Electronics

Scribbling Machines

1

Activity Description:
Scribbling machines are motorized contraptions that move in unusual ways and leave a mark to trace their paths. They are made from simple materials and set in motion by a vibrating offset motor causing them to bounce, spin, bump and move in interesting ways.

Cutting

Cu

Scissors

Electronics

El

1.5-3.0 Volt Motor
AA Battery

1

Arts & Crafts

Ar

Craft Paper
Popsicle Sticks
Pipe Cleaners

Brainstorm

Br

Markers

Other Materials

Popsicle sticks, wood skewer sticks, pipe cleaners, wire, nuts, washers, wire strippers, screwdriver, googly eyes

Joining

Jo

Masking Tape

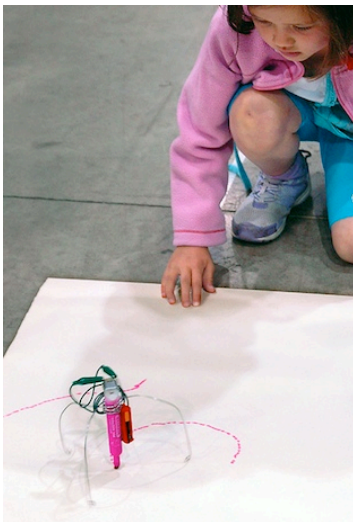
Joining

Jo

Glue
Glue Sticks

SCRIBBLE MACHINE

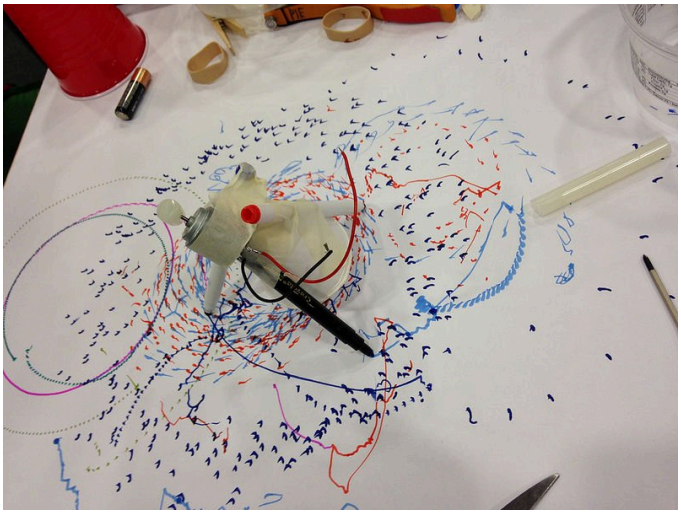
A **Scribbling Machine** is a motorized contraption that moves in unusual ways and leaves a mark to trace its path. It's made from simple materials and demonstrates the erratic motion created by an offset motor.



Step 1: Materials

Collect these things:
1.5-3.0 volt motor
AA battery
A piece of hot melt glue stick
Broccoli band (thick rubber bands used for produce)
Markers
Recyclable container such as a strawberry basket or yogurt cup
Masking tape
Paper for testing
Some other helpful materials:
Clothespins; Popsicle sticks; wood skewer sticks; pipe cleaners; wire; nuts, washers, or other small weights; wire stripper; scissors; small screwdriver; googly eyes.

Step 2: Build Your Contraption



Getting Started:
Connect the motor to the battery—a broccoli band is perfect for keeping the leads attached to the motor and still be able to disconnect them when you want to change the motor's position (masking tape can work too if you don't have a broccoli band).

Experiment with ways to offset the motor: try a piece of hot melt glue stick, wood, or clay.

Note: an *offset* weight means it is not centered on the axle of the motor. Notice how the weights in the photos stick out more on one side than the other? You can experiment with how much off-center you place the weight and see what different results you get.
What happens if you change the weight of the offset motor? Or change the length of the arm on the motor? Or change the orientation of the hot melt glue stick?

Find or build a base and attach your offset motor to it (try a strawberry basket, yogurt container, or other recyclable container).

TIP: Make sure there is enough clearance for your offset motor to spin.
Attach one or more markers to trace the jittering movement of your scribbling machine.

Turn it on and make some scribbles!

Experiment with different designs
How could you make it go really slow and smooth? Fast and jumpy? Make big and small circles? Try using a wire or pipe cleaner to hang a marker away from the body.

Step 3: Take It Further

Here are some ideas to keep playing with Scribbling Machines!

Trace-making materials: Experiment with using different materials such as paint and paintbrushes, chalk, or pencils to trace the patterns your scribbling machine makes. With chalk you can even scribble on the sidewalk!

Natural materials: Collect items like sticks, leaves, bark, and pods from a park or your backyard. Add them to your machine and set it scribbling outside to see how the natural materials leave different pathways in sand or dirt.

Incorporating switches: Experiment with making a switch to make it easer to turn your scribbling machine on and off. Try using a combination of clothespins, tinfoil, paperclips, brads, craft foam, or other materials.

Paper Circuits

2

Activity Description:
A paper circuit is a low-voltage electronic circuit that is created on paper or cardboard using conductive copper tape, LEDs and a power source such as a coin-cell battery. Creating paper circuits is a good way to teach the basics of electricity and how circuits function.

In addition to being educational, they can also be a fun makerspace project that helps to bring artwork and paper craft to life. By adding sensors, buzzers and motors to your circuit, you can also add another dimension of interactivity.

Cutting

Cu

Scissors

Electronics

El

Coin Cell Battery 3V
Copper Tape 1/4”
LED
DC Motor

2

Arts & Crafts

Ar

Craft Paper

Fixturing

Fx

Paper Clip
Binder Clip
Brass Brads

Other Materials
Ruler, tweezers, wire snippers,paper scoring tool, cutting mat

Joining

Jo

Clear Tape

creativity lab

Lighthouse Community Public Schools

in collaboration with

Maker Ed

MakerPromise

PAPER CIRCUITS

A Guide from the Creativity Lab

Authors
David Perlis
Claire TIffany-Appleton

Contributor
Anna Milada Grossi

Based on
An activity from the Tinkering Studio

Lighthouse Community Public Schools
444 Hegenberger Road
Oakland, CA 94621

www.lighthousecreativitylab.org

www.makered.org

About This Project

Paper circuits are quick projects that engage students in basic circuitry. Using simple materials, students will construct working circuits and think critically about the flow of electricity. After acquiring a basic comprehension, students will strengthen their understanding of circuitry by integrating circuitry into personal art projects.

Paper circuits are a low-barrier, high-ceiling project. What begins as a basic introduction to circuitry is easily expanded upon to include more complexity. This project is designed to give students ownership of their learning by offering minimal instruction. Students learn through the iterative process of designing, testing, and redesigning. This is a crucial element of this project and should not be viewed as supplemental. We encourage you to customize this project to the needs of your class, but maintain the ideal of students learning through exploring.

This project guide provides helpful tips and processes on the introduction of circuit blocks in the classroom, including an inquiry cycle as well as a step by step guide. Educators can chose to extend this project through art and more complex circuits, or create a community project with a paper circuit mural.

Our Story

This activity can be tailored to different ages, and can be used with teachers as well as students.

At Lighthouse, we've done this activity in anywhere from middle school making classes to professional development sessions. At Lodestar, we've started introducing paper circuits in our makerspace time, which includes students anywhere from Kindergarten to 3rd grade, and we've lead more structured projects with middle school students.

Materials & Tools

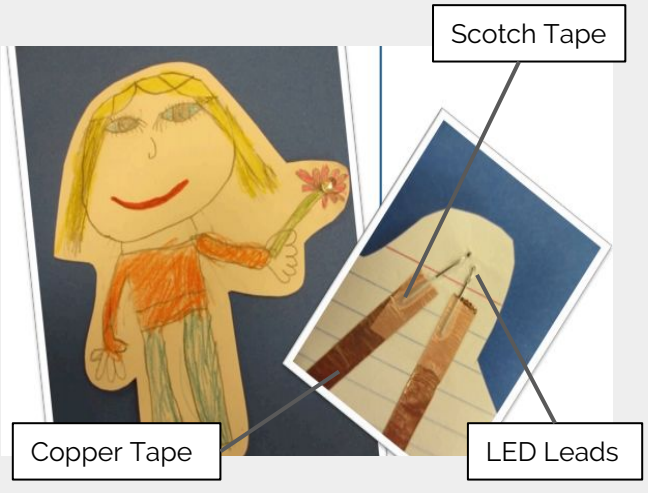
- Scotch Tape
- Paper / Construction Paper
- Binder Clips
- Aluminum Foil
- Copper Tape
- 3 to 5 mm LEDs
- 3V coin cell batteries
- Scissors
- Markers
- Assorted Batteries (Optional)
- Hobby Motors (Optional)

For a detailed list of materials:
lcl.how/PaperCircuitParts

Learning Targets

- I can construct a working circuit.
- I can describe the flow of electricity.
- I can record observations.
- I can differentiate conductive and nonconductive materials.
- I can draw a circuit schematic.
- I can explain and identify short circuits.
- I can learn all **bolded keywords**.

TIME: 50 minutes



Context: Before we make...

Paper circuits are a great introduction to circuitry. Students learn basic conventions, such as positive and negative leads / terminals, along with keywords, like LEDs (Light Emitting Diode), closed circuits, open circuits, short circuits, etc. This project is also a way to bridge science with art - once students master the circuitry basics, they can integrate light into their own pieces of art.

For inspiration and further resources, check out the links below!

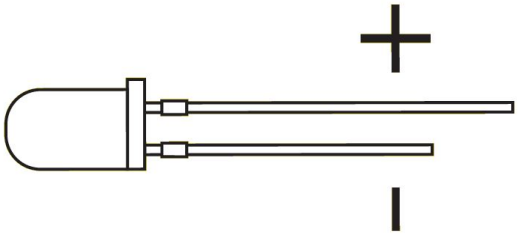
Leah Buecheley

The Tinkering Studio

Jie Qi

Material Management

When introducing paper circuits, it's helpful to limit materials to just LEDs and batteries. Students can then investigate these two pieces, and determine how to make the LED light up. This is a good time to discuss the conventions of positive and negative, and how to tell which side of the battery / leg of the LED is positive (the positive side of the battery is labeled with a "+", and the positive leg of the LED is longer).



After students have become familiar with LEDs and batteries, they can move on to creating circuits, which requires copper tape. When distributing the copper tape, it's often easier to have pre-cut pieces on the table, so the entire roll of tape isn't destroyed.

For LED storage, look for small plastic containers with screw-on lids. On the outside of the container, it's helpful to put colored tape or paper corresponding to the color of the LED.

Finally, when distributing the copper tape, pre-cut strips so the whole roll isn't undone by excited students.

Looking Closely

EXPLORE

Pass the materials out to students. As a class, identify the **battery** and the **LED**. Ask students to spend three minutes exploring their materials. Have them write observations in a journal. Come back together as a class to talk about their discoveries. Students should have discovered:

- The LED has two "legs." These are called **leads**.
- One lead is longer than the other. This is the **positive lead**. The shorter is the **negative lead**.
- The battery has two faces. These are called **terminals**.
- One terminal is (usually) marked with a "+". This is the **positive terminal**. The other is the **negative terminal**.

Supplement: Batteries come in all shapes and sizes, but they all have positive and negative terminals. Give students a variety of batteries, and challenge them to find the positive and negative terminals on each kind.

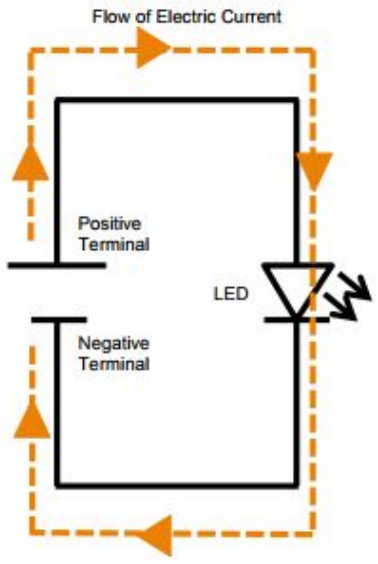
Were any students able to make their LEDs light up? If so, ask how they did so. If not, challenge them to spend another two minutes trying to. There is exactly one way to illuminate their LEDs: by connecting the LED's positive lead to the battery's positive terminal, and the negative lead to the negative terminal.

CONSIDER

Ask students if they have ideas as to what causes their LEDs to light up. Depending on the age group, they may or may not have heard of electricity. We use the term **electric current.** Just like a river current flows downstream, electric current flows from a battery's positive terminal to its negative terminal, provided there is a complete path for it to follow.

Challenge students to identify how the electric current could be flowing from their battery's positive terminal to its negative terminal. The current is able to flow from the battery's positive terminal through the LED and into the negative terminal. Current flowing through the LED makes it shine. They have completed a circuit. A complete circuit is called a **closed circuit**. An incomplete circuit is an **open circuit**.

Supplement: Give students a hobby motor. What happens when they connect each lead (wire) to a battery's different terminals? No matter how the motor's leads are connected, the motor will still turn on. Why isn't this true for the LED? It is because LED stands for "**Light Emitting Diode**," and a **diode** is a special component that only lets current flow one direction.



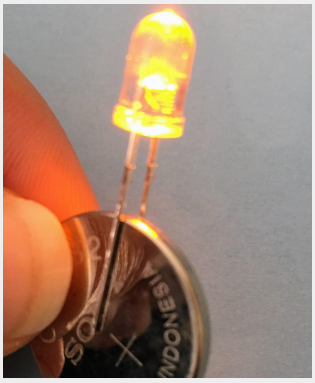
EXTEND

Have students move on to create their own circuits with LEDs, batteries, and copper tape / aluminum foil! Give students copper tape, and suggest they use it to create the bridge between their batteries and LEDs. Demonstrate how the back of the copper tape can be removed and how the tape can be stuck directly to the paper. Then give the students ten minutes to explore on their own or in small groups.

At this stage, consider giving students a wide variety of materials, such as scotch tape, popsicle sticks, paper clips, rubber bands, copper wire, aluminum foil, etc. Have students try completing their circuits using the different materials. Which work, and which don't? What patterns do students notice? For example, most metals allow current to flow through them. They are **conductive**.

Step-By-Step Guide

1. Get a coin cell battery and LED; determine the positive and negative ends
2. Sketch your circuit out on paper
    a. Note where the positive and negative ends of the battery and LED will go
    b. For younger students (or if your class period is short), it might be helpful to print out a circuit template that shows where the copper tape, battery, and LED will go
3. Add copper tape (or aluminum foil) to the track
    a. Leave a break for the LED and overhanging copper tape or foil for the top of the battery
4. Use clear tape to attach the leads of the LED over the copper tape
5. Repair any breaks in the circuit and watch it shine!



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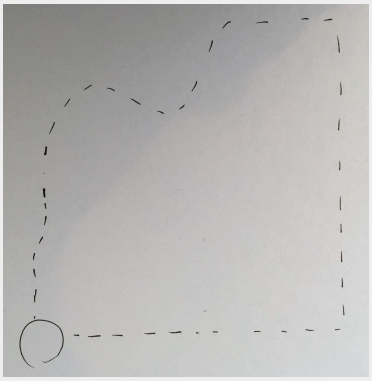

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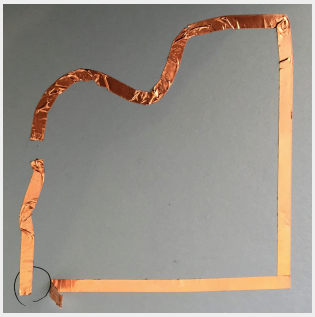
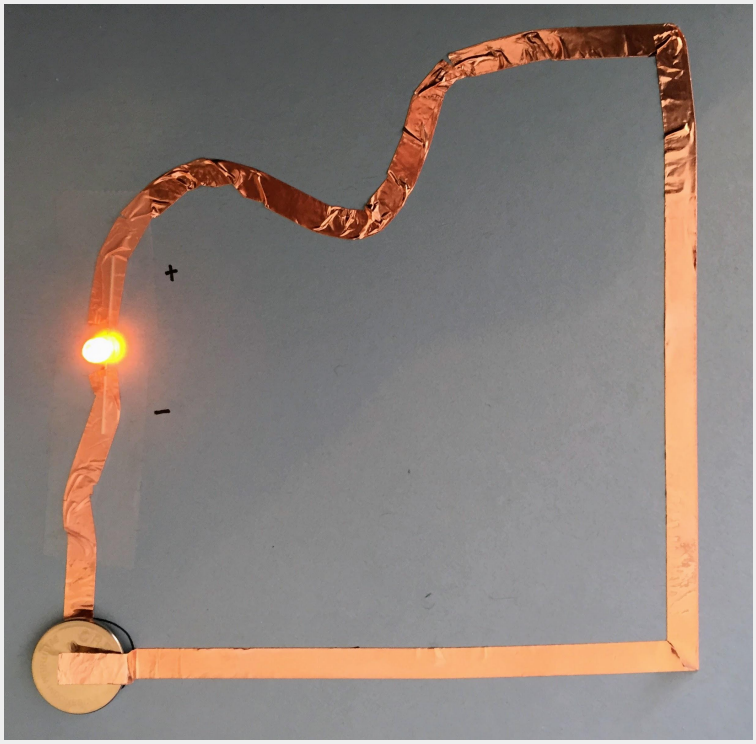


3.

4.

Troubleshooting

- Sometimes a faulty circuit occurs simply because of a dead battery or LED. Testing them against each other before spending time constructing an entire circuit is a good habit to get into.
- The back of the copper tape is not conductive because of the adhesive backing. To overcome this:
    - To form a corner, gradually and carefully bend the copper tape.
    - Use aluminum foil to create a patch for any tears in the circuit.
    - Fold the end of the copper tape so that its sticky side connects to itself. This creates a tip that is conductive on both sides.
- **Short circuits** occur when electric current takes a shortcut without passing through the LED. If the circuit looks closed, but the LED is not shining, have students search for any spots where the current might be able to bypass the LED. The current will always take the path of least resistance (not distance); going through the LED is harder than going through the copper tape. If you notice students creating short circuits, pause the class to discuss them together.

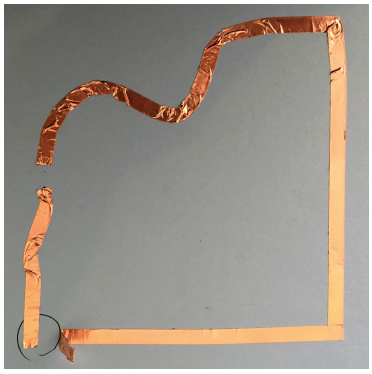


5.

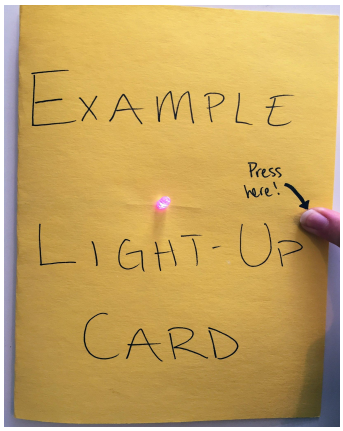
Paper Circuit Extensions

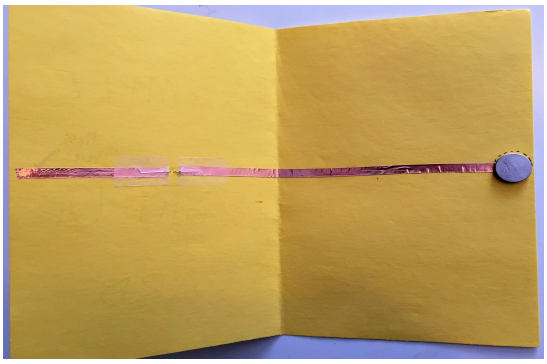
ADD ART!

Students can create a drawing or painting accented with an LED. Poke an LED through the front of the paper so the leads are on the back and the lens is on the front. Complete the circuit on the back of the paper (out of sight).



PAPER CIRCUIT CARDS





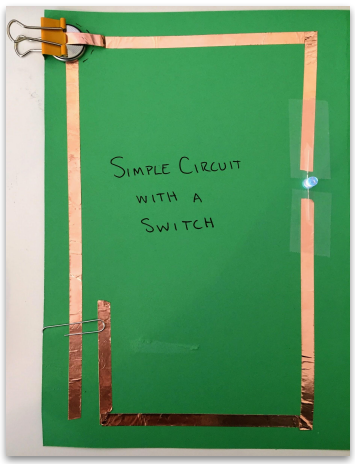
Another extension for students are paper circuit cards! These have an LED on the front of the card and a circuit on the inside. In this project, the LED lights up when an area on the front of the card is pressed, which connects the copper tape and completes the circuit. Students can design the card first or create the circuit first.

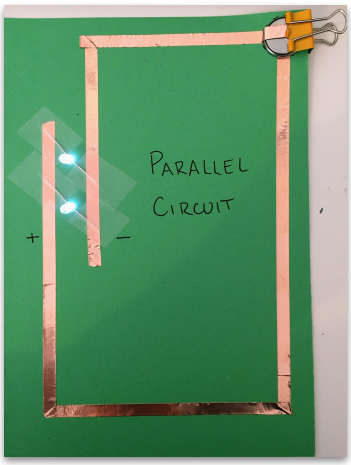
This is a good project to do in conjunction with holidays!

COMPLEX PAPER CIRCUITS

Students can also add complexity to their circuits, like a switch or a **parallel circuit**. To make a switch, leave a gap in the copper tape and connect it with anything conductive, like a paperclip. To add multiple lights, students should create parallel circuits, which are closed circuits where the electric current divides into two or more paths before recombining to complete the circuit.

Classes can spend more time discussing different types of circuits and how to replicate them with LEDs and copper tape.





Paper Circuit Extensions cont.

PAPER CIRCUIT MURALS

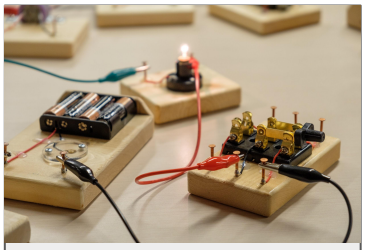
1. CREATE THE BOARD To form a mural board, use copper tape to make two parallel "tracks" on the foam board (differentiate them by putting colored duct tape under one track). The tracks should never touch, and each track must have a distinct start and end point. Attach a AA battery pack to the board with velcro. Use scotch tape (or solder) to connect one wire on each track. This creates a large parallel circuit.

2. CREATE THE ORNAMENTS Next, make ornaments from construction paper, cardstock, or foam (whatever is inspiring). When you have your ornament, poke an LED through the front so the leads are on the back. Put copper tape underneath the leads to extend them, then attach the leads on top of the copper tape with clear tape.

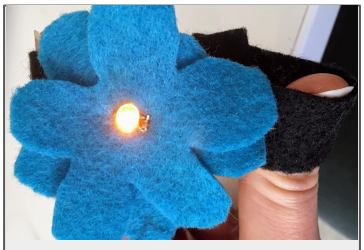
3. COMPLETE THE MURAL Use thumbtacks to secure ornaments to the foam board (it's best to place the tacks over the leads of the LED to ensure a good connection with the copper tape). The positive lead of the LED must connect to the board's positive track; same with the negative. When it's connected, watch your ornament shine!

This activity can be great for an intro to circuits, or as a team building exercise where participants must figure out how to add an ornament to the board.

