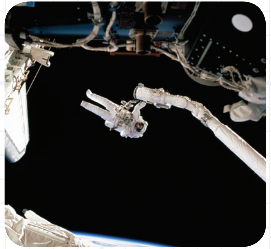
Images Courtesy NASA

PROJECT 9: Learn NASA engineering by building this robotic space arm.

GRAPPLER

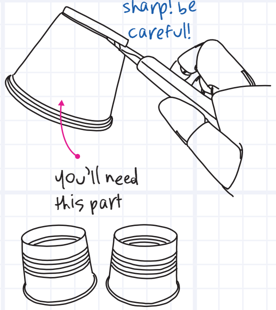
1 Start with this circuit.



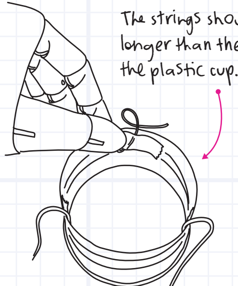


A **GRAPPLER** is on the end of the ISS Robot Arm and is used to grab onto objects in space — like astronauts!

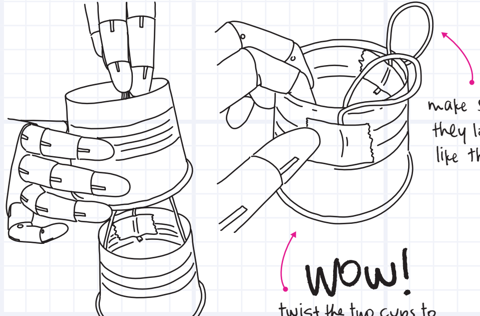
2 Cut the bottom off of 2 plastic cups.



3 Cut three pieces of string the same length. Tape them to the inside of one cup.



4 Place the other cup over the cup with strings. Feed the strings up through the top of both cups. Tape them to the outside of the outer cup.



This is a hard project, try it with a parent!

STAY SAFE! Always use with an adult.

TIME: 90 mins
DIFFICULTY: ●●●●○

YOU'LL NEED

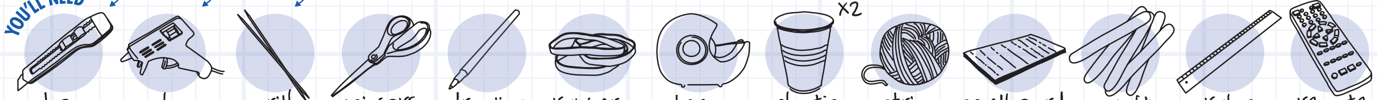
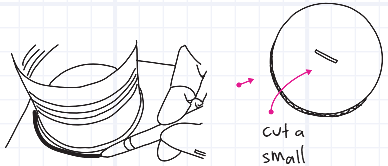
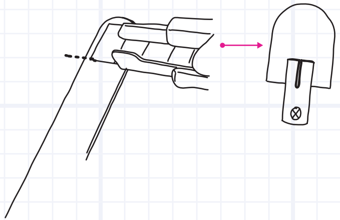


Image Courtesy NASA

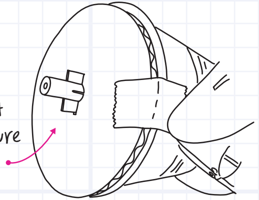
5 Trace wide end of cup on cardboard and cut out circle.



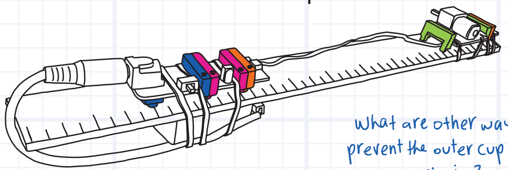
6 Cut the end off a craft stick and stick into motorMate.



7 Tape cardboard circle to inner cup and stick the craft stick in the hole.

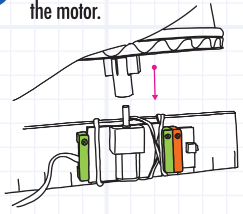


8 Put the circuit on a ruler and use rubberbands to hold in place.

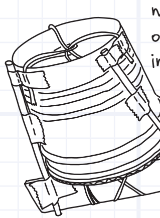


What are other ways to prevent the outer cup from spinning?