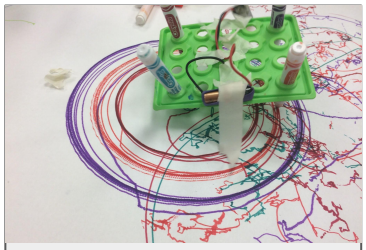
Related Extension Projects



Circuit Blocks



Sewn Circuits



Scribble Machines

Paper Circuit Mural 3

Activity Description:
A paper circuit mural is a group project that builds upon the circuitry concepts that students learn with basic paper circuits. We recommend beginning with our complete paper circuit project guide, before proceeding with this one.

3

Cutting

Cu

Scissors

Electronics

El

AA Battery Holder
AA Batteries
Copper Tape
LEDs 3mm

Arts & Crafts

Ar

Craft Paper
Assorted Color Paper

Fixturing

Fx

Paper Clip

Joining

Jo

Clear Tape
Colored Tape

Brainstorm

Br

Markers

Other Materials
Foam Board,
Thumb Tacks, Velcro

creativitylab

LIGHTHOUSE COMMUNITY CHARTER SCHOOL

Paper Circuit Mural

1st–12th Grade

1 Hour (+ 1 Hour Preparation)

MATERIALS

- Foam Board
- Thumb Tacks
- AA Battery Holder
- AA Batteries
- Copper Tape
- Colored Tape
- Scotch Tape
- Velcro
- LEDs (3mm or 5mm)
- Assorted Color Paper
- Markers

A paper circuit mural is a group project that builds upon the circuitry concepts that students learn with basic paper circuits. We recommend beginning with our complete paper circuit project guide, before proceeding with this one.

E-mail us at creativitylab@lighthousecharter.org

1. Build A Base

Use copper tape to make two roughly parallel "tracks" on the foam board. The tracks should never touch, and each track must have a distinct start and end point, i.e. a track that is a continuous loop will not work. Being able to distinguish the two tracks is also helpful. To do this, we've put a layer of red duct tape beneath one of our tracks. Using different widths of copper tape for each track is another option.

Velcro the battery holder to the board. Use scotch tape to fasten one wire to each track. (You can also solder them.)

2. Make Ornaments

Each student makes a personal ornament from construction paper. Poke an LED through the ornament, so the bulb is at the front, and the leads at the back. Use copper tape to extend the length of the leads.

3. Complete The Mural

Use thumbtacks to secure each ornament to the foam board. The positive lead of the LED must connect to the board's positive track, and the negative lead to the negative track. When a firm connection is made, the LED will shine.

Penny Batteries

4

Activity Description:
Using two different metals and some sour, salty water, we can create a cheap battery strong enough to power an LED. (Khan Academy)

4

Cutting

Cu

Scissors

Electronics

El

LED
Electrical Tape

Recycle

Rc

5+ Pennies
Thick Cardboard

Measuring

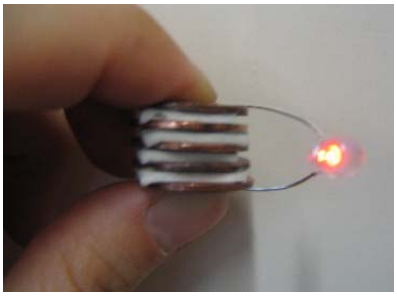
Ms

Cups

Other Materials

100 grit sandpaper, salt, vinegar

Penny Battery

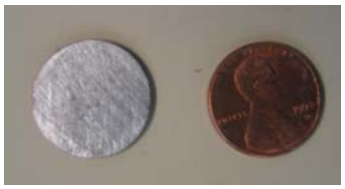


Light an LED with five cents

Use two different metals and some sour, salty water to create a cheap battery.

Materials
5 or more post-1982 pennies
100 grit sandpaper
matboard or thick cardboard
scissors
water
salt
vinegar
red LED; high-intensity ones are easier to see (Radio Shack #276-309 and 276-307 or MUCH cheaper online at Jameco #1555489)
(optional) electrical tape, voltmeter

To do and notice



1. Use sandpaper to sand the copper off of one side of four of the pennies. Leave the fifth penny intact. Sand until you see zinc (shiny silver color) covering the entire face of the coin. This takes some effort. Try placing the sandpaper on a hard surface and moving the penny. The "tails" side may be easier to sand than the "heads" since the Lincoln Memorial does not protrude as far as Lincoln's head. The sanded coins should now have a bronze-colored copper side and a silver-colored zinc side.

2. Make a saturated salt solution by adding salt into water until it doesn't dissolve anymore. Add a splash of vinegar to this solution.

3. Cut the matboard into four ½" squares. Soak the pieces in the saltwater solution.

4. Lay out the pennies with the zinc side facing up and place a damp piece of matboard on each one.

5. Stack the penny-matboard pieces on top of each other to make a tall pile. The pile should have alternating layers of penny-matboard-penny-matboard, etc., with the zinc sides all facing up. Make sure that the pennies aren't directly touching each other and, likewise, that the pieces of matboard aren't touching each other.

6. Place the intact penny on the top layer of matboard.

7. Connect the LED by touching the longer lead to the intact penny and the shorter lead to the bottom of the stack. Make sure that the leads don't touch any other layer. Did the LED turn on? If not, try adding an additional sanded-penny/soaked-matboard layer to the bottom.

Things to troubleshoot: make sure that the individual layers are separate (ie. no coins touching, no matboards touching); check for drips – a stream of saltwater can cause a short in the battery; check that the LED is in the correct orientation.

8. (Optional) Check the voltage of the battery with a voltmeter. To keep your LED lit, wrap the entire assembly together with electrical tape. The LED will grow fainter as the matboards dry out, but should stay lit over 24 hours! To recharge, just re-soak the matboards and reassemble.

What's going on?

Batteries are devices that convert chemical energy into electrical energy. When two different metals are connected by an electrolyte, a chemical reaction occurs at each metal surface, called **electrodes**, that either produces or uses electrons. When these electrodes are connected by a wire, electrons will move from one surface to the other, creating an electric current. Pennies that were made after 1982 have zinc cores that are plated with copper. By sanding off one face of a penny, you create a zinc electrode that can pair with the copper electrode on the face of the next penny. The matboard soaked in salty vinegar water serves as the electrolyte between the two terminals. Each zinc-matboard-copper stack represents one individual cell. By stacking additional matboards and sanded pennies, you've created a **battery**, which is a series of electrochemical cells. This is also called a voltaic pile, which is named after Alessandro Volta, who created the first battery in 1800 by alternating zinc and copper electrodes with sulfuric acid between them. In Volta's battery and your penny battery, an oxidation reaction occurs at the zinc electrode that produces electrons and a reduction reaction occurs at the copper electrode that consumes them.

If you have a voltmeter, you can see that each cell can generate over 0.6 V. A stack of 3 cells should actually be enough to generate the voltage to needed to light a red LED, which usually require around 1.7 V. LEDs that emit other colors require a higher voltage; so try stacking additional cells to light a green or blue LED.

Legal Disclaimer: Before 1982, pennies were made of 95% copper, but the rising costs of copper led the United States Mint to change the composition of the penny. The metal content in a pre-1982 penny is actually worth more than its one-cent face value. Consequently, in December 2006, the United States Mint implemented regulations that prohibit the melting or treatment of all one-cent coins. The Exploratorium does not take responsibility for any damaged coinage, and certainly don't try to sell your battery for more than 5¢!

References

Chemical Demonstrations: A Handbook for Teachers of Chemistry Vol. 4 by Bassam Z. Shakhashiri (1992)

US Mint: http://www.usmint.gov

Bristlebots

5

Activity Description:
A bristlebot or brushbot is an extremely simple form of walking robot. It is one of the simplest of all mobile robots, both in its function and its construction. (Wikipedia)

Cutting

Cu

Scissors

Electronics

El

1.5-3.0 Volt Motor
LR44 Button Cell Battery

5

Arts & Crafts

Ar

Googly Eyes
Pipe Cleaners

Joining

Jo

Masking Tape
Double Sided Tape

Other Materials
Toothbrush

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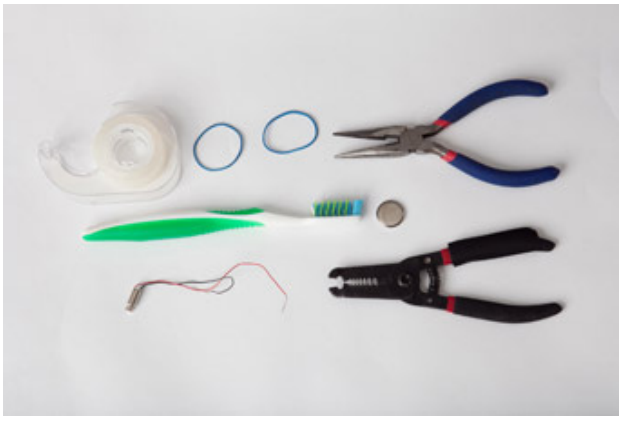
Bristle Bot

1

Here's what you need to build your own Bristle Bot!

- 1 pager motor with two wires (1-volt to 3-volt motor) No pager motor? Buy one at an electronics store or remove one from a broken electronic device that buzzes or vibrates (e.g., cell phone, electric toothbrush, pager, etc.).
- 1 button cell battery (1 volt to 3 volt, to match the pager motor)
- 1 toothbrush with bristles set at an angle. No toothbrush with angled bristles? Put a book on top of a head with straight bristles. After a few minutes, the bristles will stay angled back.
- Pliers/wire cutter

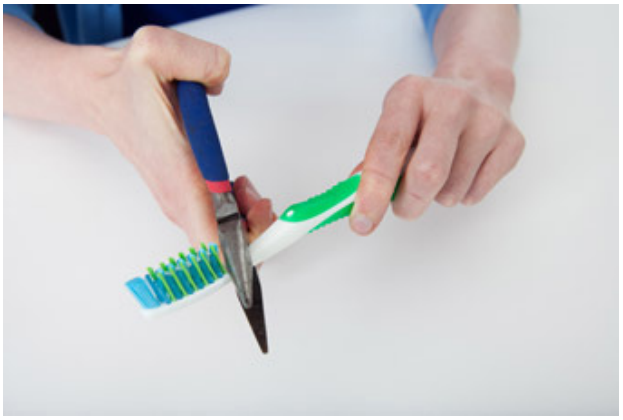


- Attachment materials (e.g., rubber band, twist-tie, zip-tie, tape, or double-stick foam tape)
- Wire stripper (optional)

2

Cut off the toothbrush head

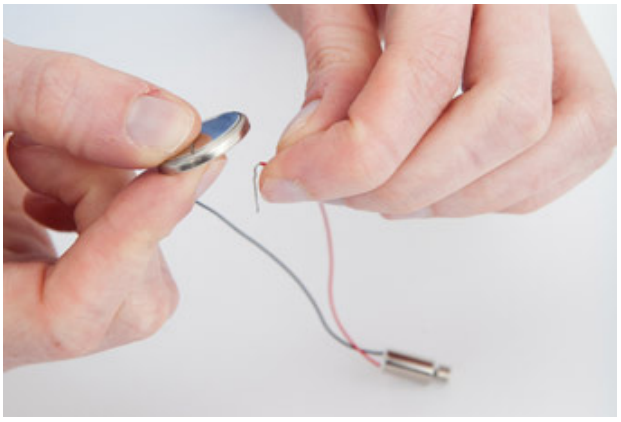
- Snip off the head, using pliers or wire cutters.
- Cut the handle close to the bristles.



3

Test the battery and motor

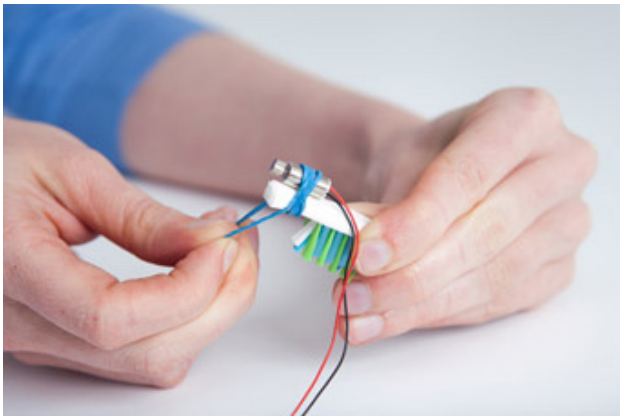
- Strip the end of the pager motor's wires so about half an inch of the metal wire shows.
- Touch one wire to the top of the battery and the other wire to the bottom.
- The motor should spin vigorously.



4

Attach the motor

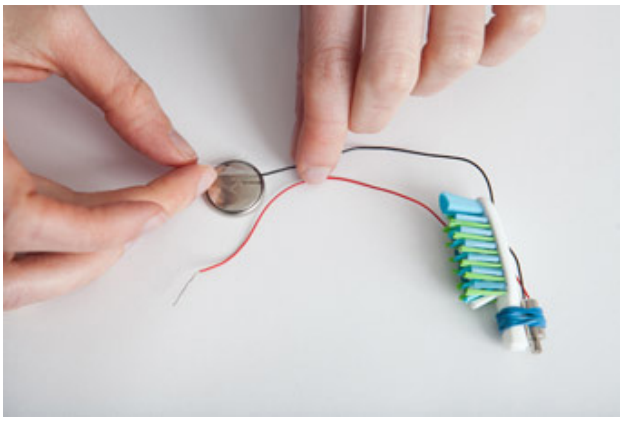
- Fasten the motor firmly to the top of the toothbrush head.
- Use a rubber band, twist-tie, zip-tie, or piece of tape or double-stick foam tape.
- Make sure the weight can spin without hitting the toothbrush.



5

Connect one wire

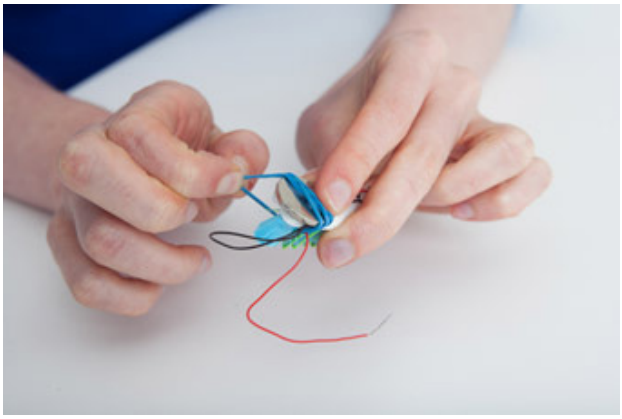
Tape one of the motor's wires to one side of the battery.



6

Attach the battery

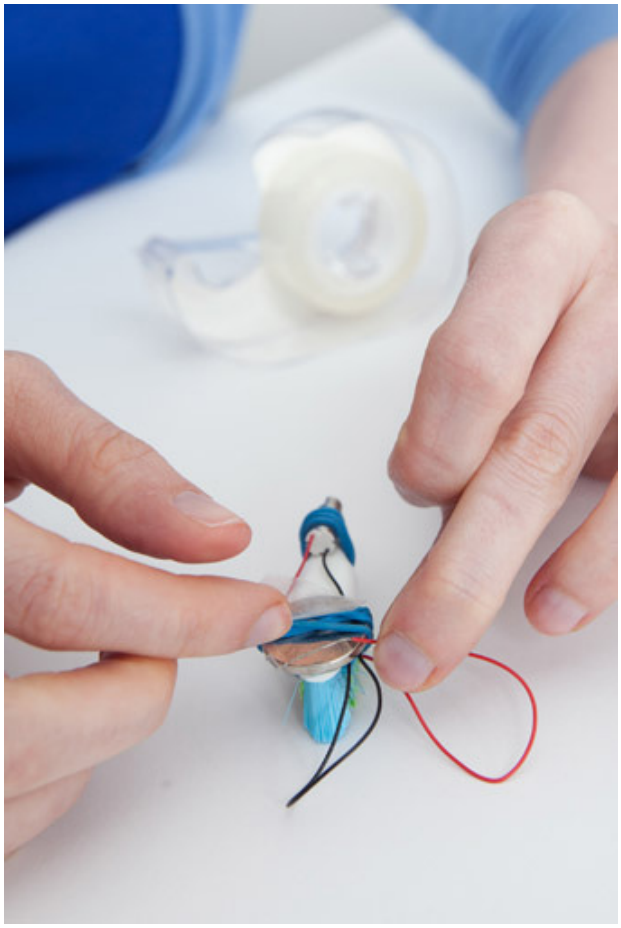
- Fasten the battery firmly to the top of the toothbrush, so the wire is on the bottom.
- Use a rubber band, twist-tie, zip-tie, or piece of tape or double-stick foam tape.



7

Connect the second wire

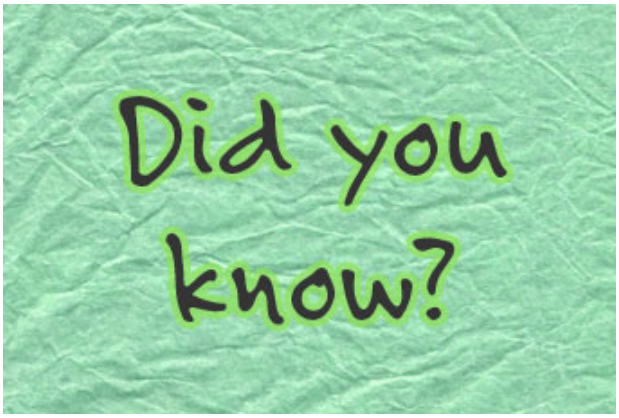
- Connect the second wire so it stays in contact with the top side of the battery.
- Not moving? Make sure the bristles are angled. The Bot moves in the direction that the bristles lean.
- Spinning or not going straight? Shift the weight. The position of the motor and battery affects how the bristles touch the surface. Move the battery and motor to put weight evenly on all the bristles.



8

Did you know?

A Bristle Bot is a lot like a Pogo Stick. For example, you bounce up and down on a Pogo Stick. The pager motor does the same thing with the toothbrush head—it bounces it up and down. To move forward on a Pogo Stick, you tilt it forward while bouncing. Similarly the Bot's bristles all tilt. Because the pager motor bounces the Bot up and down on the tilted bristles, the Bot scoots forward.



Try this next!

- **Bot bowling.** Set up a bunch of small objects for your Bot to knock over. Let your Bot loose. How many did it hit?
- **Super-size it.** Make a giant Bristle Bot out of a big brush (e.g., a scrub brush, shoe-polish brush, or hair-brush). Attach an electric toothbrush to the brush. Or attach a 3-volt hobby motor (from an electronics store). To make the motor vibrate, add a strip of duct tape to the metal shaft sticking out of the motor. Or tape a small bead to the shaft. When the shaft spins, the off-center weight of the tape or bead will bounce the motor (and the brush), moving it forward.

MAJOR FUNDING NSF PROJECT FUNDING NORTHROP GRUMMAN Foundation S. D. BECHTEL, JR. FOUNDATION STEPHEN BECHTEL FUND ADDITIONAL FUNDING

Superhero Masks

6

Activity Description:
What would your Superhero mask look like? What super-hero powers do you have? Design a mask that reflects these talents by decorating a mask with fun craft materials. Light it up using copper tape, pipe cleaners, a LED light, and a 3V ion lithium battery.

Cutting

Cu

Scissors
Hole Punchers

Electronics

El

1.5-3.0 Volt Motor
LED Lights
Copper Tape

6

Arts & Crafts

Ar

Craft Paper
Popsicle Sticks
Pipe Cleaners

Brainstorm

Br

Markers
Pencils

Other Materials
Pliers, Paper Plate

Joining

Jo

Masking Tape

Fixturing

Fx

Staplers

SUPERHERO LIGHT UP MASKS

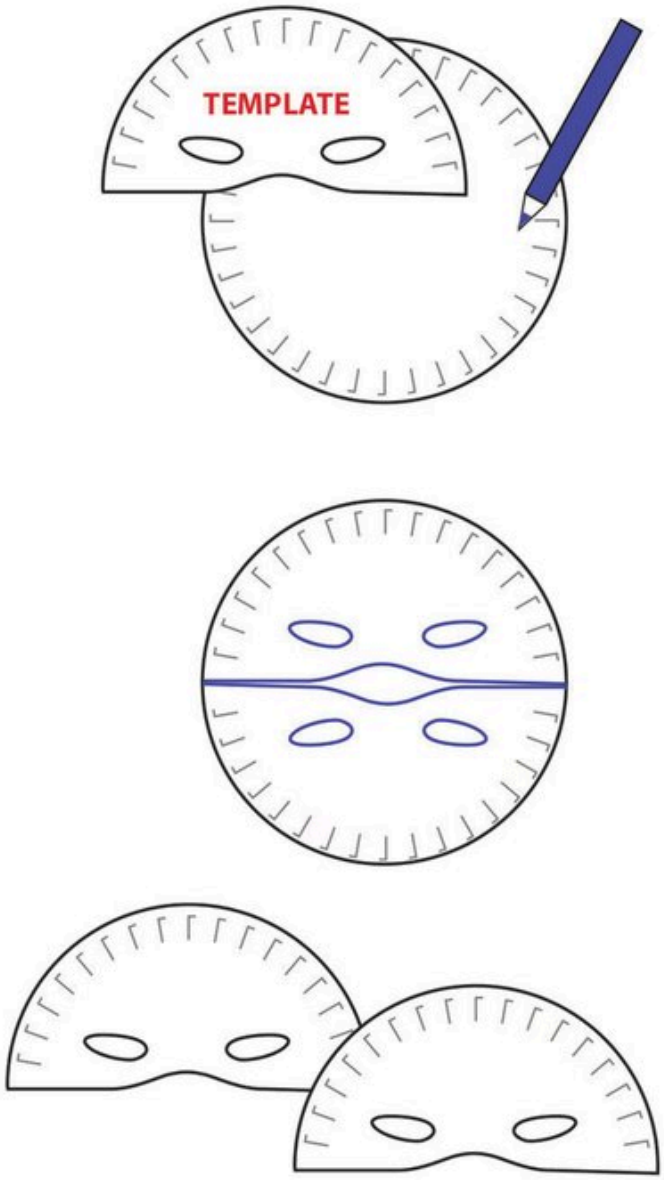



What would your Superhero mask look like? What superhero powers do you have? Design a mask that reflects these talents by decorating a mask with fun craft materials. Light it up using copper tape, pipe cleaners, a LED light, and a 3V ion lithium battery.

Step 1: Materials & Set Up

paper plate
copper tape
LED lights
3V coin cell batteries
construction paper
craft decorative materials of your choice such as feathers, beads, google eyes, and stickers
color markers & color pencils
glue sticks & glue bottles
scissors
glue guns
hole punchers (ones that make tiny holes are great)
templates to trace two masks on one paper plate
pliers
staplers

Step 2: Prep Paper Plates



Cut a paper plate in half and create a template for your masks. Include a notch for the nose and two eye holes. Label this template with "TEMPLATE" so it doesn't accidentally get used as someone's mask.

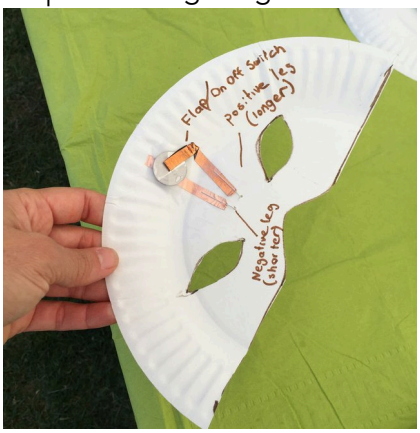
Trace your template on the top and bottom of paper plates and cut them out. You can use a hole puncher to create starter hole for scissors to cut out the eye holes.

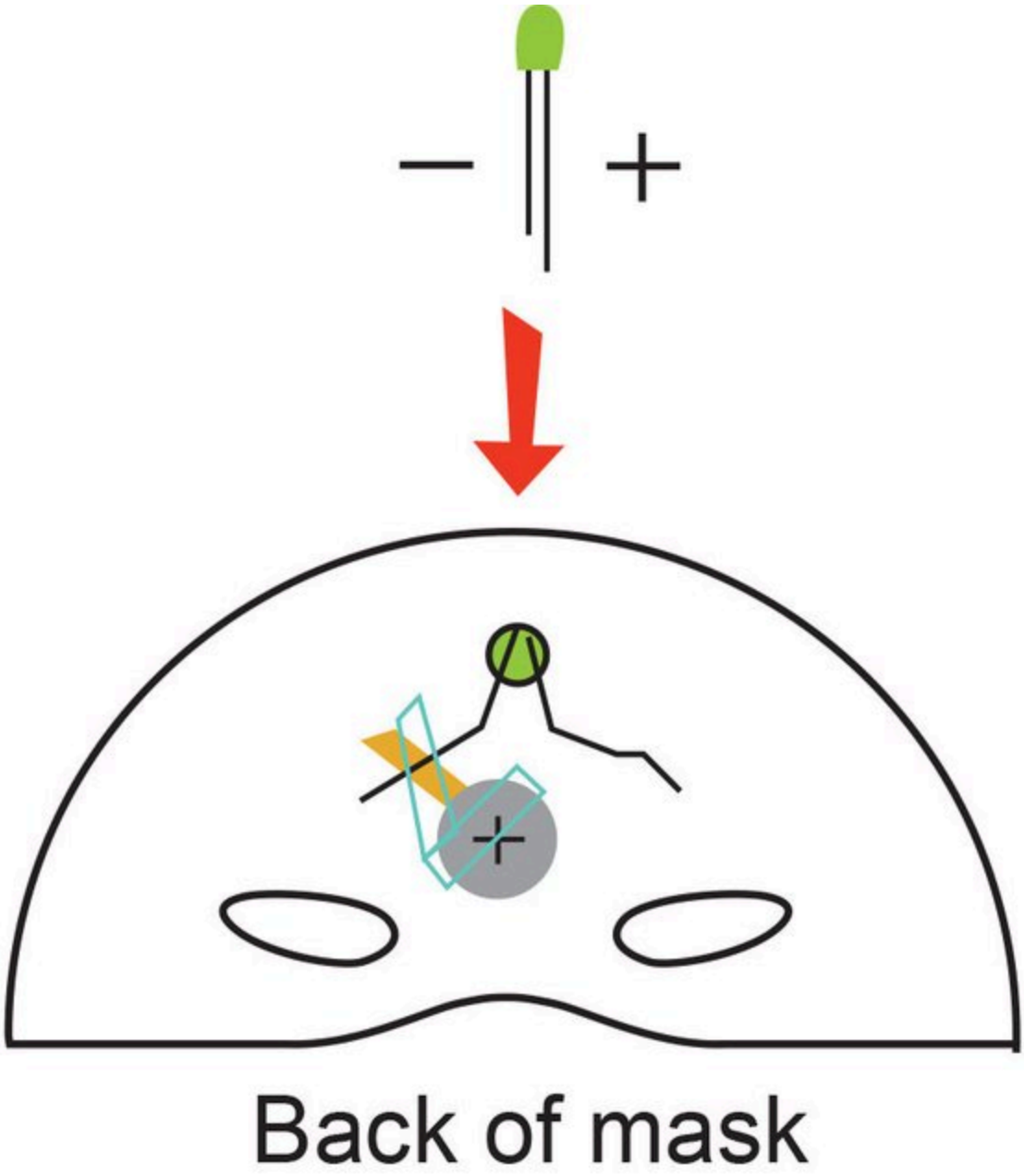
Step 3: Design Your Mask

start to shape and decorate it. You can also invite students to imagine where they would put their light on their mask. Attach decorations using glue, glue sticks, staplers and hot glue guns.

Elastic or string can be attached to wear the masks. Another option is a straw handle so you to hold up mask to their face.

Step 4: Adding a Light to the Mask, Part 1



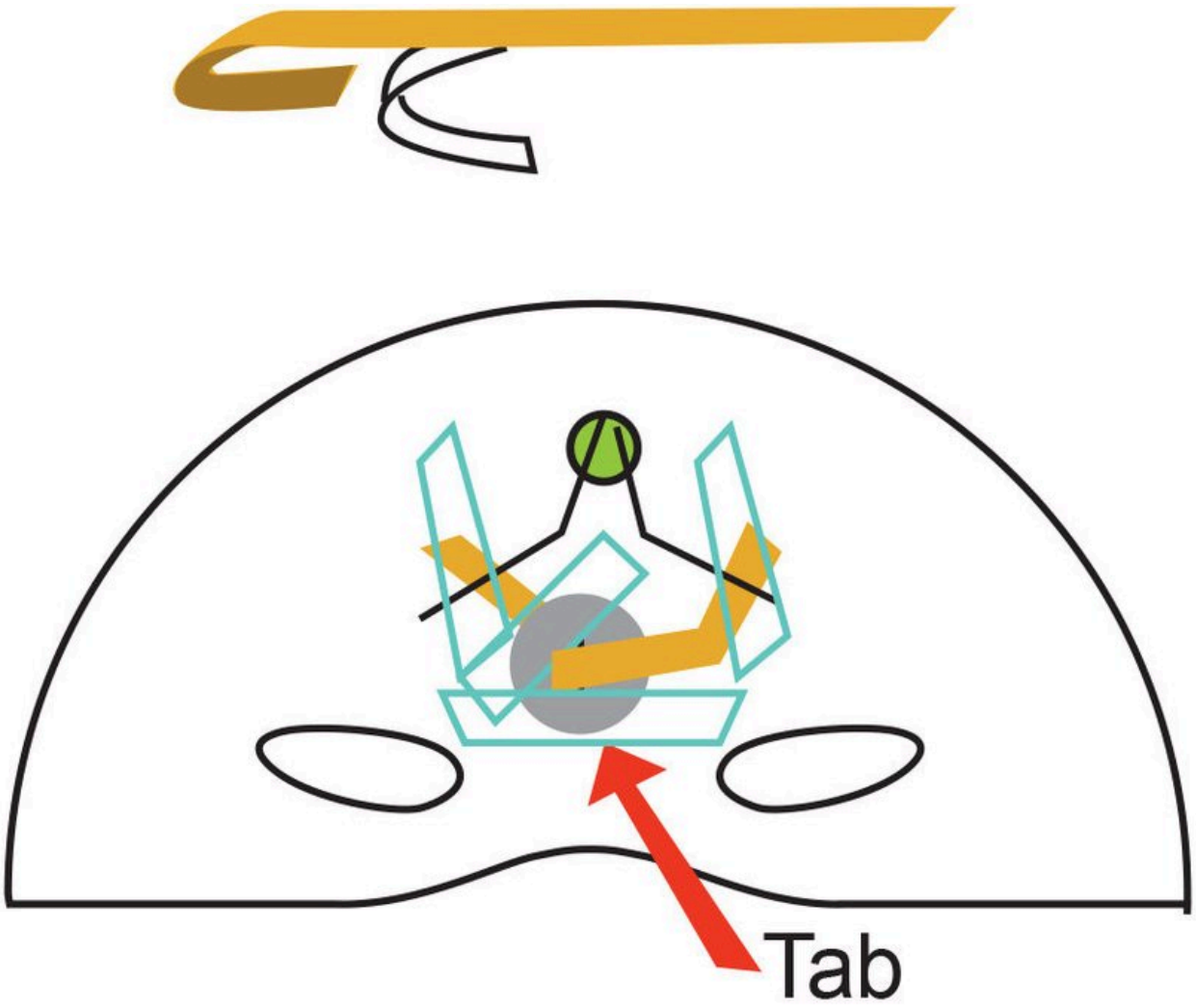


Once the decorations are added, you can add in the circuitry. We found it useful to have a sample mask with circuitry in it to pass around. Poke a hole in the paper plate for the LED light legs and place your LED light into the hole with the LED light facing the front of the mask.

1. On back side of the mask, split the legs of the LED light (tip: kink the positive LED leg to easily keep track of positive and negative legs). The longer LED leg is usually the positive side.
2. Slowly peel and place a short strip of copper tape and extend it from under the negative LED leg to a spot you will place your battery.

3. Using electrical tape or clear tape, tape down the negative LED leg to the copper tape. Tape the battery with the negative side facing down onto the copper tape. Be sure that you still have some of the positive side of the battery exposed without tape on it.

Step 5: Adding a Light to the Mask, Part 2



1. Peel and place a short strip of copper tape from under the positive LED leg to the top of the battery that is exposed and without tape. The copper tape end that taps the battery should be folded over so that it does not stick to the battery. This is your pressure switch.
2. Using electrical tape or clear tape, tape positive LED light leg down onto copper tape.
3. If the mask is designed as shown here in the diagrams, the mask will turn on when you wear it as the pressure switch is activated by the pressure of your forehead.

Happy superhero mask wearing!

Pipe Cleaner Circuitry

7

Activity Description:
This project engages students in an open ended activity exploring art and circuitry. Students learn about electrical circuits by creating an illuminating art object out of pipe cleaners. They are invited to design an off/on mechanism for their creation. An extension project could be to invite students to create a scale model of a public space light feature or a paper and pipe cleaner model of a hand held illumination device.

Cutting

Cu

Scissors

Electronics

El

LED
Lithium Button Battery

Arts & Crafts

Ar

Craft Paper
Pipe Cleaners

Brainstorm

Br

Markers
Colored Pencils

Joining

Jo

Tape

Fixturing

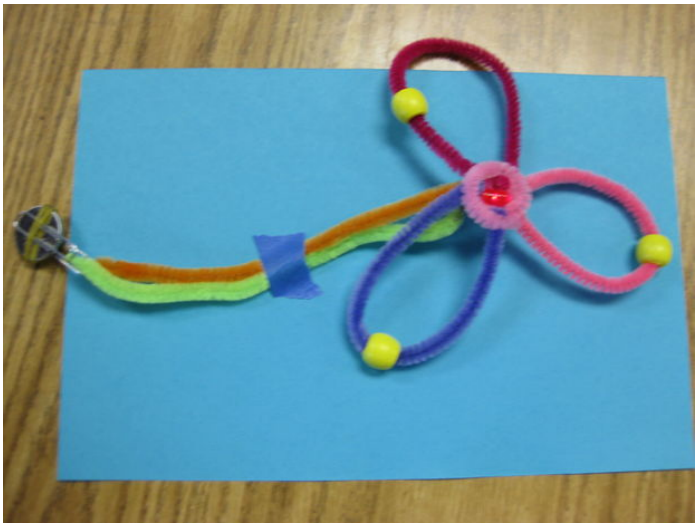
Fx

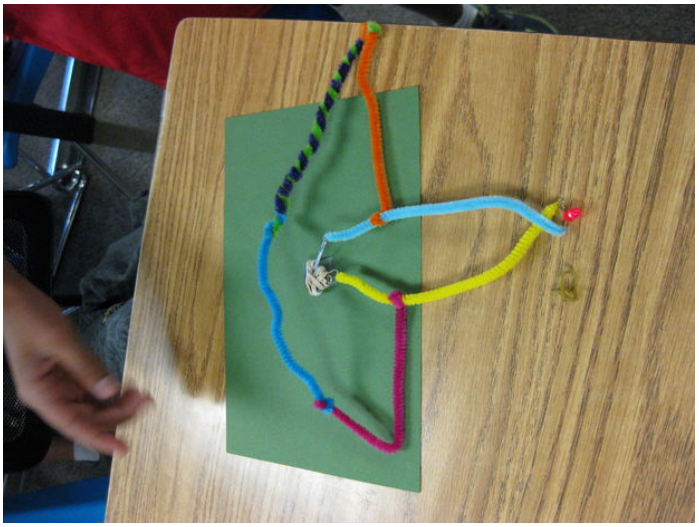
Paper Clips
Small Rubber Band

7

Intro: Pipe Cleaner Circuitry

This project engages students in an open ended activity exploring art and circuitry. Students learn about electrical circuits by creating an illuminating art object out of pipe cleaners. They are invited to design an off/on mechanism for their creation. An extension project could be to invite students to create a scale model of a public space light feature or a paper and pipe cleaner model of a hand held illumination device.





Step 1: Materials & Tools

MATERIALS PER STUDENT:

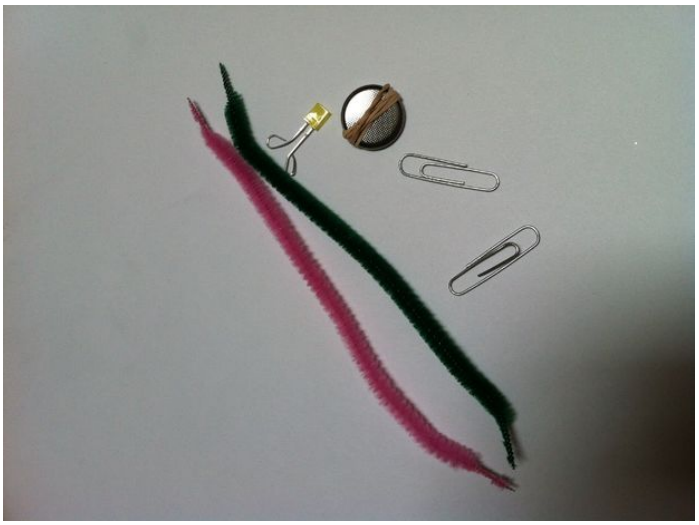
- Two pipe cleaners (ends stripped of fuzz)
- two paper clips
- five or six additional pipe cleaners
- construction paper
- tape or small rubber band
- one lithium button battery (from IKEA store)
- one LED light with anode and cathode legs curled
- Colored pencils optional.

TIPS: Remind students to be careful with stripped ends of pipe cleaners as they can poke. Test out that the LED light works with the battery before you begin. (Do this by straddling the anode and cathode “legs” of the LED light on either side of the button battery so that these “legs” touch an opposite side of the battery. If the light does not light up, then flip the battery around and test with the anode and cathode touching the opposite sides)

There is a bit of prep time to cut off the fuzz on the pipe cleaner ends and to curl the LED light “legs” (anode and cathode wires). To cut off the fuzz on the ends of the pipe cleaners, use scissors and trim almost parallel to the wire to cut fuzz close to the wire.

TOOLS NEEDED:

- pliers
- scissors



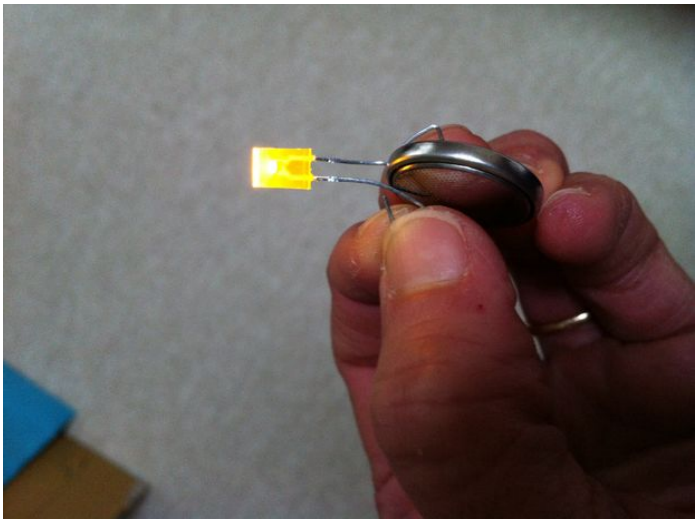
Step 2: Get Inspiration!

You will be drawing with wire soon, so get your imagination going with some cool wire art:

- Explore Alexander Calder's wire art for inspiration
  Above "Rearing Stallion" by Alexander Calder, photo by Eric Wilcox on Flickr
  (CC BY-NC 2.0)
- Explore a few pipe cleaner circuitry student models: online student album.
- Explore Pinterest boards on wire art

Step 3: Building a Simple Working Circuit/ Attaching the paper clips to the pipe cleaners

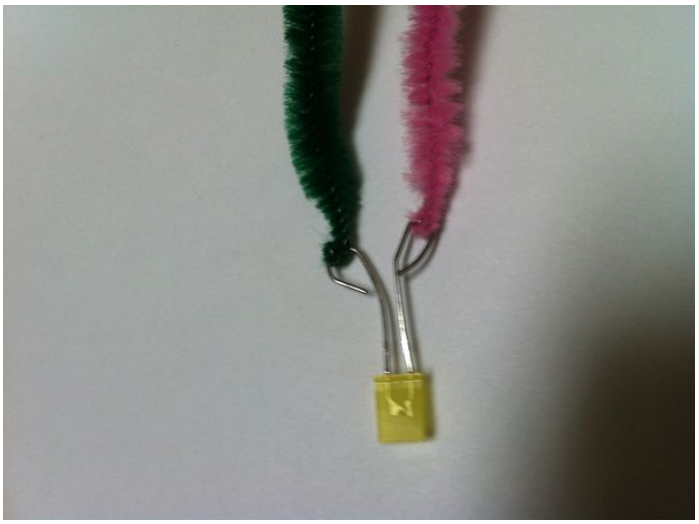
1. Students check that they each have all the materials needed to make a basic circuit: two paper clips, battery, led light and two pipe cleaners with the ends stripped of fuzz.
2. Students check that the light works with their battery by having it straddle the battery. Set the battery aside.
3. Students wrap a raw wire end of a pipe cleaner to a paper clip. They take their second pipe cleaner and attach a paper clip in the same way. They should now have two pipe cleaners, each with a paper clip foot. They should double check that they wrapped the wire tightly around each paper clip and that the wire of the pipe cleaner is touching the wire of the paper clip.

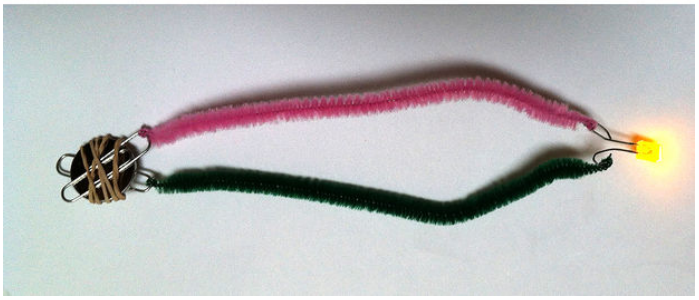


Step 4: Building a Simple Working Circuit: attaching the LED light to the pipe cleaners

Now the students will attach the LED lights.

1. The other end of each pipe cleaner (the end not attached to a paper clip)is wrapped around one loop of the LED light (the anode and cathode legs need to be curled with pliers to create the loops).
2. The LED light now looks like it has two pipe cleaner legs with paper clip feet. Students test out the circuit by touching the paper clips at the same time to different sides of the battery. If it doesn't work one way, flip the battery and try again.





Step 5: Make IT Art!

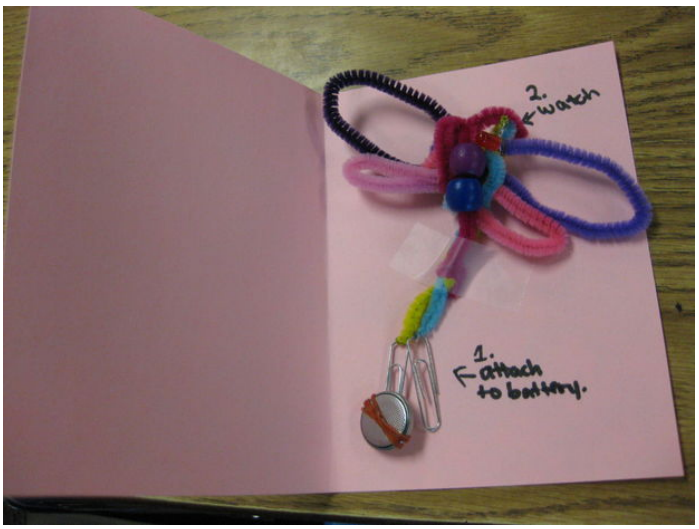
At this point students have a working circuit! Now to turn it into art!

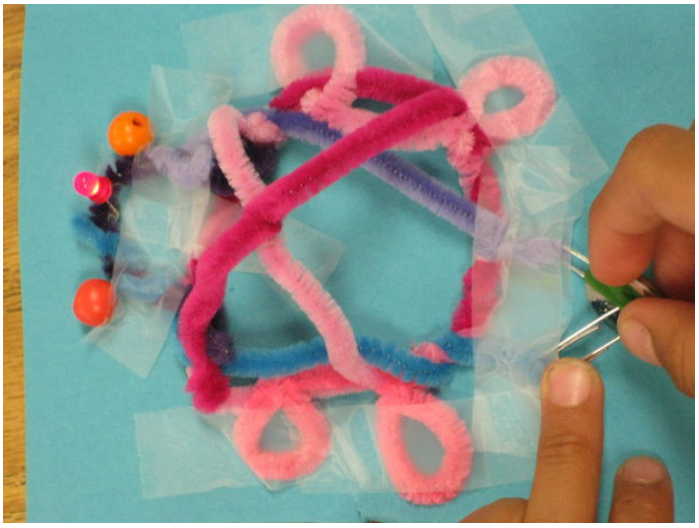
1. Students can attach one paper clip foot to the battery with a rubber band or tape. The other paper clip foot is the on/off switch that they tap against the battery to turn on.
2. Students now pick up six extra pipe cleaners and a sheet of paper to turn their circuit into wire art.
3. taping the whole structure to construction paper can also add support to the design.

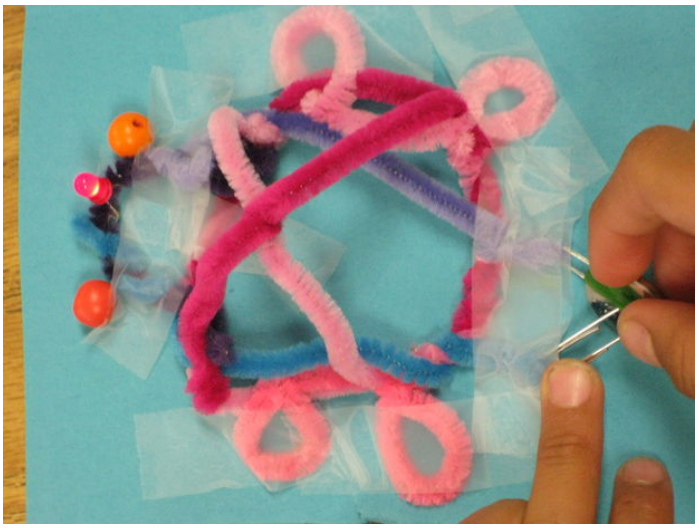
THINGS TO TRY: Can you make an on off/switch in a fun and creative way? Can you collaboratively design a series of pipe cleaner units that light up to illuminate up a light?