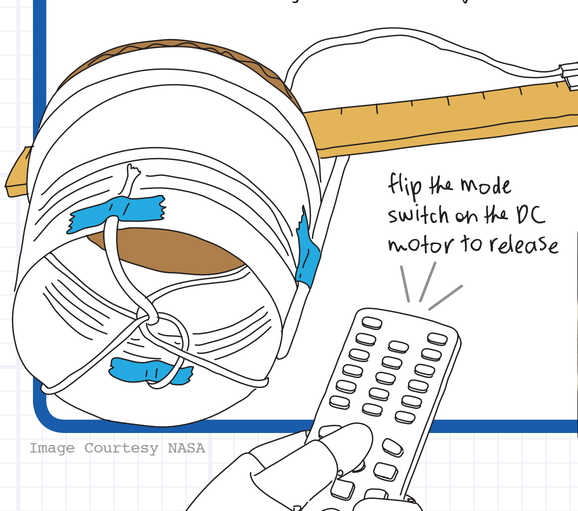
9 Place motorMate onto D-shaft of the motor.



10 Secure the outer cup to the ruler using wooden skewers and tape.



Use a household remote to control your grappler. This is similar to the arm that grabs onto moving vehicles in space!



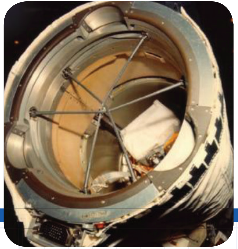
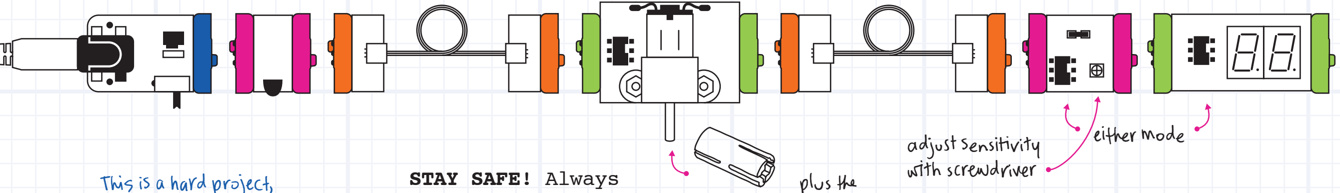


Image Courtesy NASA

PROJECT 10: Learn how NASA scientists are able to explore new worlds!

MARS ROVER

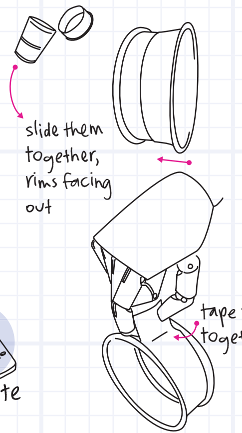
1 Make this circuit.



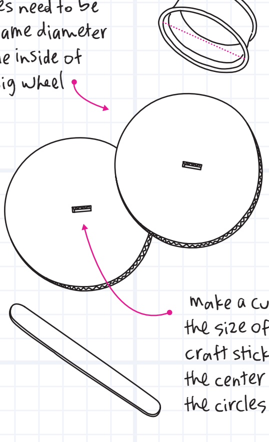
January 2004
Mars Exploration Rover "Opportunity" lands.

Image Courtesy NASA/JPL-Caltech

2 Make the big wheel.



3 Make 2 cardboard circles for the inside of the big wheel.

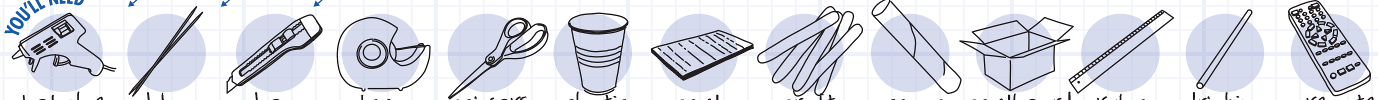


This is a hard project, try it with a parent!

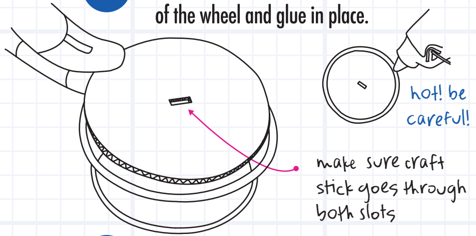
STAY SAFE! Always use with an adult.

TIME: 2 hrs
DIFFICULTY: ●●●●●

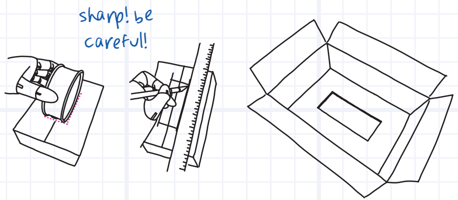
YOU'LL NEED



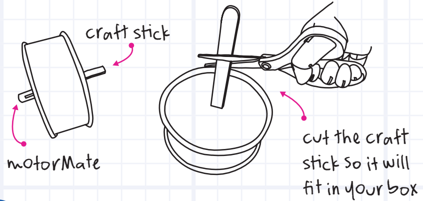
4 Place cardboard circles on both sides of the wheel and glue in place.