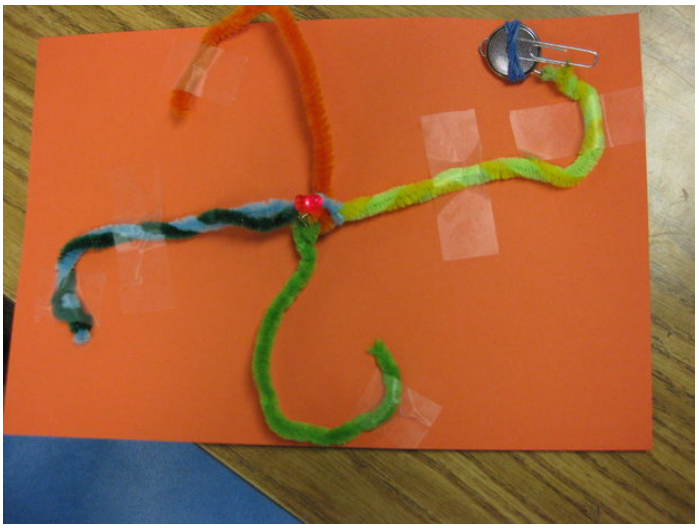
ACTIVITY MANAGEMENT TIPS: Have accessible only the basic material for making the circuit on the tables. After they make a successful pipe cleaner circuit with the LED light, then they go to the materials table for construction paper and more pipe cleaners and beads (optional) to add to the circuit. Also, it is helpful to demonstrate how to make a tight winding of the pipe cleaner around the paper clip and LED wires. If students are struggling to get their light light up, ask them to problem solve and investigate where the break in the circuit might be. Is everything connected well? They can ask their neighbors for advice, too.

Per unit cost: .70 cents per student (spreadsheet of costs) cost of pliers is $5.00 each (students can share pliers in pairs)









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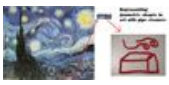

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DIY Tripod Made Out of PIpe Cleaners by JakeTripplJ

ArtBot by skitterypigeon

LED Pipe Cleaner Bracelet by gitterbug23

Pipe Cleaner Flowers by macdog360

How To Make A Touch Screen Stylus! by CommanderCookie

LED Popsicle Flashlight

8

Activity Description:
Make your own flashlight using a few simple everyday items! This hands-on project is not only fun and easy to make but illustrates how a switch works!

8

Cutting

Cu

Scissors

Electronics

El

Copper Wire
LED
Copper Tape or Tin Foil
3V Coin Cell Batteru

Arts & Crafts

Ar

Popsicle Sticks

Joining

Jo

Glue
Glue Sticks

Joining

Jo

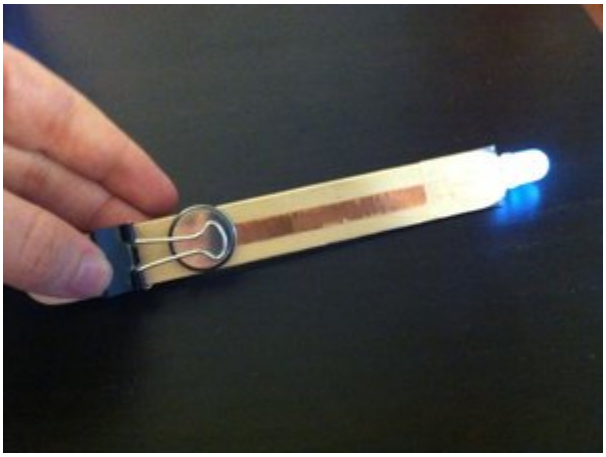
Tape

Fixturing

Fx

Binder Clip

LED POPSICLE FLASHLIGHT

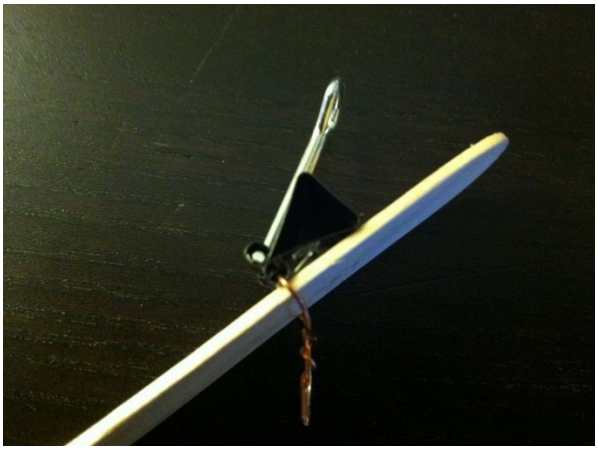


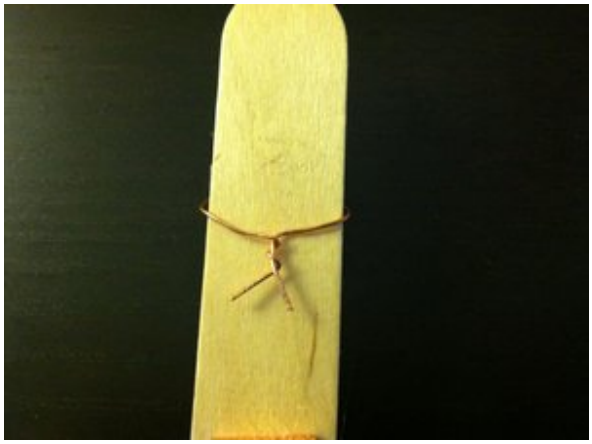
Make your own flashlight using a few simple everyday items! This hands-on project is not only fun and easy to make but illustrates how a switch works!

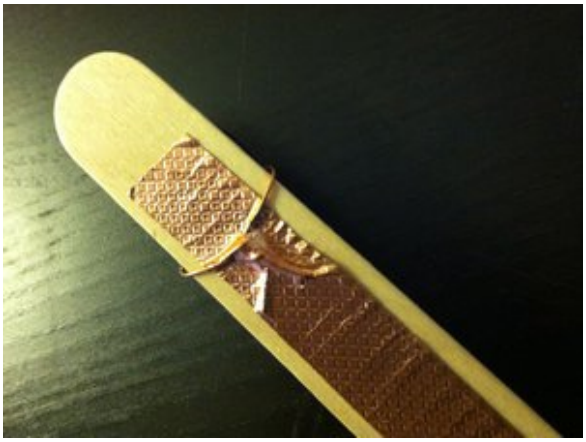
Step 1: Materials

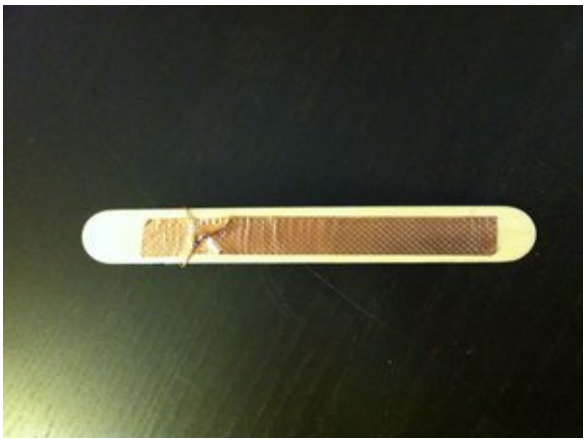
popsicle sticks
medium size metal binder clip
copper wire (22 guage, solid)
3V coin cell battery (CR 2032)
LED
copper tape (or tin foil, if you really want to keep costs down)
non-conductive tape (masking, electrical, scotch, duct, etc)
hot glue gun & glue sticks
scissors

Step 2: Make the Switch



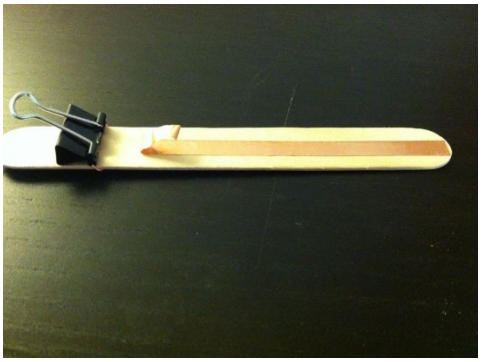
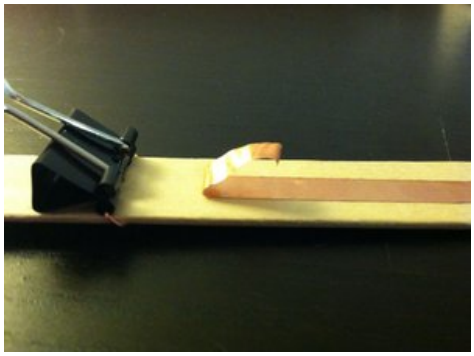


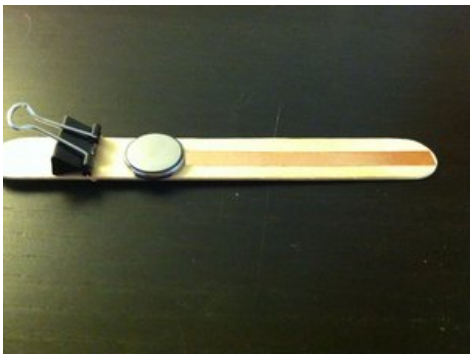




1. First, you'll need to remove the second leg of the metal binder clip. Simply pinch the sides together near the top of the clip and wiggle it out.
2. Using a little hot glue, adhere the metal binder clip flat onto the popsicle stick, about 1.5" from one end. Make sure not to use too much hot glue or the copper wire won't fit through the binder's hole.
3. Next, cut (and strip if necessary) about 2.5" - 3" of copper wire. Feed the wire through the two holes of the binder clip. Previously, these holes were holding the leg we removed. Twist the wire around the back of the popsicle stick and try to make it lay flat.
4. Then, take one strip of copper tape (or tin foil) and place it on the back of the popsicle stick. It should cover the twisted copper wire and go almost to the end, leaving about .25" - .5" at the other end of the popsicle stick free.

Step 3: Add the Battery

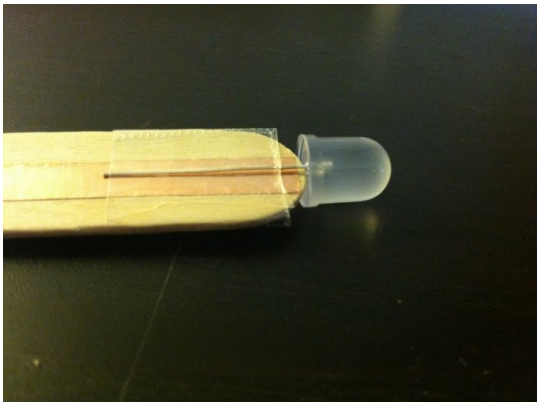



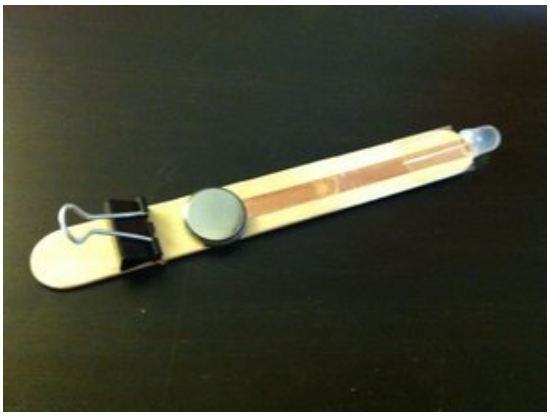
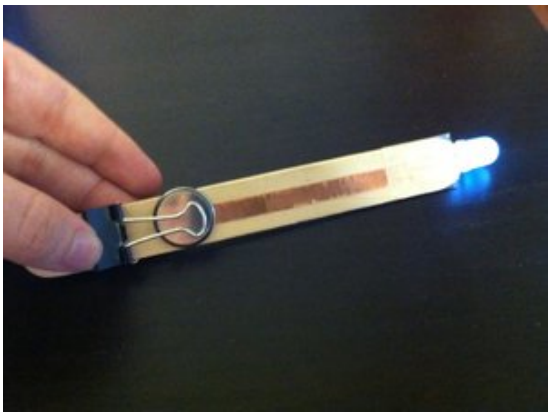


1. Flip your popsicle stick back over, so the metal binder clip is facing up.
2. Lay another piece of copper tape (or tin foil) down the front of the popsicle stick. It should run from one end to about .5" from the metal clip. Make sure it doesn't touch the metal clip or your flashlight won't work (because positive and negative will be touching).
3. Bend the extra bit of copper tape back, so the sticky side is up, place the positive side of the battery (the smooth side) down onto the sticky copper tape and press it firmly down so it touches and lays flat against the popsicle stick.

TEST PLACEMENT
Here's a good time to test if you've placed everything in a good spot. Flip the metal leg down. It should touch the negative side of the battery. If it doesn't, move your battery closer or farther away until you're happy with it's placement and the metal leg touches the battery. Make sure your battery isn't touching the metal leg; otherwise, you're light won't work

Step 4: Add the LED



The final step is adding the LED! The positive side is the top (or side with the metal clip) and the negative side is the bottom (or side with the twisted wire).
The LED's cathode (long lead) goes on top, and it's anode (short lead) goes on the bottom. Affix your LED in place with some non-conductive tape. Make sure both leads are touching their respective copper tape sides. If you want to test that your light works before taping it in place, just flip the switch.
If your light doesn't work, here are a few common debugging solutions:
- make sure you've got the LED leads touch their respective correct sides
- make sure the copper tape is firmly adhered to the twisted copper wire on the back
- make sure the battery isn't touching the metal clip
- make sure the battery is laying flat and touching the copper tape on top

Once your LED is in place and taped onto the popsicle stick, you're done! Flip the switch and enjoy your very own LED Popsicle Flashlight!

Junkbot

9

Activity Description:
Robots from recycled materials!

Cutting

Cu

Scissors

Arts & Crafts

Ar

Googly Eyes
Pipe Cleaners
Craft Paper

9

Recycle

Rc

Junk
Old Electronics
Plastics
Cardbaord

Brainstorm

Br

Markers

Other Materials
Wire Cutters

Joining

Jo

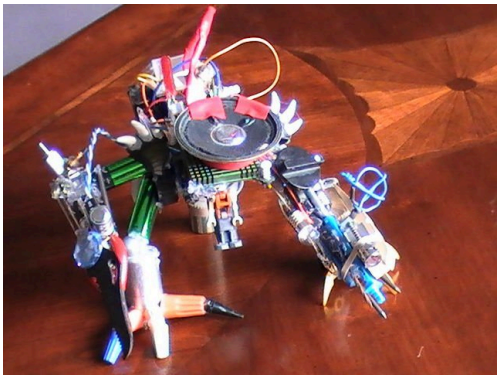
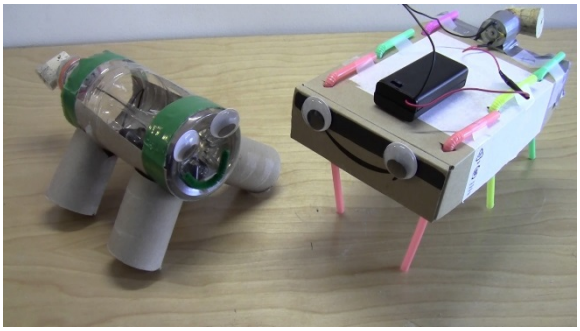
Tape

Joining

Jo

Glue
Glue Sticks

HOW TO MAKE A JUNKBOT

Step 1: Gather Materials and Tools
Junk! (see instructions)
Recyclable materials: old electronics, plastics, cardboards, etc
Scissors
Wire cutters (optional)
Paper clips
Glue guns
Gorilla glue (if available)
Tape

Step 2: Planning
Get creative—what is the design of your robot? Look at pictures online of robots for inspiration.

Step 3: Building
Consider design, symmetry, balance of robot. Recommend that students start with the legs to make sure it will stand on its own…then build the body and then arms.

***There are numerous websites for additional information and examples of junkbots…these can also include electronics so that they are more sophisticated with movement and lights

Mini Cars

10

Activity Description:
DIY at HOME will teach you how to make a super fast mini electric car toy very simple very easy using a 9V battery and powered with a dc motor!

10

Cutting

Cu

Scissors

Electronics

El

DC Motor
9V Battery
On/Off Switch
Battery COnnector

Arts & Crafts

Ar

Craft Paper
Popsicle Sticks
Pipe Cleaners

Measuring

Ms

Straws

Joining

Jo

Tape

Joining

Jo

Glue
Glue Sticks

Other Materials
Thumbpin, toothpicks, gear, bottle caps

How to Make MINI Electric CAR - DIY at HOME Easy - Simple Powered CAR Science Project for Kids

by DIYatHOME247

DIY at HOME will teach you how to make a super fast mini electric car toy very simple very easy using a 9V battery and powered with a dc motor for school science projects for kids !!!

Just follow the step by step instructions and have fun by trying out by yourself !!!

https://youtu.be/AHOb4M5Nq_w

Step 1: Things Required

2 toothpicks

1 dc motor

1 9V battery

1 battery connector

1 on/off switch

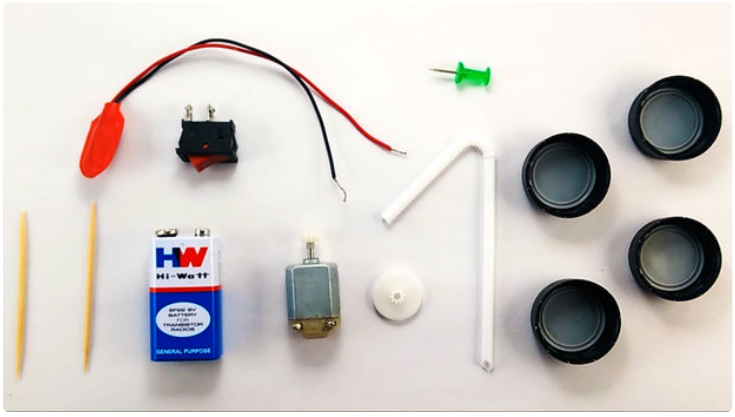
4 bottle caps

1 big scraw

1 gear

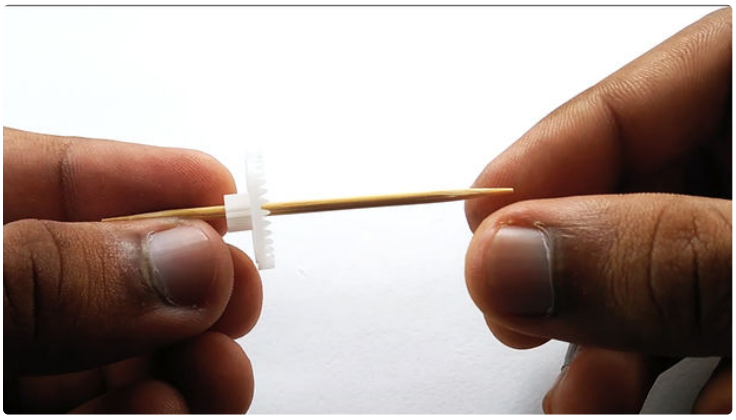
1 thumbpin

and some hot glue

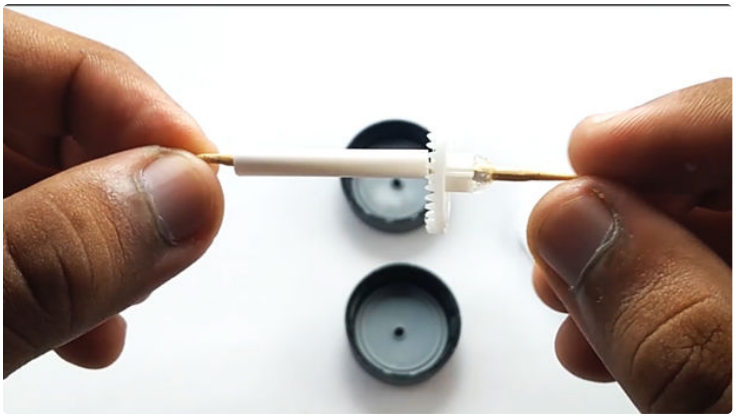


Step 2: Make Holes at Centre of Each Bottle Cap Using Thumbpin

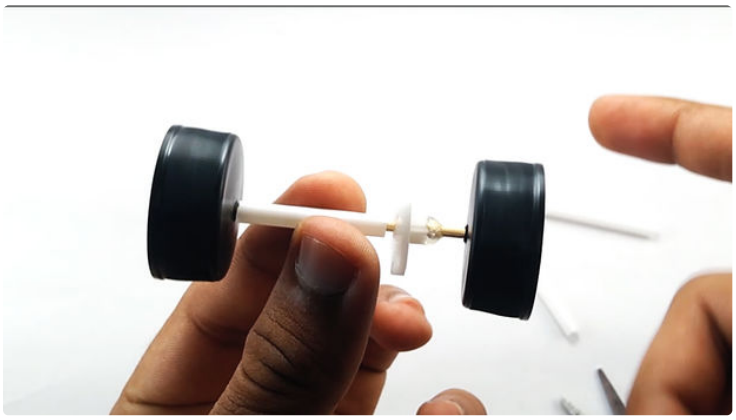
Step 3: Stick the Gear to the Toothpick Using Hot Glue or Strong Liquid Glue



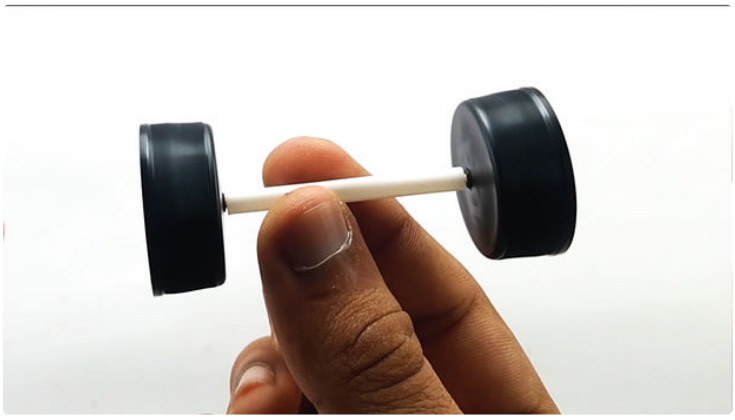
Step 4: Cut Appropriate Length of Straw Yo Hold the Toothpick to Rotate



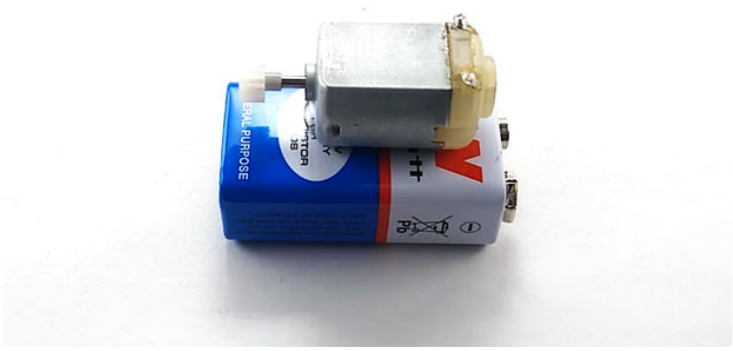
Step 5: Stick Bottle Caps to Toothpick Using Hot Glue or Liquid Super Glue



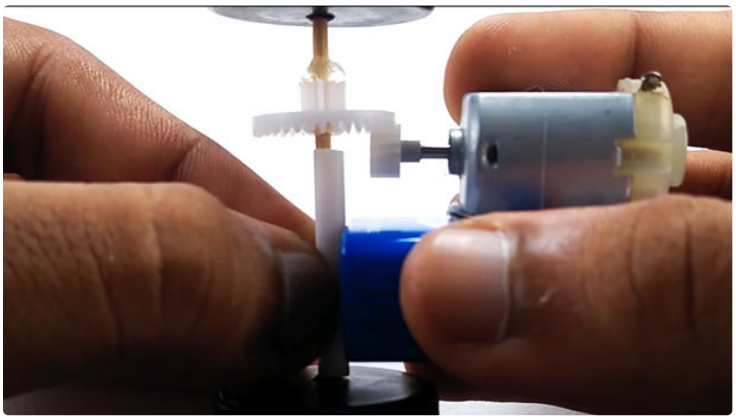
Step 6: Make Another Arrangement Without Gear



Step 7: Stick Motor Upon the Battery Using Hot Glue

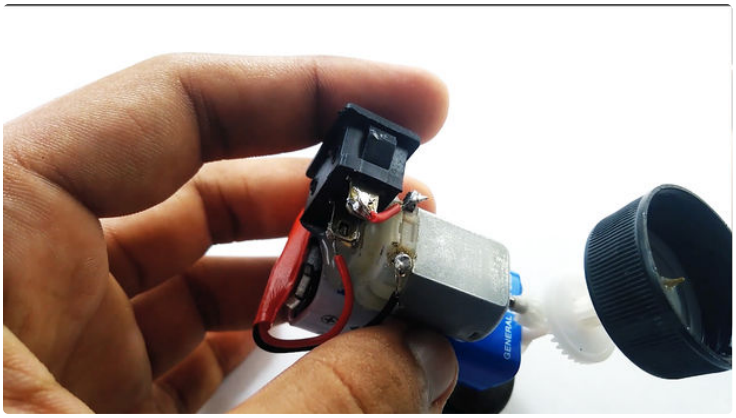


Step 8: Stick the Battery Motor Arrangement to the Straw As Per the Image



Step 9: Stick the On/off Switch

Step 10: Put the Battery Connector and Make the Connections



Step 11: Stick the Remaining Wheel Arrangement Below the Battery As Per the Image

Step 12: AND YOU ARE READY TO PLAY WITH IT

https://youtu.be/AHOb4M5Nq_w

What a fun little car! Thanks for sharing!

My Pleasure ! Glad you liked it :)

Engineer & Science

Strawkets

11

Activity Description:
Straw rockets powered by blown air.

Cutting

Cu

Scissors

Measuring

Ms

Straws

11

Arts & Crafts

Ar

Craft Paper

Joining

Jo

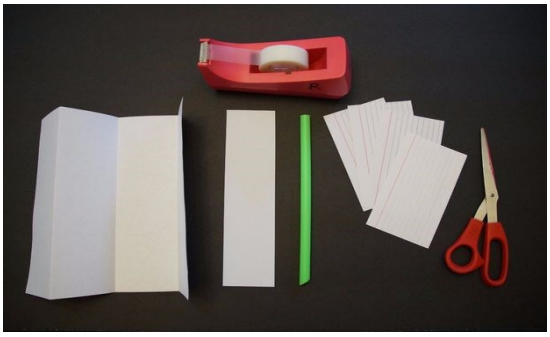
Tape

Straw Rockets or Strawkets

Step 1: Gather your supplies

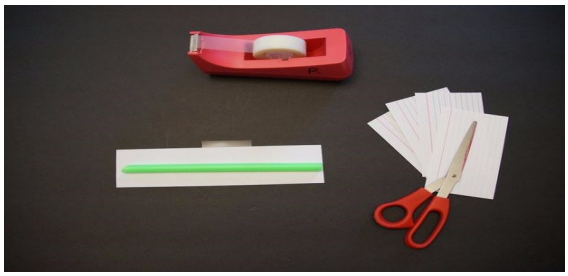
Supplies List:

- straws
- 8 1/2 in x 2 3/4in strips of paper (fold a copy paper width-wise half, and then half again, giving you four pieces of 8 1/2 in x 2 3/4in strips
- Index cards or pieces of cardstock paper
- Scotch Tape
- Scissors



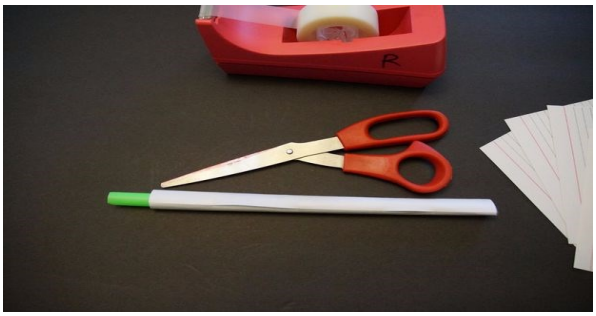
Step 2: Fold, Cut, & Tape

1. Fold a piece of copy paper width-wise half, and then half again, giving you four pieces of 8 1/2 in x 2 3/4 in strips.
2. Cut a piece of 8 1/2 in x 2 3/4 in strip of paper.
3. Put a piece of tape on the paper (as see in the photo). This great idea came from a 1st grader two years ago. Before that, I used to tape it while rolled up around the straw.



Step 3: Roll & Tape

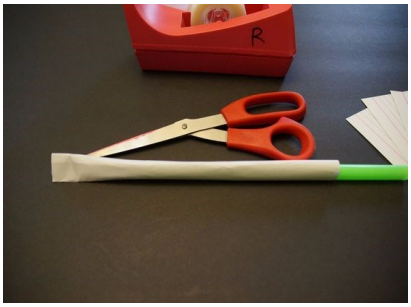
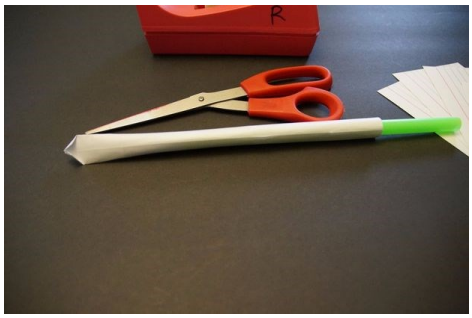
1. Wrap the paper around the straw and tape down the seam. Make sure it doesn't stick to the straw, and that the straw can slide in and out easily.




Step 4: Making a nose cone

1. Flatten out one end.
2. Fold it in go create a triangular cone.
3. After creating the cone, put a piece of tape around it to prevent the air from escaping.

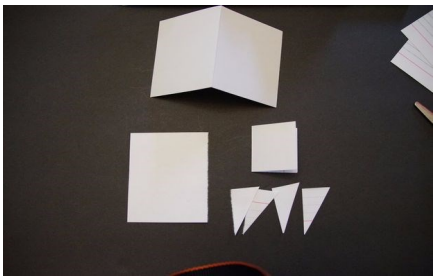
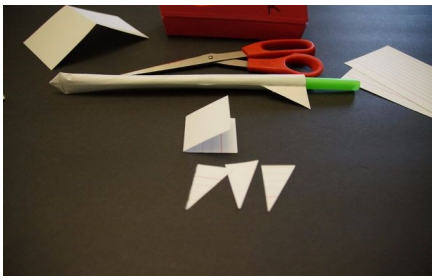
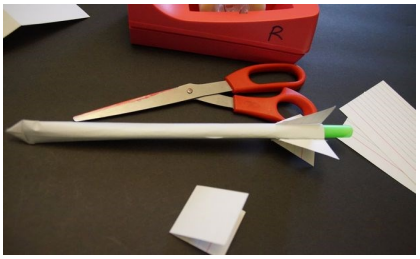
Now, put the partially built rocket on your straw and blow it. It won't fly very well.

Step 5: On to the fins

1. Now, cut out fins from a piece of an index card and tape it on the rocket. Any place you choose.

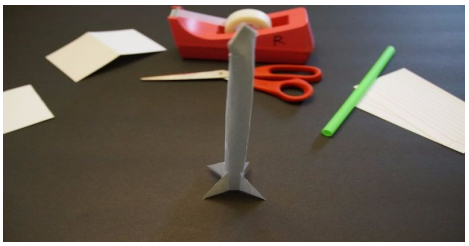
When I do this project with K to 2nd graders, I usually cut the index cards in half and hand them out. I want to restrict the size of the fins they can create.

Step 6: Done

1. Now, blow it and see how it flies.
2. If it doesn't fly well, tweak it. Take it apart or build another one to make it fly better.

Engineering is all about failure and overcoming that failure.



Step 7: Additional Comments:

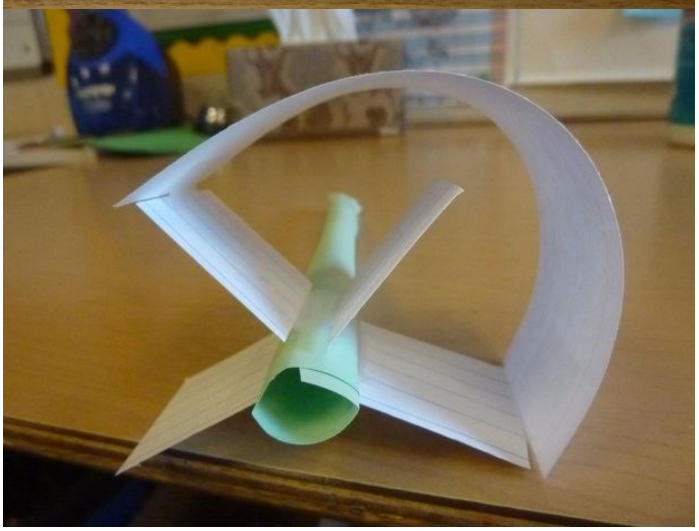
When I do this project, I give the students two challenges:

1. Farthest distance
2. Trickiest rocket - boomerang and tight spiral (what I'm looking for is an indication that there was some thought behind the design)

Sometimes I change things around by asking the kids for accuracy, but they kids are pretty challenged year after year by these two challenges.

Step 8: Some awesome designs from elementary school kids:

Curiosity. Imagination. Perseverance. And FAIL SPECTACULARLY!



Comments

Craft Stick Catapult

12

Activity Description:
The craft stick castle isn't going to invade itself! With a quick craft stick catapult, you'll be launching pom-poms over pipe cleaner parapets in no time. Whether you're using it to learn about levers simple machines, or want to join in a 2,400 year history of launching projectiles, the craft stick catapult can be your new favorite toy.

12

Cutting

Cu

Scissors

Fixturing

Fx

6 Rubber Bands

Arts & Crafts

Ar

7 Popsicle Sticks
Pom Poms
Scruntched Up Pipe Cleaners

Joining

Jo

Glue
Glue Sticks
Hot Glue Gun

Other Materials
Bottle cap or plastic egg for catapult basket

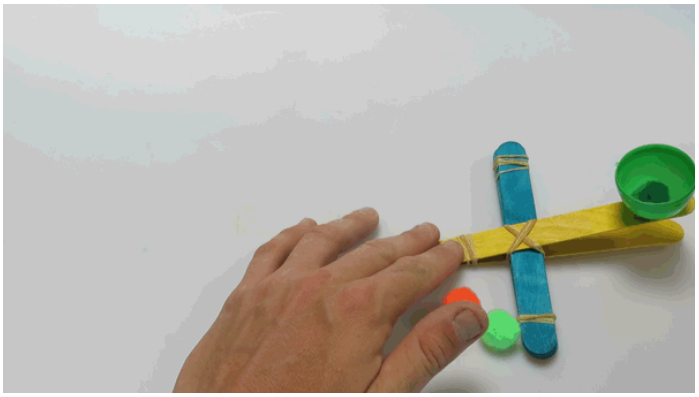
Author:The Oakland Toy Lab
The Oakland Toy Lab is a community-based wonder lab for students to build, tinker, explore, make, break, and learn! We are writing up engaging science experiences so that educators, parents, youth, and families can have access to these anywhere in the world. Hope you enjoy and can't wait to meet you! (all built and documented by Sam Haynor)

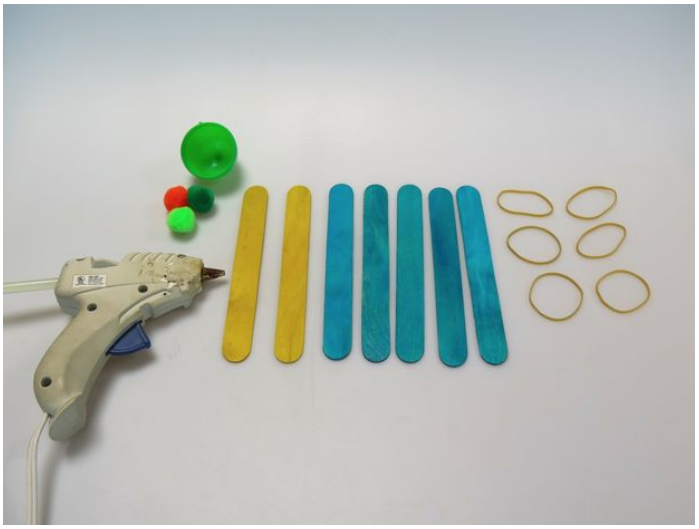
Intro: Craft Stick Catapult!

The craft stick castle isn't going to invade itself! With a quick craft stick catapult, you'll be launching pom-poms over pipe cleaner parapets in no time. Whether you're using it to learn about levers simple machines, or want to join in a 2,400 year history of launching projectiles, the craft stick catapult can be your new favorite toy.

- What: Craft Stick Catapult
- Concepts: levers, simple machines, projectiles
- Time: ~ 3 minutes for your first
- Cost: ~ $0.05
- Materials:
  - 6 rubber bands
  - 7 craft sticks
  - catapult basket (bottle cap, plastic egg, etc)
  - pom-poms or other projectiles
- Tools:
  - hot glue gun

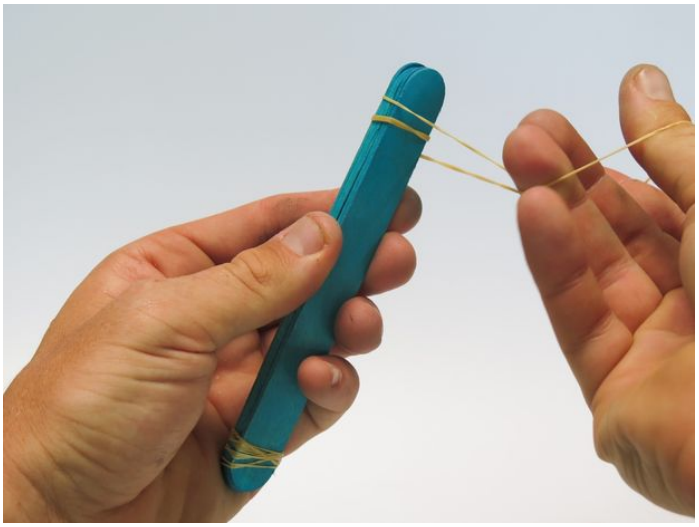
Let's launch!

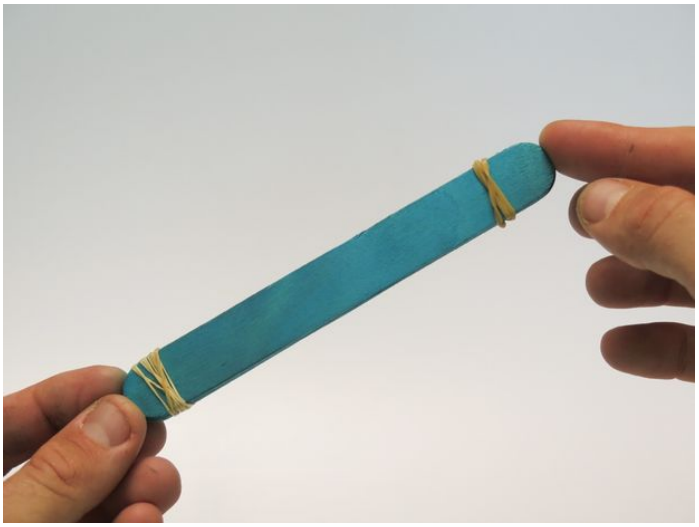




Step 1: Prep Thy Fulcrum

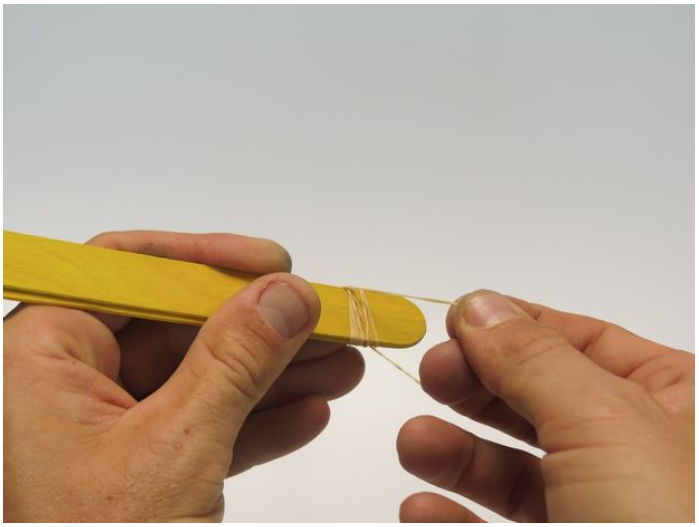
Slap five craft sticks together, and rubber band them at both ends, wrapping the rubber bands until tight. You can add more or take some away later to test different build designs.

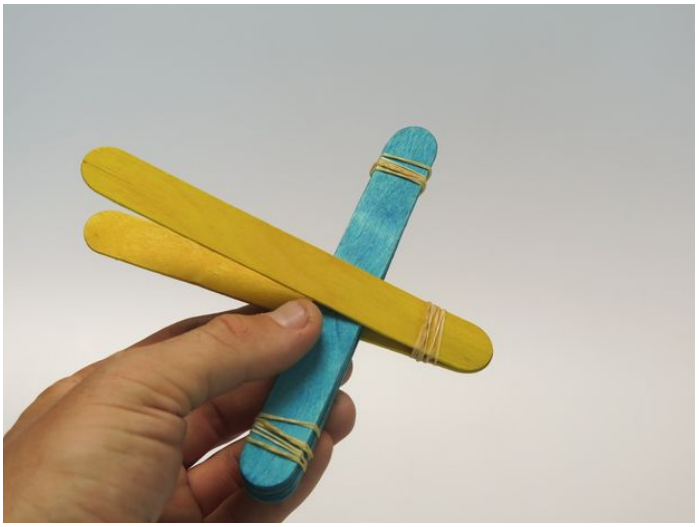




Step 2: Attach Thy Flinger

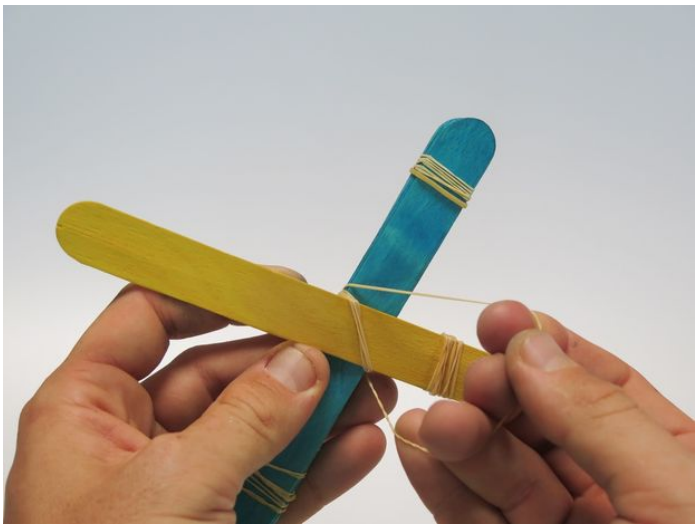
Take your two remaining craft sticks, and rubber band them at one end. Wedge the fulcrum in the middle so they splay apart. You can change the lever length of your catapult by moving your fulcrum to different positions. This is great for learning about leverage.

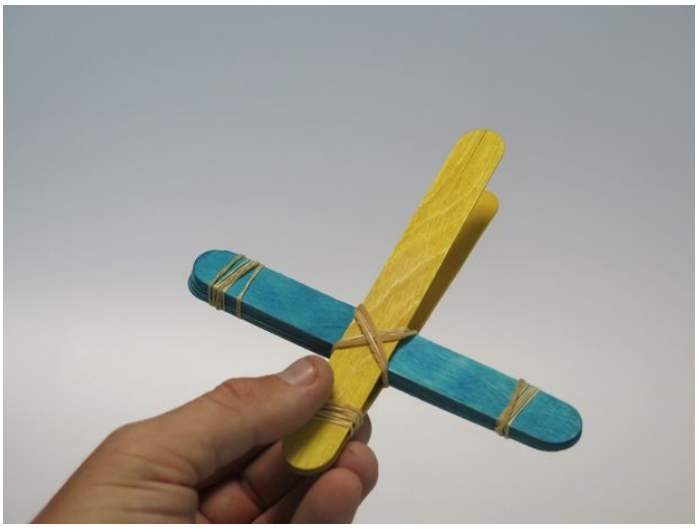




Step 3: Secureth In Place

Use two rubber bands to make an "X" around the entire flinger and fulcrum. Leave it loose enough so that you can change the lever length when you want to.





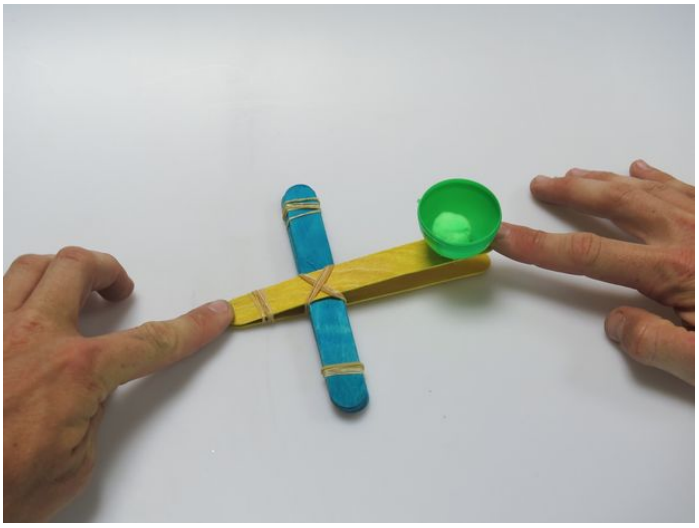
Step 4: Attach Thy Basket and Launch!

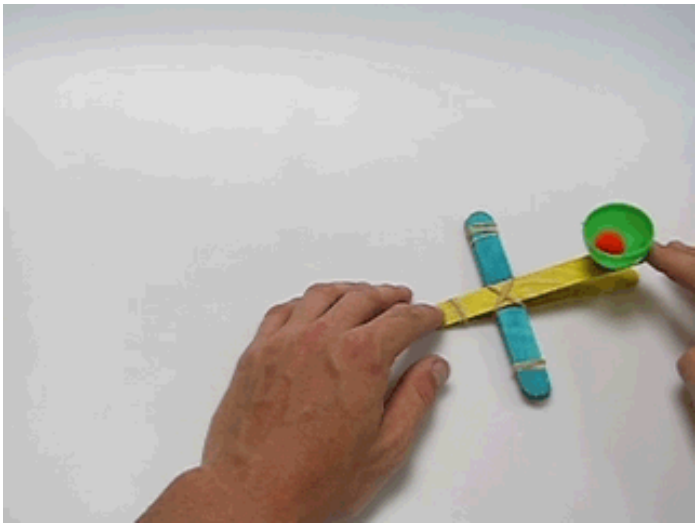
Be it plastic egg, bottle cap, clay, or folded paper, hot glue it to the end of the flinger. Load it up with some projectiles, pull back, aim (not at humans or animals), and fire away!

After you fling a few pom-poms around, try making some targets out of paper or cups, and adjust the fulcrum height and lever length to play with different designs.

Which lever length works the best? How does it change the flight path of the pom-pom?

Have fun, and keep exploring!