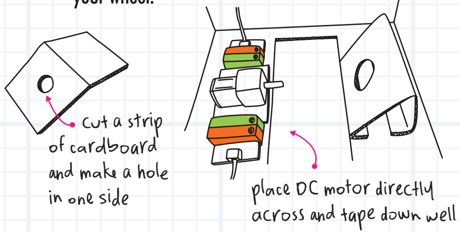
5 Cut a hole in the base of a box large enough to fit your wheel.



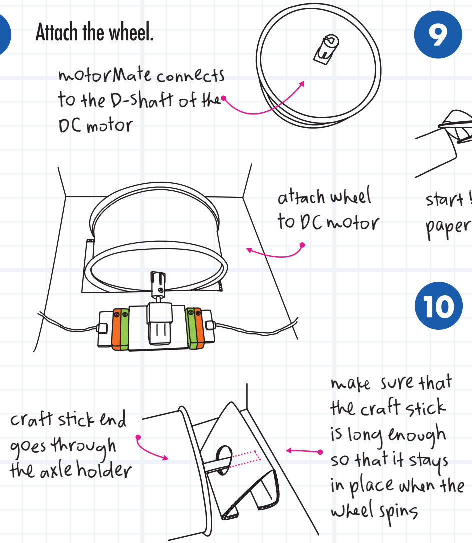
6 Put the craft stick through the slots and add the motorMate to one end of it.



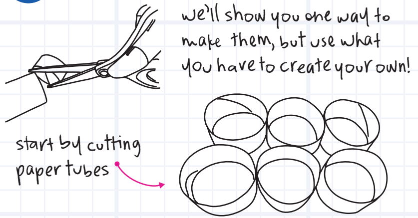
7 Make an axle holder for the craft stick on your wheel.



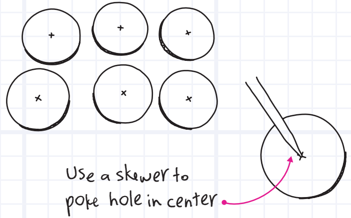
8 Attach the wheel.



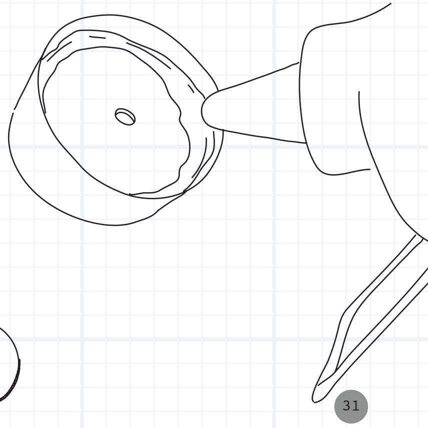
9 Make 6 wheels!



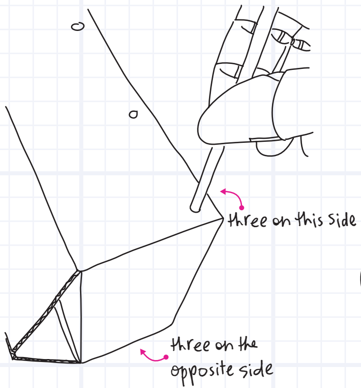
10 Cut six cardboard circles to fit inside the wheels.



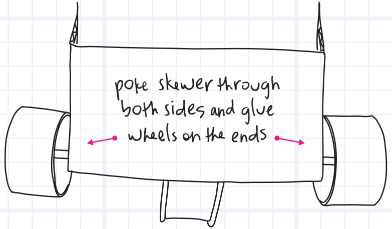
11 Place cardboard circle in paper tube and glue in place.