Related Instructables

The Marshmallow Trebuchet by onebrokenneck

Popsicle Stick Bomb by EmilyR4

Disc Shooter Physics Challenge (Photos) by CitizenScientist

Cork Launcher by WYE_Lance

Building Machines From Paperclips by biochemtronics

3D Printed Vertical Ball Launcher (video) by Ben Finio

Comments

Solar Oven

13

Activity Description:
Scribbling machines are motorized contraptions that move in unusual ways and leave a mark to trace their paths. They are made from simple materials and set in motion by a vibrating offset motor causing them to bounce, spin, bump and move in interesting ways.

Cutting

Scissors

Cutting

AA Battery

13

Cutting

Craft Paper
Popsicle Sticks
Pipe Cleaners

Cutting

Glue
Glue Sticks

Other Materials
Popsicle sticks, wood skewer sticks, pipe cleaners, wire, nuts, washers, wire strippers, screwdriver, googly eyes

Cutting

Masking Tape

Cutting

Markers

Making a Pizza Box Solar Oven

Perhaps you've helped your mom make cookies. The first thing she usually does is to turn on the big kitchen oven to pre-heat it. But what if you didn't have electricity or gas to heat your oven? What if you didn't even have a kitchen? Or even a house? What if you lived in a refugee camp in Africa, because your family moved there to escape some really bad people? Or what if you lived on a tiny island that had never had electricity?

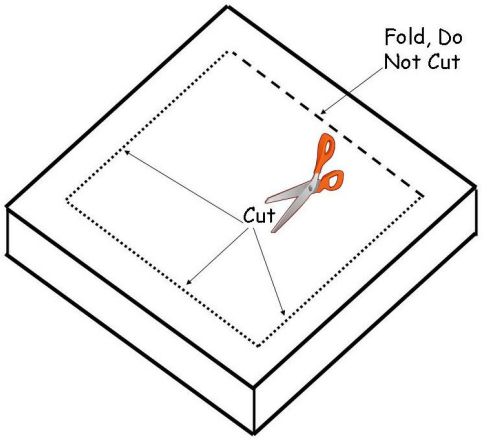
Chances are, the only way you could cook is to cut down trees for firewood, just like the Native Americans used to do. This works OK, as long as there are trees to cut down, but it is hard and dirty work, and the smoke makes the air dirty too.

If you did live on a tiny tropical island, you might see the sun high overhead. What if you could take its powerful rays to cook for you? You can.

The pizza box solar oven can reach temperatures of 275 degrees, hot enough to cook food and to kill germs in water. A general rule for cooking in a solar oven is to get the food in early and don't worry about overcooking. Solar cookers can be used for six months of the year in northern climates and year-round in tropical locations. Expect the cooking time to take about twice as long as conventional methods, and allow about one half hour for the oven to preheat.

What You'll Need

- Recycled pizza box
- Black construction paper
- Aluminum foil
- Clear plastic (heavy plastic laminate works best)
- Non-toxic glue, tape, scissors, ruler, magic marker
- Wooden dowel or straw



How to Make Your Pizza Box Oven

Draw a one inch border on all four sides of the top of the pizza box. Cut along three sides leaving the line along the back of the box uncut.

Diagram # 1

Form a flap by gently folding back along the uncut line to form a crease. (Diagram #2). Cut a piece of aluminum foil to fit on the inside of the flap. Smooth out any wrinkles and glue into place. Measure a piece of plastic to fit over the opening you created by forming the flap in your pizza box. The plastic should be cut larger than the opening so that it can be taped to the underside of the box top. Be sure the plastic becomes a tightly sealed window so that the air cannot escape from the oven interior.

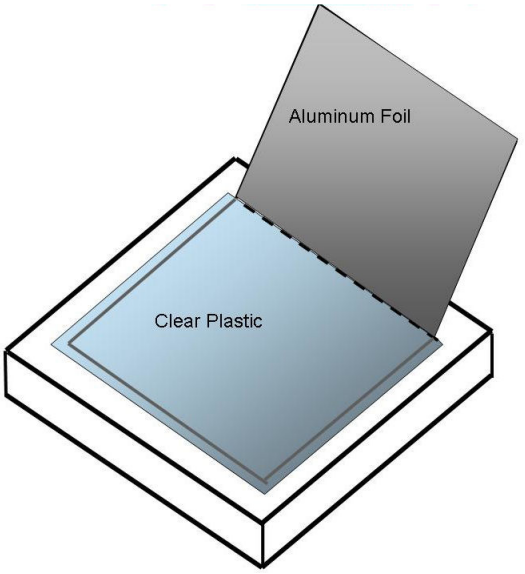
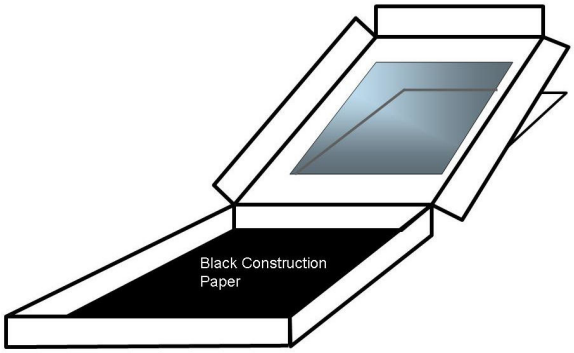
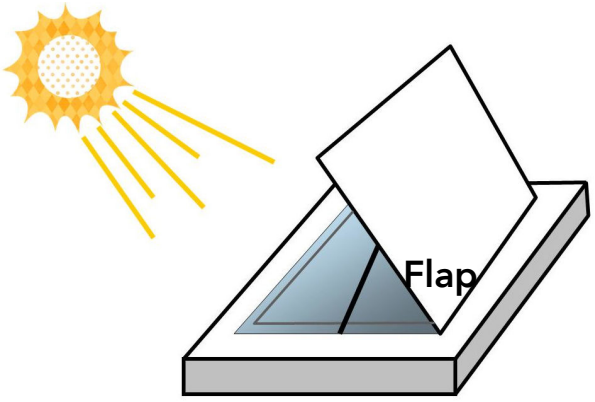


Diagram #2



Cut another piece of aluminum foil to line the bottom of the pizza box and carefully glue into place. Cover the aluminum foil with a piece of black construction paper and tape into place. (Diagram #3)

Diagram #3



Close the pizza box top with the window, and prop open the flap with a wooden dowel, straw, or other device and face towards the sun. (Diagram #4) Adjust until the aluminum reflects the maximum sunlight through the window into the oven interior.

Your oven is ready! You can try heating s'mores, English muffin pizzas, or hot dogs, or even try baking cookies or biscuits. Test how hot your oven can get using a simple oven thermometer!

Diagram #4

S'mores: Stack a piece of chocolate bar and a marshmallo between two graham crackers and heat until melted.

Hot dogs: Hot dogs come fully cooked from the package. Just heat until they are warm.

This solar oven has been adapted from many designs Please feel free to improvise!

Plans and instructions courtesy of Solar Now, Inc., (www.solarnow.org) of Beverly, MA, dedicated to promoting education about renewable energy and the environment.

Balloon Rocket Cars

14

Activity Description:
Cars powered by balloons.

14

Cutting

Cu

Scissors

Fixturing

Fx

Rubber Bands

Measuring

Ms

Straws

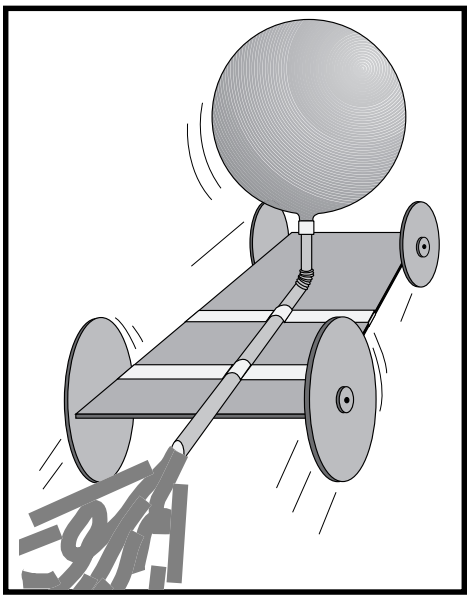
Joining

Jo

Tape

Other Materials

Cardboard, cofee stirrers or toothpicks, bottle caps, foam disks, or cardboard for wheels



Teacher Information

Rocket Car

Objectives:

- To construct a rocket propelled vehicle.
- To experiment with ways of increasing the distance the rocket car travels.

Description:

Students construct a balloon-powered rocket car from a styrofoam tray, pins, tape, and a flexible straw, and test it along a measured track on the floor.

Science Standards:

Science as Inquiry
Physical Science - Position and motion of objects
Science and Technology - Abilities of technological design
Unifying Concepts and Processes - Change, constancy, and measurement

Science Process Skills:

Observing
Communicating
Measuring
Collecting Data
Inferring
Making Models
Interpreting Data
Making Graphs
Controlling Variables
Defining Operationally
Investigating

Mathematics Standards:

Mathematics as Problem Solving
Mathematics as Communication
Mathematics as Reasoning
Mathematical Connections
Measurement
Statistics and Probability
Patterns and Relationships

Management:

This activity can be done individually or with students working in pairs. Allow 40 to 45 minutes to complete the first part of the activity. The activity stresses technology education and provides students with the opportunity to modify their car designs to increase performance. The optional second part of the activity directs students to design, construct, and test a new rocket car based on the results of the first car. Refer to the materials list and provide what is needed for making one rocket car for each group of two students. Styrofoam food trays are available from butchers in supermarkets. They are usually sold for a few cents each or you may be able to get them donated. Students can also save trays at home and bring them to class.

Materials and Tools:

- 4 Pins
- Styrofoam meat tray
- Masking tape
- Flexible straw
- Scissors
- Drawing compass
- Marker pen
- Small round party balloon
- Ruler
- Student Sheets (one set per group)
- 10 Meter tape measure or other measuring markers for track (one for the whole class)

If compasses are not available, students can trace circular objects to make the wheels or use the wheel and hubcap patterns printed on page 38.

If using the second part of the activity, provide each group with an extra set of materials. Save scraps from the first styrofoam tray to build the second car. You may wish to hold drag or distance races with the cars. The cars will work very well on tile floors and carpeted floors with a short nap. Several tables stretched end to end will also work, but cars may roll off the edges.

Although this activity provides one car design, students can try any car shape and any number, size, and placement of wheels they wish. Long cars often work differently than short cars.

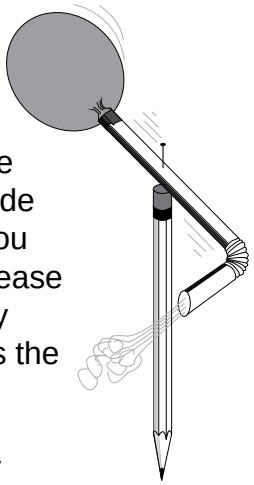
Background Information:

The rocket car is a simple way to observe Newton's Third Law of Motion. (Please refer to pages 15-16 of the rocket principles section of this guide for a complete description.) While it is possible to demonstrate Newton's Law with just a balloon, constructing a car provides students with the opportunity to put the action/reaction force to practical use. In this case, the payload of the balloon rocket is the car. Wheels reduce friction with the floor to help cars move. Because of individual variations in the student cars, they will travel different distances and often in unplanned directions. Through modifications, the students can correct for undesirable results and improve their cars' efficiency.

Making a Rocket Car:

1. Distribute the materials and construction tools to each student group. If you are going to have them construct a second car, tell them to save styrofoam tray scraps for later. Hold back the additional materials for the second car until students need them.
2. Students should plan the arrangement of parts on the tray before cutting them out. If you do not wish to use scissors, students can trace the pattern pieces with the sharp point of a pencil or a pen. The pieces will snap out of the styrofoam if the lines are pressed deeply.
3. Lay out a track on the floor approximately 10 meters long. Several metric tape measures joined together can be placed on the floor for determining how far the cars travel. The students should measure in 10 centimeter intervals.
4. Test cars as they are completed. Students should fill in the data sheets and create a report cover with a drawing of the car they constructed.
5. If a second car will be constructed, distribute design pages so that the students can design their cars before starting construction.

Extensions:



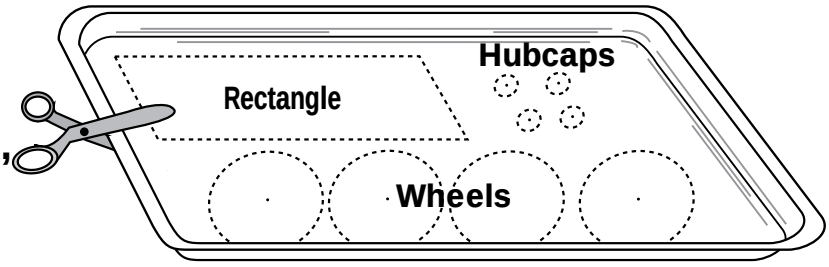
- Tie a loop of string around the inflated balloon before releasing the car. Inflate the balloon inside the string loop each time you test the cars. This will increase the accuracy of the tests by insuring the balloon inflates the same amount each time.
- Make a balloon-powered pinwheel by taping another balloon to a flexible straw. Push a pin through the straw and into the eraser of a pencil. Inflate the balloon and watch it go.

Assessment:

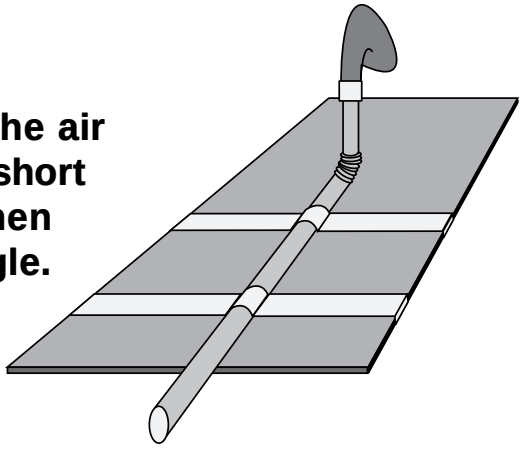
Students will create "Rocket Car Test Reports" to describe test runs and modifications that improved their car's efficiency. Use these reports for assessment along with the design sheet and new car, should you choose to use the second part of this activity.

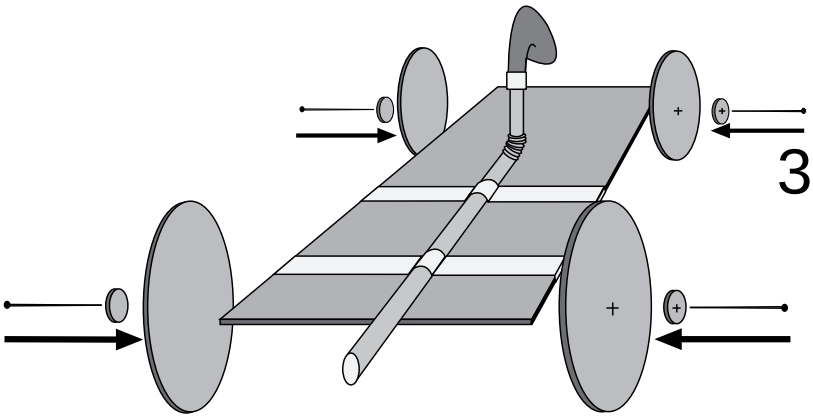
How To Build A Rocket Car

1. **Lay out your pattern on a styrofoam tray. You need** 1 **rectangle,** 4 **wheels, and** 4 **hubcaps. Use a compass to draw the wheels.**

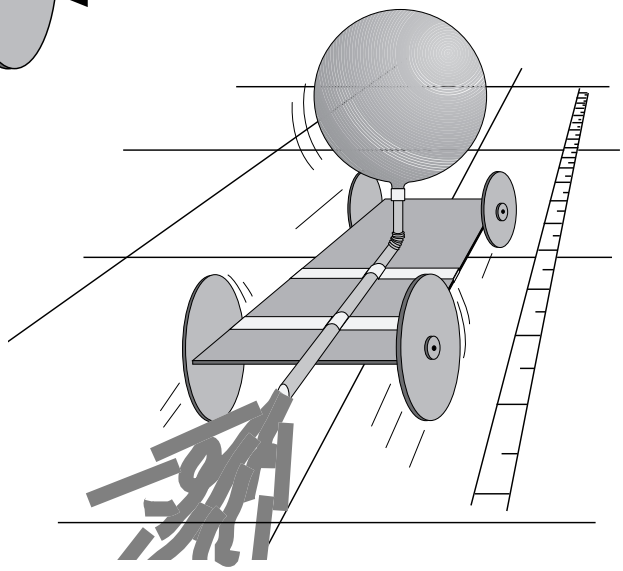


2. **Blow up the balloon and let the air out. Tape the balloon to the short end of a flexible straw and then tape the straw to the rectangle.**





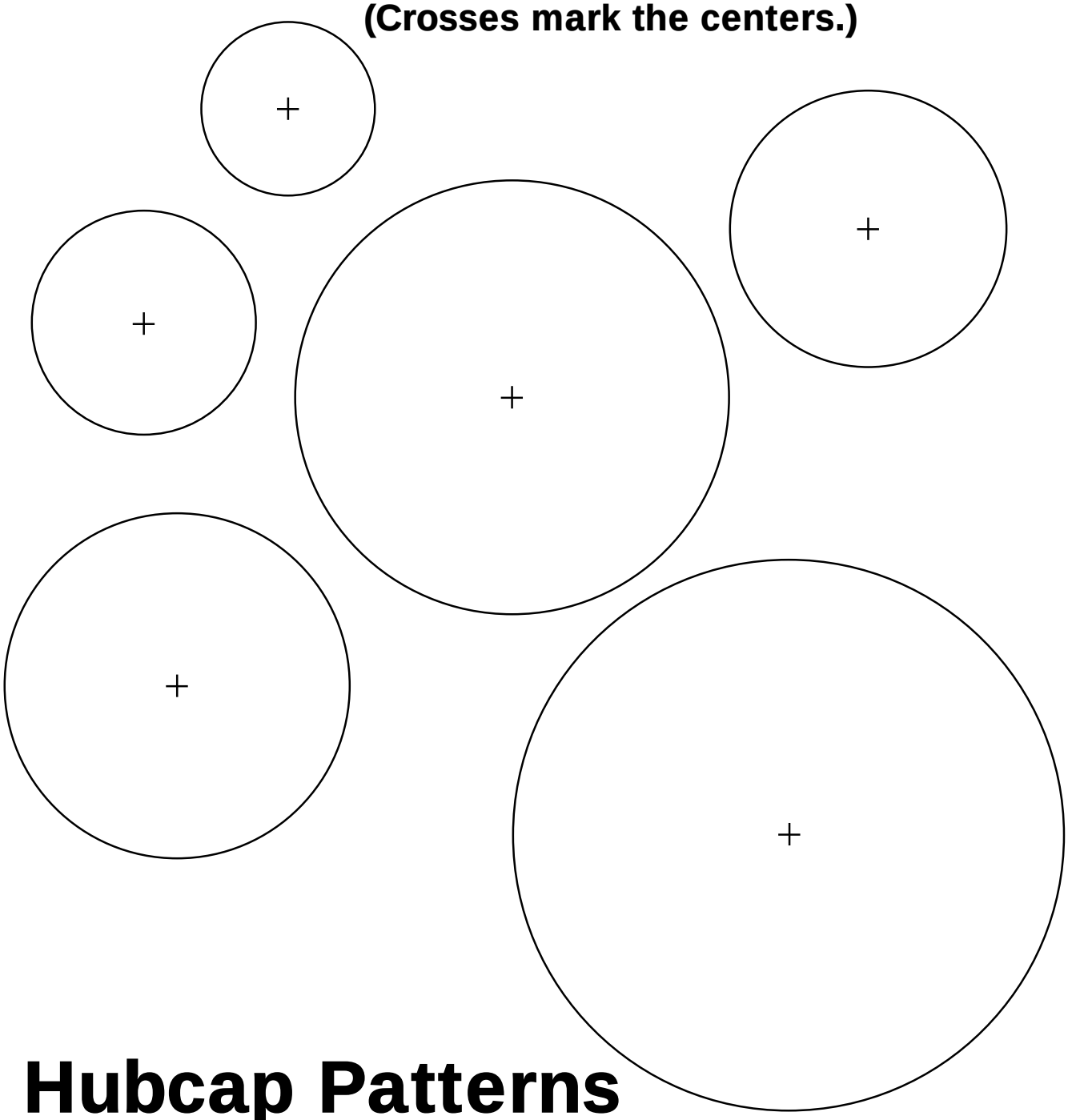
3. **Push pins through the hubcaps into the wheels and then into the edges of the rectangle.**



4. **Blow up the balloon through the straw. Squeeze the end of the straw. Place the car on floor and let it go!**

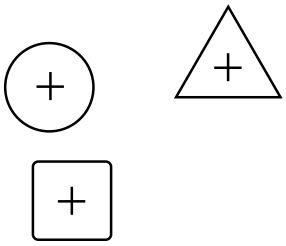
Wheel Patterns

(Crosses mark the centers.)



Hubcap Patterns

(Crosses mark the centers.)



Rocket Car
Test Report

Draw a picture of your rocket car.

BY

_____

_____

DATE: _____

Rocket Car Test Report

Place your rocket car on the test track and measure how far it travels.

1. Describe how your rocket car ran during the first trial run.
   (Did it run on a straight or curved path?)

   _____

   How far did it go? _____ centimeters

   Color in one block on the graph for each 10 centimeters your car traveled.

2. Find a way to change and improve your rocket car and test it again.

   What did you do to improve the rocket car for the second trial run?

   _____

   _____

   How far did it go? _____ centimeters

   Color in one block on the graph for each 10 centimeters your car traveled.

3. Find a way to change and improve your rocket car and test it again.

   What did you do to improve the rocket car for the third trial run?

   _____

   _____

   How far did it go? _____ centimeters

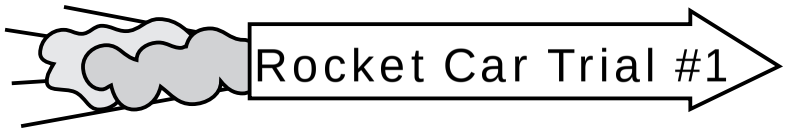
   Color in one block on the graph for each 10 centimeters your car traveled.

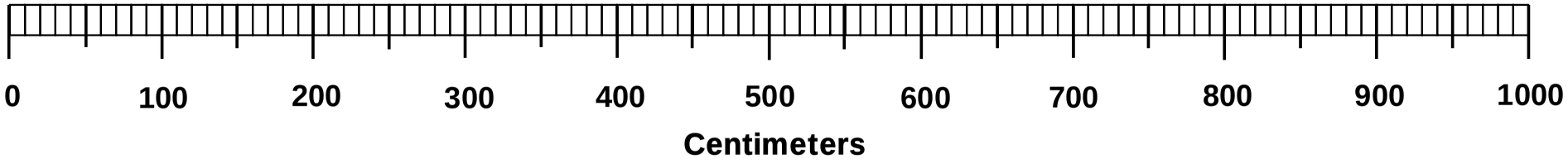
4. In which test did your car go the farthest? _____

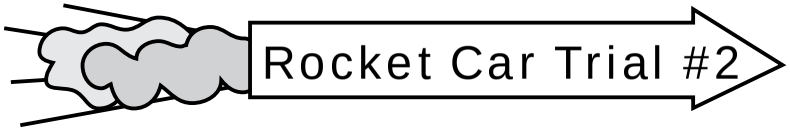
   Why? _____

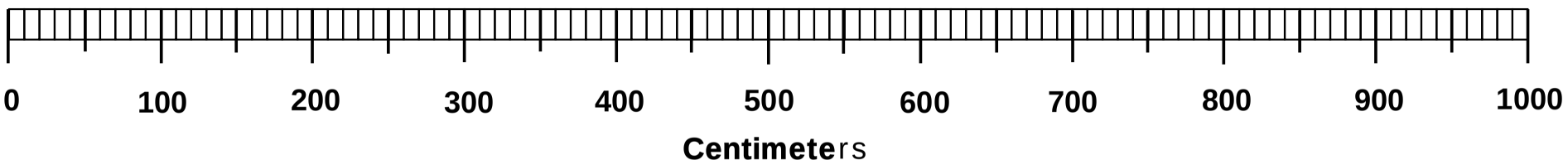
   _____

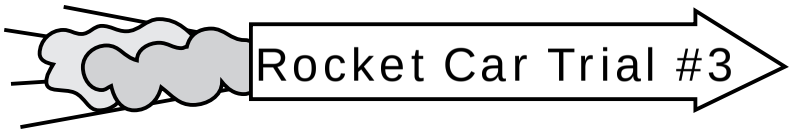
Rocket Car Data Sheet

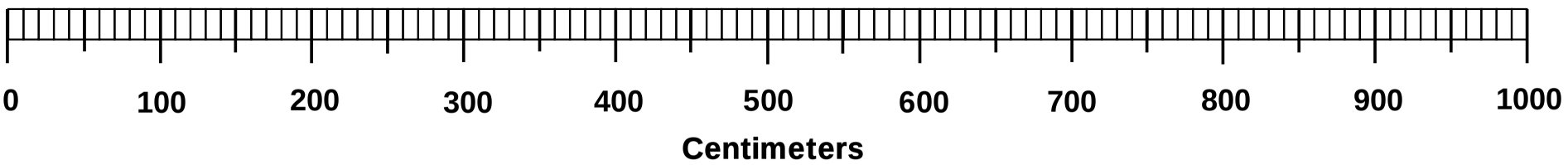












DESIGN SHEET

Design and build a new rocket car based on your earlier experiments.

Front View

Top View

Side View

Egg Carton Engineering

15

Activity Description:
Scribbling machines are motorized contraptions that move in unusual ways and leave a mark to trace their paths. They are made from simple materials and set in motion by a vibrating offset motor causing them to bounce, spin, bump and move in interesting ways.

15

Cutting

Scissors

Cutting

AA Battery

Cutting

Craft Paper
Popsicle Sticks
Pipe Cleaners

Cutting

Glue
Glue Sticks

Cutting

Masking Tape

Cutting

Markers

Other Materials
Popsicle sticks, wood skewer sticks, pipe cleaners, wire, nuts, washers, wire strippers, screwdriver, googly eyes

EGG CARTON ENGINEERING

Engineering task: make an airplane for an egg crate that will fly

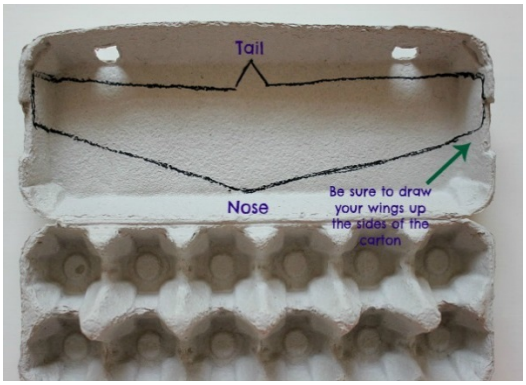
Supplies:

Hot glue gun and hot glue
Cardboard egg crate
Scissors
Pencils
Tape
Objects for weight balance—paperclips, small rocks, etc.

Instructions:

Step 1: Design

Have students create and decide on the design on their airplane. If making a traditional plane shape, make the cockpit from two egg crate pieces glued together. Cut nose from one of the protruding pieces that separates the eggs. The rest of the plane can be cut out from the flat part of the egg carton. Draw outlines of where the cuts should be on the egg carton prior to cutting.



Step 2: Cutting

Cut out all parts of the plane from the egg carton/

Step 3: Construction & Engineering

Encourage students to think of balancing all parts of the plain so that it can flight (i.e. does the cockpit feel heavier than the rest of the plane? How can you fix this?). Encourage engineering design and thinking to solve problems during this construction phase—if the cockpit is too heavy, should you add weight the back end with paper clips?

Use hot glue to glue all of the plane pieces together. Tape can also be used if glue guns are not available.

Step 4: Testing

Encourage students to test their airplane. Is it gliding well? Are there issues that still need to be addressed? Does there need to be a lighter cockpit? Are the front and back counterbalanced? Do the wings need to be larger? Issues with the rudder?

Paper Plate Pinball

16

Activity Description:
Challenge students to create a pinball-like marble maze game using a paper plate, some basic craft supplies, and marbles. Encourage students to create cool structures on their paper plates for their marbles to go through as they tilt the plate different directions using their hands.

16

Cutting

Cu

Scissors

Measuring

Ms

Straws

Arts & Crafts

Ar

Craft Paper
Pipe Cleaners

Brainstorm

Br

Markers
Colored Pencils

Joining

Jo

Tape

Fixturing

Fx

Paper Clips
Small Rubber Band

Other Materials
Paper plates, marbles

PLATE PINBALL

Challenge students to create a pinball-like marble maze game using a paper plate, some basic craft supplies, and marbles. Encourage students to create cool structures on their paper plates for their marbles to go through as they tilt the plate different directions using their hands.

Materials for Paper Plate Pinball Challenge

Paper plates (The ones with high edges work best)
Scissors
Construction paper
Tape
Markers
Marbles
pipe cleaners, straws

Directions for Paper Plate Pinball Challenge

If your students are not familiar with pinball machines, watch some pinball machine YouTube videos together. Notice the different ramps, bumpers, and other pinball machine parts.

1. Provide each child with one paper plate, marble and access to materials listed.
2. Let the kids get busy creating and testing out their pinball machines with marbles.
3. After students have had time playing their pinball game, encourage students to exchange pinball plates to experience other challenges!

Paper Plate Bucky Balls

17

Activity Description:
Students will create a 20-sided geodesic sphere by folding circular paper plates into interlocking triangles to form a sphere. Students will transform paper plates into triangles to create spheres. Through the folding and stapling, students will create a 3-D object from a 2-D material.

Arts & Crafts

Ar

Craft Paper

Fixturing

Fx

Stapler

17

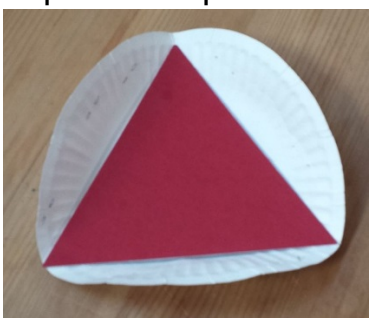
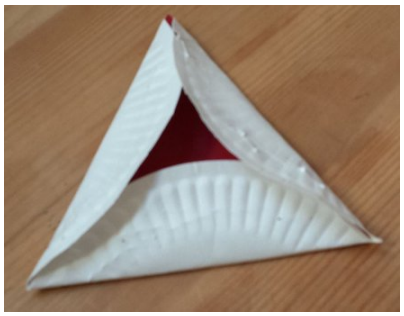
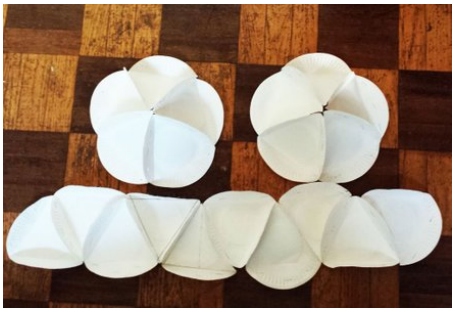
Other Materials
Paper plates

Paper Plate BuckyBalls

Students will create a 20-sided geodesic sphere by folding circular paper plates into interlocking triangles to form a sphere. Students will transform paper plates into triangles to create spheres. Through the folding and stapling, students will create a 3-D object from a 2-D material.

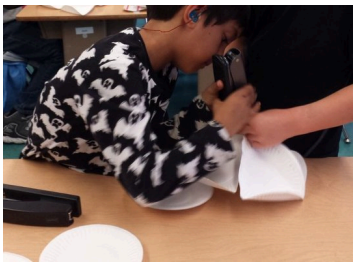
MATERIALS:
6 inch paper plates (the thin, white, inexpensive ones) - 20+ per student
5-inch equilateral triangle folding template cut from cardstock - 1 per student
Stapler

Step 1: Cut Template and Demonstration

1. Each student cut a 5-inch equilateral triangle folding template cut from cardstock
2. Demonstrate to students how to use the folding triangle template. With the template centered on the plate, use one hand to hold it still and the other hand to crease each side. Remove the template and strengthen each crease by rubbing with a finger a second time.
3. Have students fold at least 5 plates before beginning to staple together. To make a sphere, students should piece together 5 triangles into a star pattern. Make a 2nd star pattern and then piece together 10 triangles in a long row. The long row should be stapled like a "belt" with the two star pattern circles on the top and bottom.

Step 2: Tinkering Time



Encourage students to work together. Many will find that it's easier for one student to hold the plates while the second student staples.

Lego Challenges

18

Activity Description:
Have students pick lego cards with a variety of challenges on them. Adapt the cards to create additional challenges that could include time constraints, amount of legos you can use etc...

Legos

Le

Lego Boxes

18

Inspiring Lifelong Learners

LEGO® Education Solutions for primary school provide the engaging, hands-on experiences students need to explore core STEM concepts and link them to real-life phenomenon. LEGO® bricks, programming tools, and supporting lesson plans for teachers ignite students natural curiosity, helping them develop essential communication, creativity, collaboration, and critical thinking-skills in a fun and exciting way. Tactile, flexible solutions grow with students as they problem-solve and discover how science, technology, engineering, and math affect their everyday life.

LEGO Education also brings this creative spirit to robotics clubs, coding programs, and maker spaces. With fun new Maker activities, LEGO Education makes the joy of discovery even more accessible.

https://education.lego.com/en-us/elementary/intro

Build Students' Skills for Any Challenge

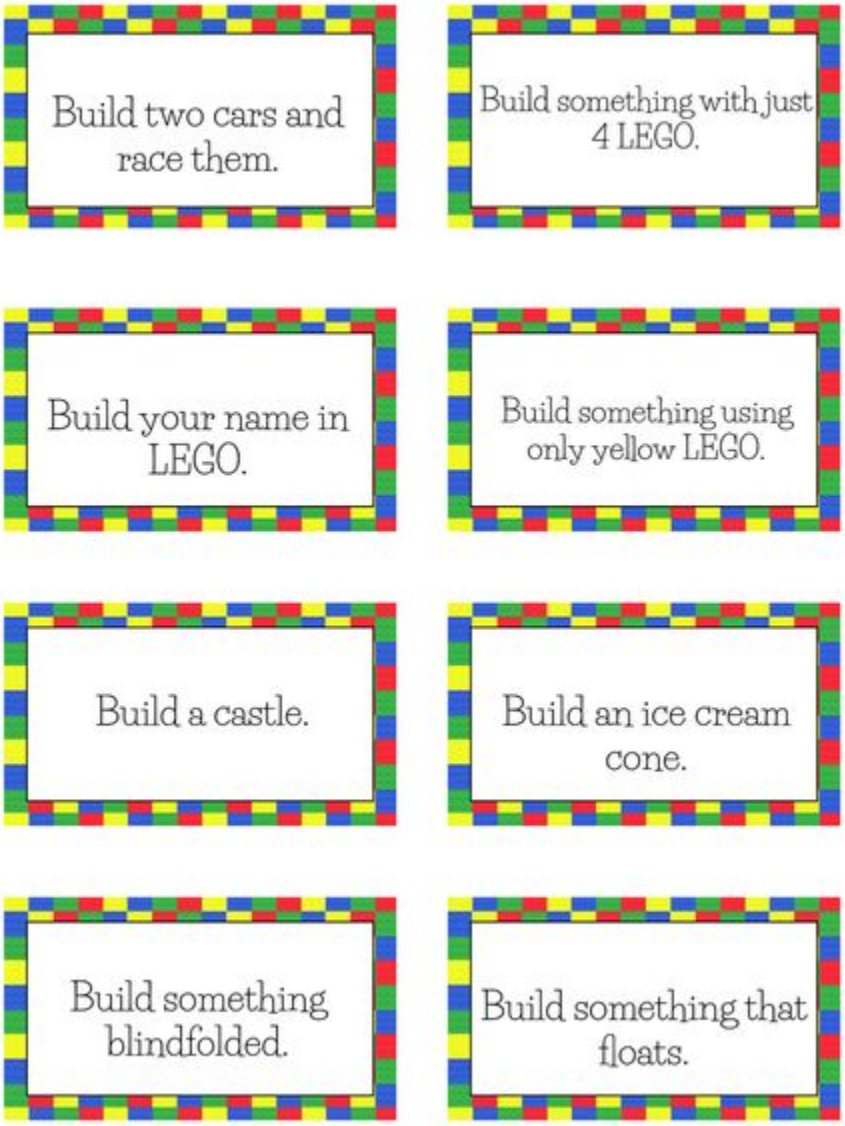
Hands-on LEGO® Learning is a universal language and LEGO® Education solutions for secondary school grow with students as they engage at every level, providing hands-on experiences that stimulate communication, creativity, collaboration, and critical thinking skills. When students learn with LEGO® bricks, coding tools, and supporting lesson plans for teachers, they ignite their natural curiosity and sharpen their scientific inquiry, engineering design, and data analysis skills — so they can succeed in their STEM classes today and realize their full potential as digital citizens and leaders tomorrow.

LEGO Education also brings this creative spirit to robotics clubs, coding programs, and maker spaces. With fun new Maker activities, LEGO Education makes the joy of discovery even more accessible.

https://education.lego.com/en-us/middle-school/intro

LEGO CHALLENGE CARDS

Find free, printable LEGO challenge cards online for elementary and secondary students. For example…



K'nex Challenges

19

Activity Description:
Have students pick knex cards with a variety of challenges on them. Adapt the cards to create additional challenges that could include time constraints, amount of knex you can use etc...

Knex

Kn

K'nex Box

19

Contents

1. Introduction

The K'NEX construction kit has been used successfully by UK Primary Schools since 1995. Initially, K'NEX was seen just as an innovative and exciting way of helping pupils to understand the Design and Technology curriculum, but increasingly K'NEX has been put to many different uses in primary schools, including:

- Design and Technology curriculum
- Science curriculum
- Maths curriculum
- History curriculum
- ICT curriculum
- Early Years
- Children with special needs
- Gifted and talented children
- After-school clubs and Lunchtime clubs
- School-based family learning
- Staff team-building

The purpose of this short guide is to explain how K'NEX can be used to best effect in Primary Schools, in all the above settings, from Nursery to Year 6.

1.1 Who is this guide for?

This Guide has been written for everyone who has an interest in Primary School education, including:

- Headteachers
- Teachers
- Nursery Nurses
- Learning Support Assistants
- After-school Club leaders
- Parents

1.2 What is K'NEX

K'NEX is one of the most successful construction kits in the world, second in popularity only to Lego. It is based around a series of "rods", which can be joined together by "connectors" such as the one shown in our logo. Once they have mastered using these simple components, children and adults alike can use their imagination to make potentially millions of different working models.

It is ease of use and versatility that make K'NEX such a good investment for educational purposes, whether in schools, home education, children's clubs, childcare schemes, family learning or post-16 education. You will find that there is no age limit for enjoying K'NEX - it is suitable for all ages from 5 to 95. There is also a version of K'NEX with bigger components for 3 to 7 year olds, called Kid K'NEX, as shown in the photo.

Building K'NEX models helps children and adults to understand subjects such as structures, forces and simple machines, in the way that Meccano educated an earlier generation. However, Meccano was aimed and advertised exclusively at boys, whereas both girls and boys find K'NEX easy and enjoyable to use. K'NEX can also be used effectively with adults, once they have mastered the basic techniques for joining rods and connectors together, and overcome any initial nervousness.

A further strength of K'NEX is that, when used to set Challenges, it can help both children and adults to develop skills such as innovation skills, problem-solving skills and team-working skills. These are skills that are much sought after by employers. It is also worth remembering that even though educational organisations use K'NEX because of its high educational value, children and adults enjoy using K'NEX simply because it is fun. This makes K'NEX a good vehicle for engaging hard-to-reach pupils, such as disaffected pupils and pupils with behavioural and emotional difficulties.

Version 1.1 12/10/04

Author Andy Shercliff of the K'NEX UK User Group, a not-for-profit division of 4children2enjoy Ltd

Email info@knexusergroup.org.uk

Website www.knexusergroup.org.uk

2. K'NEX in the KS1 and KS2 curriculum

This section describes how Primary Schools are able to use K'NEX in the National Curriculum at Key Stages 1 and 2.

2.1 Why use K'NEX at KS1 and KS2?

K'NEX is a versatile construction system, that can help Primary Schools meet the common requirements of the National Curriculum at KS1 and KS2, including:

- Communication skills
- Mathematical skills
- Problem-solving skills
- Creative skills

Not only is K'NEX "educational", but pupils also regard it as "fun and exciting", which helps to ensure that all pupils in a class often stay involved and perform to the best of their ability when a K'NEX project is being completed.

There are very few barriers to pupils using K'NEX. All they need to learn are a few basic techniques for joining rods and connectors together. Time and again, teachers find that pupils excel at K'NEX, even if they are poor in other areas, such as literacy. This can be a great advantage in developing the self-esteem of pupils

2.2 K'NEX models from instructions

All K'NEX education sets arrive with step-by-step instructions showing how to build a number of K'NEX models, plus guidance for teachers. Building models from instructions is the best way to learn how to use K'NEX, for both teachers and pupils.

The Appendix contains six K'NEX Instruction Cards, that are designed to allow pupils to build models from a photographic representation. The cards may be printed out, or displayed via a data projector.

2.3 K'NEX challenges

Whilst building models from instructions is in itself educational, the real strength of K'NEX comes when pupils are set *K'NEX challenges*, in which they must build a model without instructions. Six K'NEX challenges are included in the Appendix, and 20 more challenges may be found on the K'NEX User Group website www.knexusergroup.org.uk.

A typical whole-class K'NEX challenge might be delivered as follows:

1. Decide on the K'NEX challenge you are going to provide (eg Crash Helmet challenge)
2. Provide a compartmented tray of K'NEX for every four or six pupils, working in pairs.
3. Give each pair of pupils a copy of the Challenge Card, or, if you prefer, explain the challenge verbally to pupils.
4. If any of the pupils haven't used K'NEX before, explain the "Handy Hints" listed in the Appendix.
5. Each pair of children can then work at their own pace to complete the challenge, to the 1st, 2nd or 3rd level of difficulty.
6. Wander round the classroom, answering any questions, giving the children any assistance they require, and encouraging each pair to work together as a team.
7. When each pair of pupils has completed the challenge to level 1, ask them to demonstrate how it works, and praise them for all their hard work.
8. If there is time, ask the pair of pupils to go on to complete level of difficulty 2, and then 3.
9. At least 15 minutes before the end of the lesson, ask the pupils to show each other the models they have built. Then ask them to dismantle their models, and put the K'NEX back tidily in the tray.

If the challenge chosen is within the capabilities of every pupil, it can be delivered by the teacher alone, but additional staff may be useful if the class includes pupils with special educational needs.

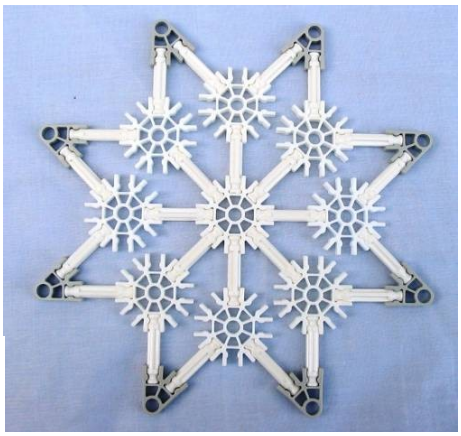
Some of the advantages of the "K'NEX challenge" approach over the "Model-building" approach are that:

- Setting challenges helps to develop the problem-solving skills and creativity skills of pupils
- Setting challenges helps pupils to apply mathematical skills (eg shape, space and measure), rather than just copying them.
- Setting challenges helps ensure that the communication skills developed by pupils extend further into the vocabulary of technology and problem-solving.

2.4 Design and Technology curriculum

K'NEX projects can be designed to meet many of the requirements of the Design and Technology curriculum, including:

- Focused practical tasks
- Use of construction kits
- Designing skills
- Making skills
- Understanding structures
- Understanding simple mechanisms
- Designing and making products
- Computer control (see section 2.7)



K'NEX snowflake

Many K'NEX projects only require K'NEX rods, connectors and wheels, but K'NEX can also be usefully extended with other equipment and materials, for instance:

1. Simple electrical circuits, such as a K'NEX lighthouse, or K'NEX house with burglar alarms
2. Paper or card, such a K'NEX castle with walls, or a K'NEX fan with card blades.
3. Cuddly toys, such as building a K'NEX house or a K'NEX car for a teddy bear.

There are a number of K'NEX education sets that explore particular aspects of the DT curriculum, as shown in Appendix B.

2.5 Science curriculum

K'NEX can be used effectively to help pupils in KS1 and KS2 learn about physical science in a practical way. Such an approach can ensure that pupils gain a better understanding of the principles involved, and retain that knowledge longer than if they had learned it only as theory.

Aspects of the Science curriculum that K'NEX can assist with include:

- Pushes and pulls
- Forces and motion
- Balanced and unbalanced forces
- Wheels, axles and inclined planes
- Pulleys
- Gears
- Motors
- Science investigations

K'NEX challenges based around a science investigation can be particularly effective, for instance:

1. Building a fan with K'NEX which is driven via a gear train, and investigating how different gears can be used in combination to change speed and the direction of motion.
2. Building a catapult out of K'NEX, and adjusting variables in the model to see how far a missile can be fired (eg length of throwing arm, angle of release, starting position).
3. Building a block and tackle out of K'NEX, and investigating the effect of using pulleys in combination.

There a number of K'NEX education sets that are based on Science, as shown in Appendix B.

2.6 Maths curriculum

In building K'NEX models and completing K'NEX challenges, pupils will be applying many different mathematical principles, including:

- Counting components required
- Selecting components by shape and size
- Creating patterns
- Interpreting 2-D diagrams of 2-D or 3-D models
- Using 2-D shapes such as squares, rectangles and triangles
- Using 3-D shapes such as cubes, cuboids, pyramids and prisms
- Applying symmetry
- Using 45 degree and 90 degree angles

Furthermore, K'NEX projects can be designed specifically as a vehicle for developing maths skills in KS1 and KS2 children, for instance:

1. Asking pupils to build K'NEX shapes in different sizes, and then fit the shapes one into another, or calculate the areas and volumes of the shapes.
2. Asking pupils to make a measuring wheel out of K'NEX, and then using it help to create a map.
3. Setting pupils the challenge of building (say) a K'NEX bridge, and then asking them to cost that bridge by assigning a monetary value to each K'NEX piece (eg £10 for a grey rod, £7 for a red rod, etc).

Appendix B gives details of the K'NEX education sets that are based on Maths, and the "UK Guide to using K'NEX for Hands-on Maths".

2.7 IT curriculum

Children now spend a significant amount of their time in school working on computers. K'NEX can be used to broaden the value of computer-based work, by:

1. Setting "K'NEX Computer challenges" that include both a K'NEX building element and an IT element.
2. Carrying out computer control projects in which a computer is used to program and control a K'NEX model.