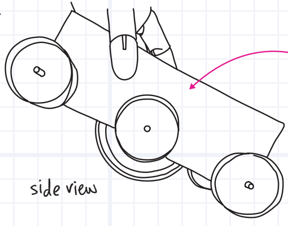


12 Make holes for axles.



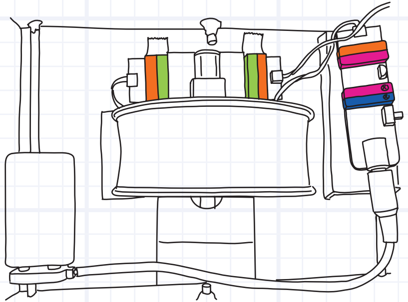
13 Put the wheels on.





special note!
Only the first and last wheel axles go all the way through, the middle wheels are just glued in with short axles and don't spin

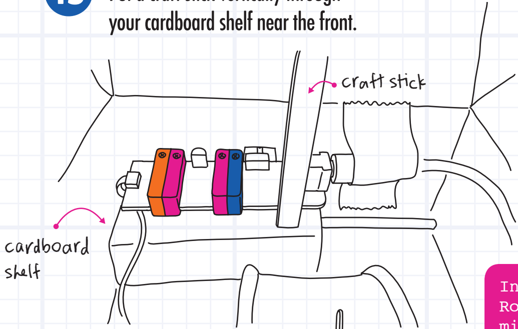
14 Arrange everything in the box.

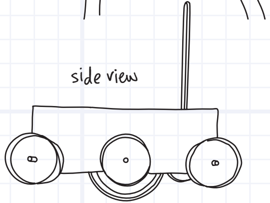


Tape everything down making sure that nothing interferes with the axles...

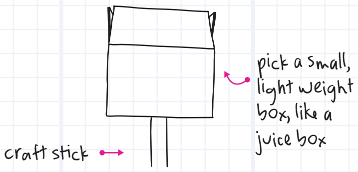
PRO TIP: you may need to build a cardboard shelf for your modules to sit on

15 Put a craft stick vertically through your cardboard shelf near the front.





16 Stick a small box on top of the craft stick and hot glue in place.



NASA TODAY

In **May 2013**, the Mars Exploration Rover "Opportunity" exceeded 22.22 miles (35.76 km) since its landing in January 2004. This breaks the record for the greatest distance driven by a NASA vehicle on a world other than Earth since the Lunar Roving Vehicle was driven 22.21 miles (35.74 km) on the moon, in December 1972.

17 Tape the light sensor and number modules to the front of the small box.

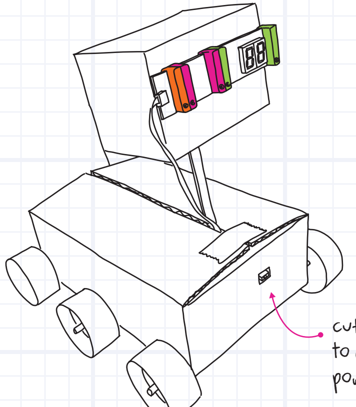
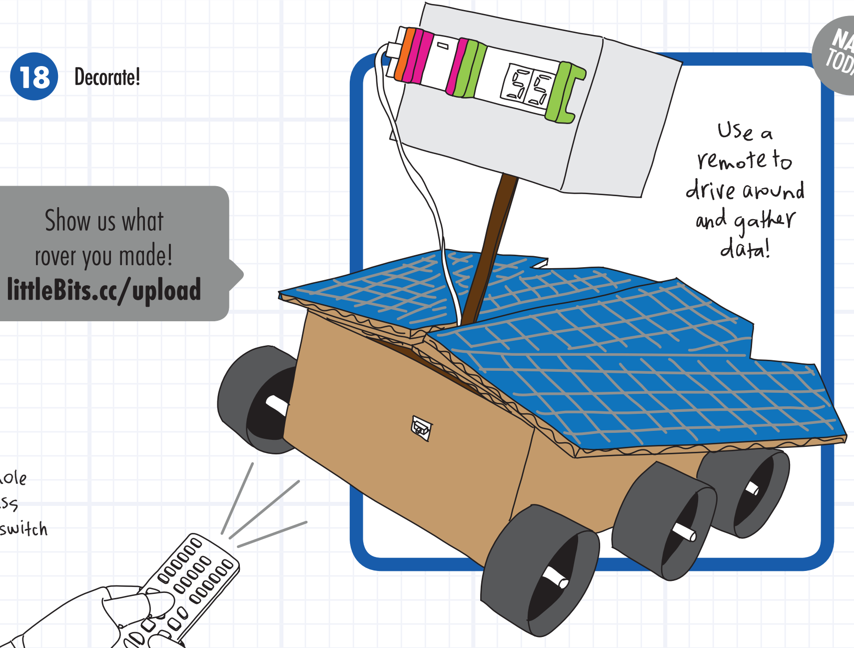


Image Courtesy NASA/JPL-Caltech

18 Decorate!

Show us what rover you made!
littleBits.cc/upload



NASA TODAY

NASA engineers send instructions to the rovers via radio communications. Depending on where the planets are in their orbits, a radio signal traveling at the speed of light will arrive on Mars between just over 3 minutes or as long as 20 minutes. Due to these time delays it is impossible to communicate with and control the rover in real time. To send instructions to rovers on Mars, NASA scientists must have a line-of-sight between Earth and Mars. Occasionally Earth and Mars are on opposite sides of the sun, called conjunction. During this time, the sun can disrupt or block radio communication between the two planets.

Martian landscape image taken by Opportunity

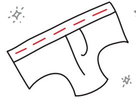
DID YOU KNOW?
The moon is actually egg shaped with the large end pointed towards Earth!

1ST MOONWALK WAS MADE BY AMERICAN ASTRONAUT
NEIL ARMSTRONG
DURING THE MISSION
APOLLO 11

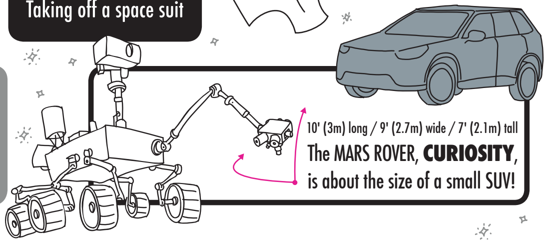
ON EARTH A SPACESUIT WEIGHS APPROXIMATELY 280 LBS (127 KG)

DONNING
Putting on a space suit

DOFFING
Taking off a space suit



DON'T LET THE NAME FOOL YOU
BLACK HOLES
are actually enormous amounts of matter packed into incredibly small spaces. WOW!



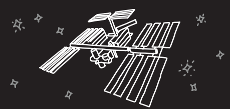
10' (3m) long / 9' (2.7m) wide / 7' (2.1m) tall
The MARS ROVER, **CURIOSITY**, is about the size of a small SUV!

SPUTNIK 1

THIS WAS THE FIRST SATELLITE LAUNCHED INTO SPACE. THIS WAS IN
1957

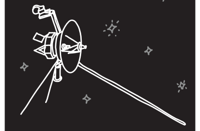
NASA'S Global Precipitation Measurement Satellite can see
INDIVIDUAL RAINDROPS
in a storm from
250 MI (402 KM) AWAY!

INTERNATIONAL SPACE STATION



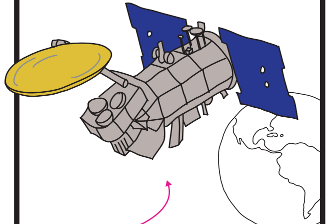
Since Expedition 1 launched on
OCTOBER 31, 2000
the station has been visited by
OVER 200 INDIVIDUALS

VOYAGER 1
WAS LAUNCHED IN 1977 AND IS NOW 11 BILLION MILES (17.7 BILLION KM) AWAY!



SEPTEMBER 12, 2013
NASA announced that Voyager 1 had entered **interstellar space**. It is the first manmade object to do so. It continues to travel away from us at 10.6mi/s (17km/s)

16 NASA SATELLITES
ORBIT EARTH
14 TIMES A DAY TO CREATE DAILY GLOBAL IMAGES OF OUR PLANET



5 MORE SATELLITES WILL LAUNCH BY EARLY **2015**

OCTOBER 11, 1984
THE 1ST U.S. WOMAN TO WALK IN SPACE WAS
KATHERINE SULLIVAN

ONE
MARS YEAR
EQUALS
23 EARTH MONTHS

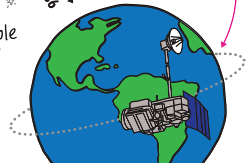
M&M™'s have been a staple since they were first on the space shuttle in 1981.

the Sun is 4.6 billion years old

PLASMA FROM THE SUN TRAVELS **11 BILLION MI** (18 BN KM) INTO SPACE TO THE EDGE OF THE **HELIOSPHERE**

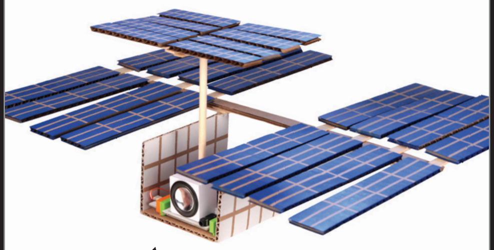
92.96 million mi (149.6 million km)

Landsat 5 holds the Guinness World Record for 'Longest-operating Earth observation satellite' 28 years and 10 months.




MAKE SOMETHING THAT DOES SOMETHING™

INTERNATIONAL SPACE STATION



learn how to play music on the ISS!

This booklet's over but the fun's not done.

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INTERNATIONAL SPACE STATION
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and
TONS MORE PROJECTS at
www.littleBits.cc/space

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