An example of a K'NEX Computer challenge would be to:

a. ask pupils to building a K'NEX car that will travel down a ramp,

b. investigate how far the car will travel with the ramp set at different angles.

c. record the data collected into a spreadsheet.

d. produce graphs and charts from the spreadsheet.

A further example would be to take photos of a K'NEX model as it is being constructed, and then use Windows Movie Maker to turn the photos into a video

K'NEX swing

showing a K'NEX model apparently building itself.

An example of a K'NEX computer control project would be:

a. To build a 50cm high K'NEX washing machine with a drum and opening door.

b. To program the computer to provide a wash cycle and a spin cycle.

c. To use a magnetic sensor that turns off the washing machine when the door is opened.

The Members Area of our website also includes lots of ideas for using K'NEX for computer control.

2.8 History curriculum

K'NEX challenges can be used as an enjoyable way of providing hands-on history projects to pupils, by asking them to design and build structures and mechanisms from different periods of history, including:

- Castles
- Windmills
- Waterwheels
- Bridges
- Railways
- Cranes
- Piers
- Lighthouses
- Mangonels and catapults
- Helmets and armour
- Swords and shields

The User Group website www.knexusergroup.org.uk includes challenges for a number of the above.

Kid K'NEX character

Kid K'NEX Vehicles set

3. Kid K'NEX in Early Years and KS1

"Traditional" K'NEX can be used by children aged 3 to 5, with supervision, but some children of this age may find that their fingers are not strong enough to join K'NEX rods to connectors.

The manufacturers of K'NEX recognised this problem, and in 2003 brought out the new Kid K'NEX range, as seen in the photos below. Kid K'NEX is suitable for ages 3 to 7, so there is some age overlap.

Kid K'NEX is a version of K'NEX with larger, chunkier rods and connectors that small hands can more easily join together. The bright, almost fluorescent colours appeal to young children, but undoubtedly the most attractive feature of Kid K'NEX are the eyes, ears and feet, as the photo shows.

The eyes can be made to look in any direction by swivelling them, and as the ears are also moveable, children can make Kid K'NEX characters with a whole range of expressions. The ears can also be used as wings, when making flying creatures.

The latest Kid K'NEX sets have also got some new components, including two different sizes of wheel, to make vehicles with.

Primary Schools are already confirming that the new Kid K'NEX fully upholds the K'NEX tradition, of being a product that children love to play with, but from which schools can also gain significant educational benefits. The skills that Kid K'NEX can help enhance include:

- Number skills
- Colour and Shape matching skills
- Problem-solving skills
- Spatial relations
- Strength and coordination
- Self-direction and self-esteem

As with traditional K'NEX, Kid K'NEX is especially valuable when children play with it in small groups. This helps them to develop additional skills such as:

- Language skills
- Cooperative skills

Kid K'NEX characters can also be used to link into other activities that the age group enjoy, such as story telling.

All Kid K'NEX sets come with full-colour instruction cards. Once the children have used these to become familiar with Kid K'NEX, teachers can allow "free play", or guide the children towards specific objectives such as:

1. Build a house for the Kid K'NEX creatures you have built (see Appendix A).
2. Make a table and chair for the Kid K'NEX creatures to use.
3. Make a Kid K'NEX garden.
4. Make a Kid K'NEX bus (if you have the Vehicles set).

The Kid K'NEX education sets currently available may be found in Appendix B.

4. Helping children with special educational needs

Many schools have found that K'NEX can assist some children with special educational needs to develop essential skills. This is not always the case. Every child with special educational needs is different, but we have been told about many different K'NEX projects in which children with special educational needs have done well, and on occasion exceeded the expectations of their teachers.

The following notes may assist:

1. We suggest you start by assessing whether each child is physically able to make use of K'NEX or Kid K'NEX. For instance, some children with visual impairments, or cerebral palsy that affects their arms, or severe learning difficulties may find K'NEX too difficult to use.
2. If you decide you would like to try using K'NEX with a child, we suggest that you use Kid K'NEX for children aged 3 or 4, because less strength is needed to put the pieces together. For children aged 5+, it is usually better to use K'NEX rather than Kid K'NEX, but this is not always the case, and some children with special educational needs may prefer to stay with Kid K'NEX until age 7 or more.
3. You should then think carefully about how you introduce the K'NEX or Kid K'NEX set to the child. Start with easy tasks that are within the child's capability, and give as much assistance as is needed. Early failure may cause the child to reject the whole idea, even though by starting with simple tasks and then gradual development onto more difficult tasks, the child could have achieved excellent results.
4. If you find that the child does enjoy using K'NEX, you might then think about purchasing one or more of the smaller K'NEX education sets specifically for him or her. Prices start at £18 (see Appendix B), and the sets come with instruction books that are designed for educators. The "Discovery Building set" is a good general-purpose starter set.
5. Some children will not wish to develop beyond the stage of building the models in the instruction book you receive with the set, but if they do, you might like to start building the models from the Instruction Cards in this Guide, and then progress onto the K'NEX Challenges.
6. We suggest you also consider encouraging your child to build K'NEX models and carry out K'NEX challenges in a team of two or three children. Such an approach can help develop the communication skills and team-working skills of all the children participating.

Note that not only can K'NEX help children with special educational needs develop the curriculum skills shown in section 2, but achieving success with K'NEX can also help to develop self-esteem and confidence.

5. Helping gifted and talented children

Schools also report that K'NEX challenges are an excellent way of developing the skills and experience of gifted and talented children.

Some of the reasons why K'NEX challenges can work well with gifted and talented children are:

- Completing K'NEX challenges will help gifted and talented children to develop skills in Design and Technology, Maths and Science that go beyond the requirements of the National Curriculum. This broadening of the curriculum will help to keep gifted and talented children interested, and may help them to discover new interests and talents.
- Setting K'NEX challenges to gifted and talented children will help stretch them to the limits of their ability. For instance, the third level of difficulty of some of our challenges are difficult even for adults.
- Completing K'NEX challenges helps gifted and talented children to develop "life skills" such as problem-solving skills, creativity skills and team-working skills. These will be essential in the children's later life, whatever career they eventually follow.

Note that it is not necessary to segregate gifted and talented children before setting them K'NEX challenges. The main reason that all the K'NEX challenges in this Guide and on our website have three levels of difficulty is so that they can be used in classes or groups of mixed ability. For instance, in allowing a KS2 class an hour to complete the Crash Helmet challenge:

1. Children with special needs might only complete level of difficulty 1.
2. The majority of children in the class might complete level of difficulty 2.
3. Gifted and talented children might complete level of difficulty 3.

6. Using K'NEX in after-school clubs and family learning sessions

A school's "investment" in K'NEX and Kid K'NEX can usually be justified solely by the benefits that the school will gain in delivering the National Curriculum during the school day. However, many schools then increase the return on their investment by using K'NEX and Kid K'NEX in non-curricular activities at the school, that might include:

- After-school clubs
- Lunchtime clubs
- Wet weather playtimes
- Playschemes
- Family learning sessions

K'NEX and Kid K'NEX can be used successfully in clubs, playtime and playschemes as a "free play" resource, that children can use as and when they like. Increased educational value, and enjoyment for the children, can be gained if staff on occasion set them K'NEX challenges, such as the ones in Appendix A, and on our website www.knexusergroup.org.uk.

The User Group has also written a £5 20-page "Guide to using K'NEX in Children's clubs and Childcare schemes", which provides lots of extra resources, including a further 10 challenges – see Appendix B.

K'NEX challenges can also be used very effectively to attract parents into primary schools, for instance by setting a Dinosaur challenge after school for parents. It is the User Group's experience that your children will be very keen to bring parents, grandparents and other family members into school to help them complete the challenge, and you may attract parents who have not been into school before. Furthermore, K'NEX challenges develop the skills of adults as well as children, and because of this you may find that local community education organisations are very keen to assist you if are considering any family learning sessions in your school.

The User Group has written a £5 20-page "Guide to using K'NEX for Family Learning", which will assist you if you considering running a K'NEX Family Learning event – see Appendix B.

Appendix A – Photocopiable resources

Handy Hints

- Hint L1 - 3 ways to connect rods and connectors
- Hint L3 - Making corners with blue & purple connectors

Instruction cards

- Bridge
- Frisbee
- Go-kart
- K'NEX House
- Kid K'NEX House
- Weighing Scales

Challenge cards

- Crash Helmet
- Dinosaur
- Ferris Wheel
- Shopping Trolley
- Sundial
- Suspension Bridge

Appendix B – K'NEX Catalogue and Order Form

- Set reviews of popular K'NEX Education sets
- K'NEX Order Form

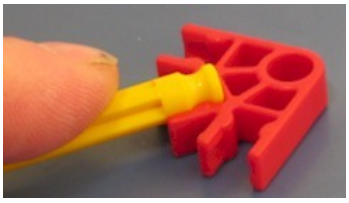
Note that more full-colour Handy Hints, instruction cards and K'NEX challenges are available on www.knexusergroup.org.uk.

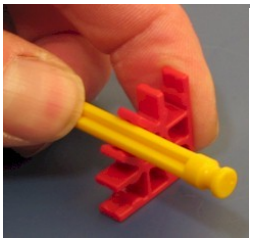
Handy Hints

Hint L1 - 3 ways to connect rods and connectors

There are only three ways to connect K'NEX rods to K'NEX connectors: End-on, Side-on, and Through the hole in the middle. All three are shown in the main picture.

To make an End-on connection, put the connector on the table, position the rod over the side of the slot in which you wish it to go, and push down gently. If it won't connect easily, reposition the rod, and try again. You don't need a lot of strength to make End-on connections.



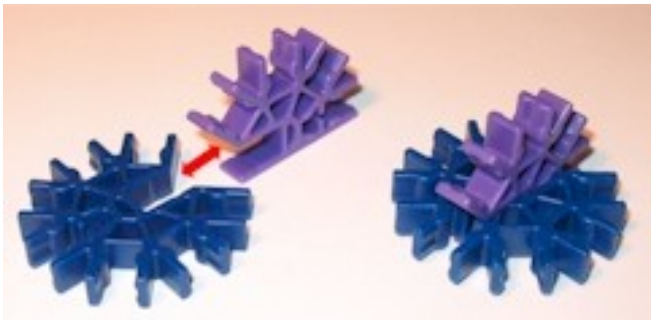


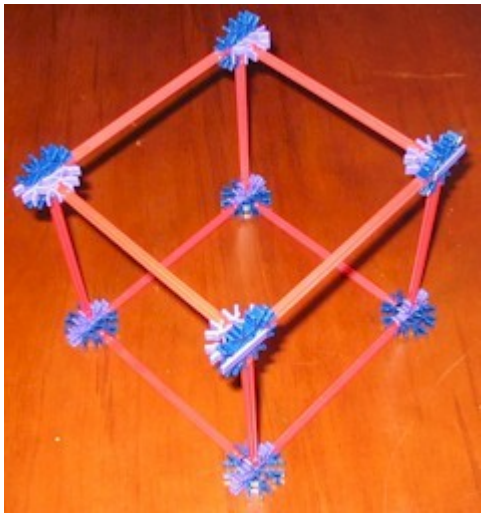
To make a Side-on connection, hold the connector in one hand, the rod in the other, and push the edge of the rod into one of the slots. You will need to push quite hard - young children may find this type of connection difficult. Note that you can only make this type of connection where there are ridges along a rod - so Side-on connections can't be used with the short green rods, or right at the end of any rod.

To make a connection through the hole in the middle, simply put the rod through the hole. Note that a few special-purpose connectors don't have a hole in the middle.

Hint L3 - Making corners with blue & purple connectors

Blue and purple connectors have slots in. This means you can connect two purple connectors to each other; two blue connectors to each other; or a blue connector to a purple connector. To do this, put one slot inside the other slot, and push until you hear a click.



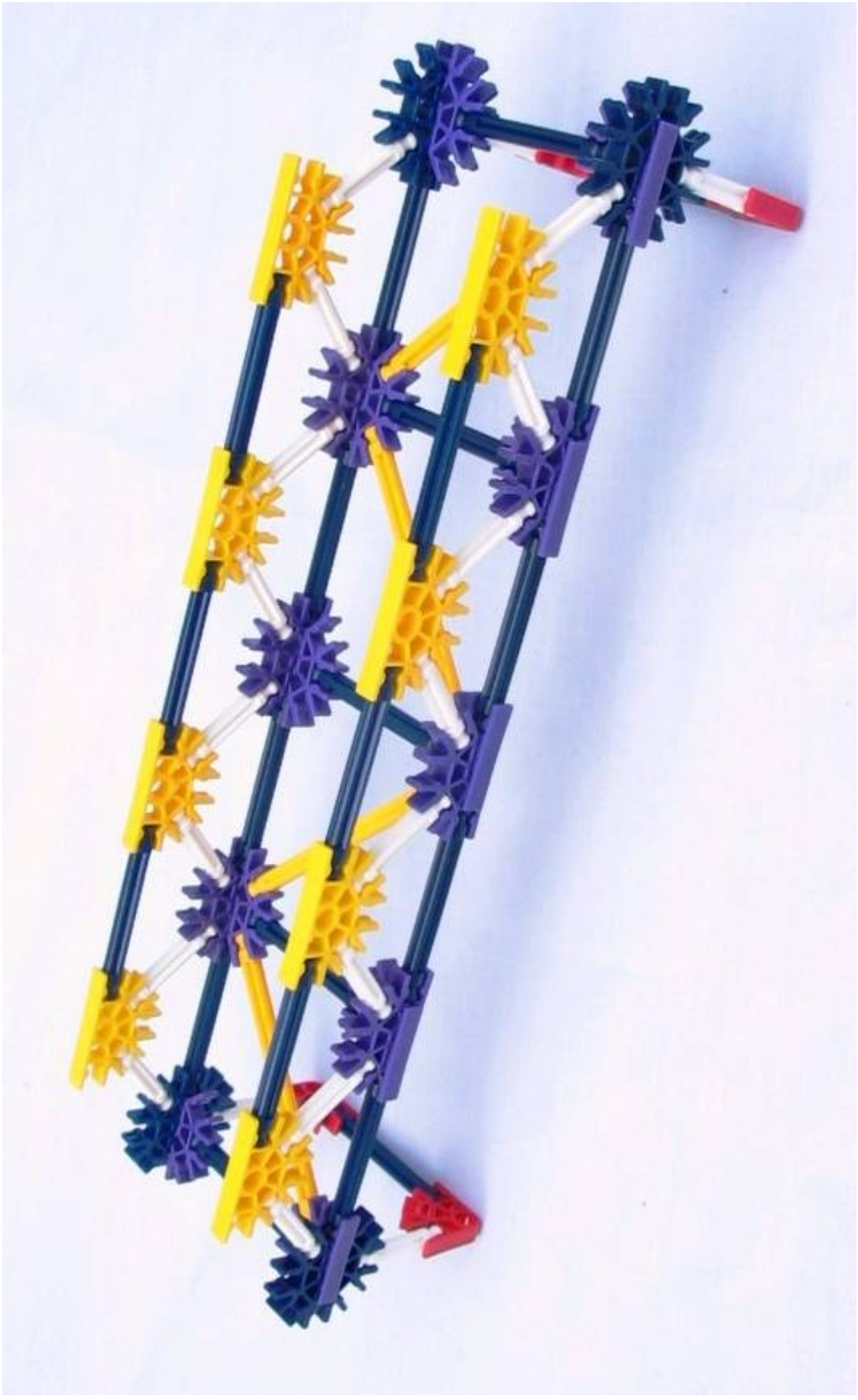


Using blue and purple connectors together like this is very useful if you are making a 3-D K'NEX model which needs corners, which can be a good starting point for some K'NEX challenges.

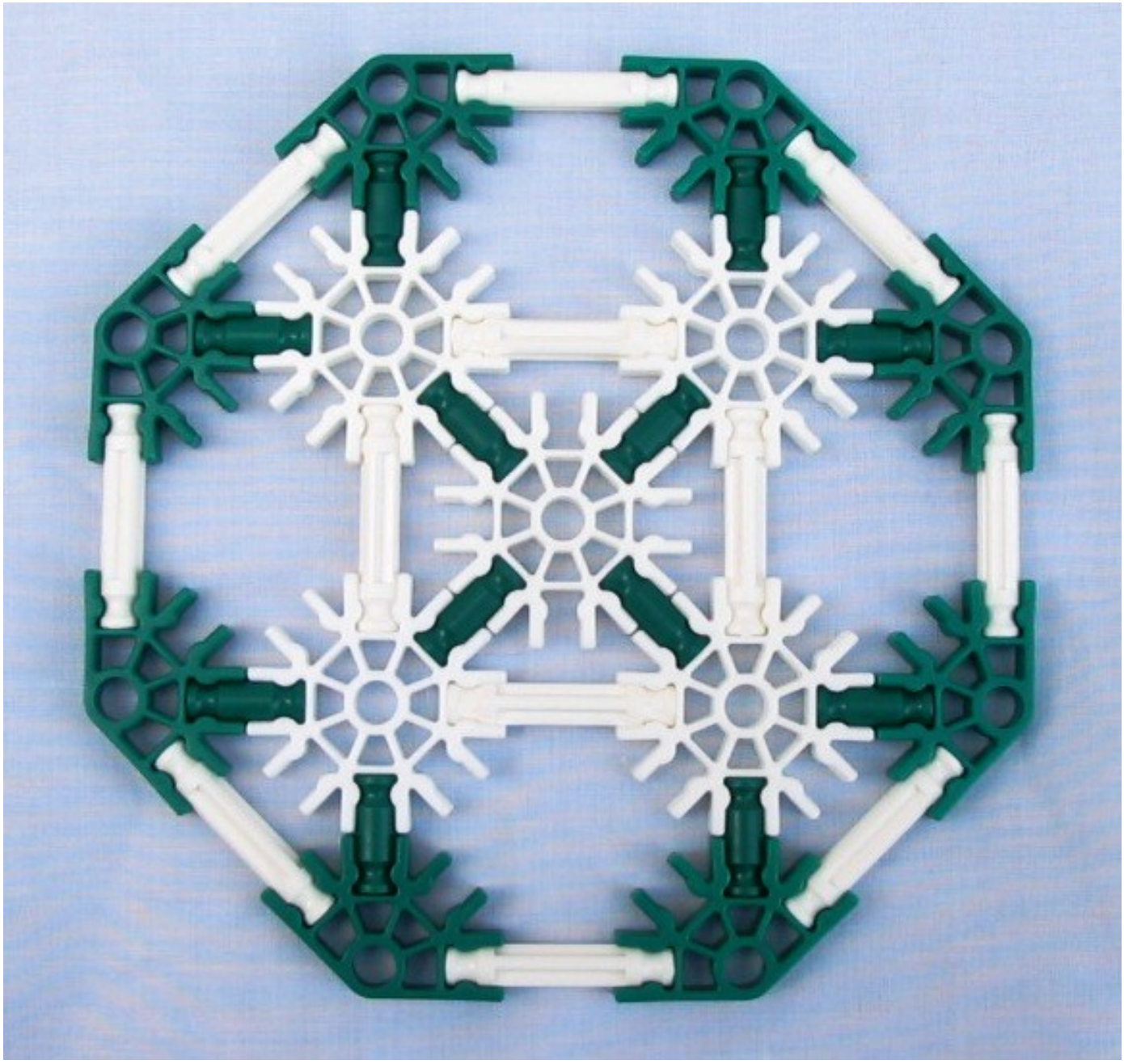
Younger children may find connecting blue and purple connectors together quite difficult. You may prefer to join them together yourself for them, before they start their K'NEX challenge.

Note that in K'NEX sets that have mainly grey components, rather than components in primary colours, the corresponding connectors are mid grey and dark blue.

Bridge Instruction Card

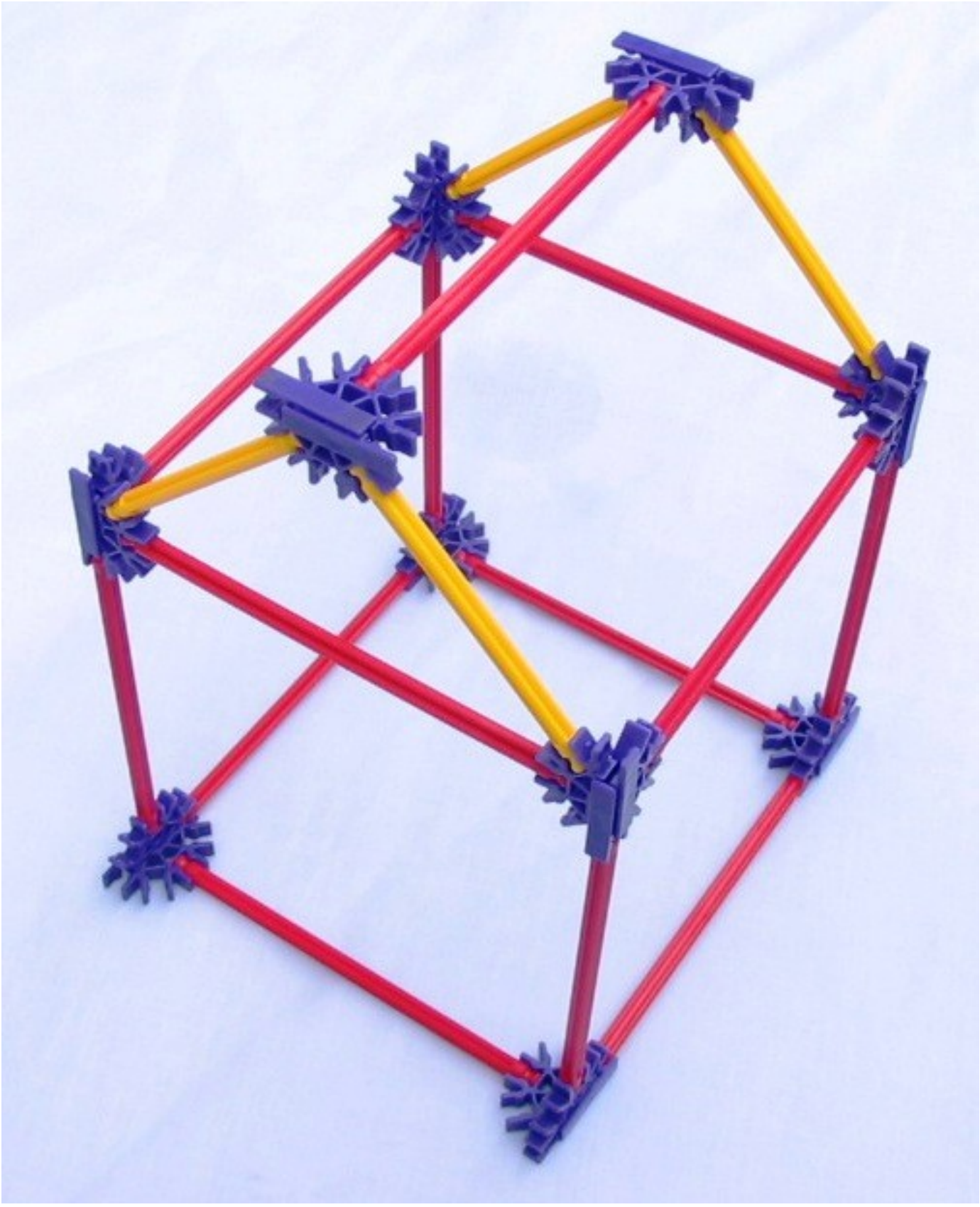


Frisbee Instruction Card

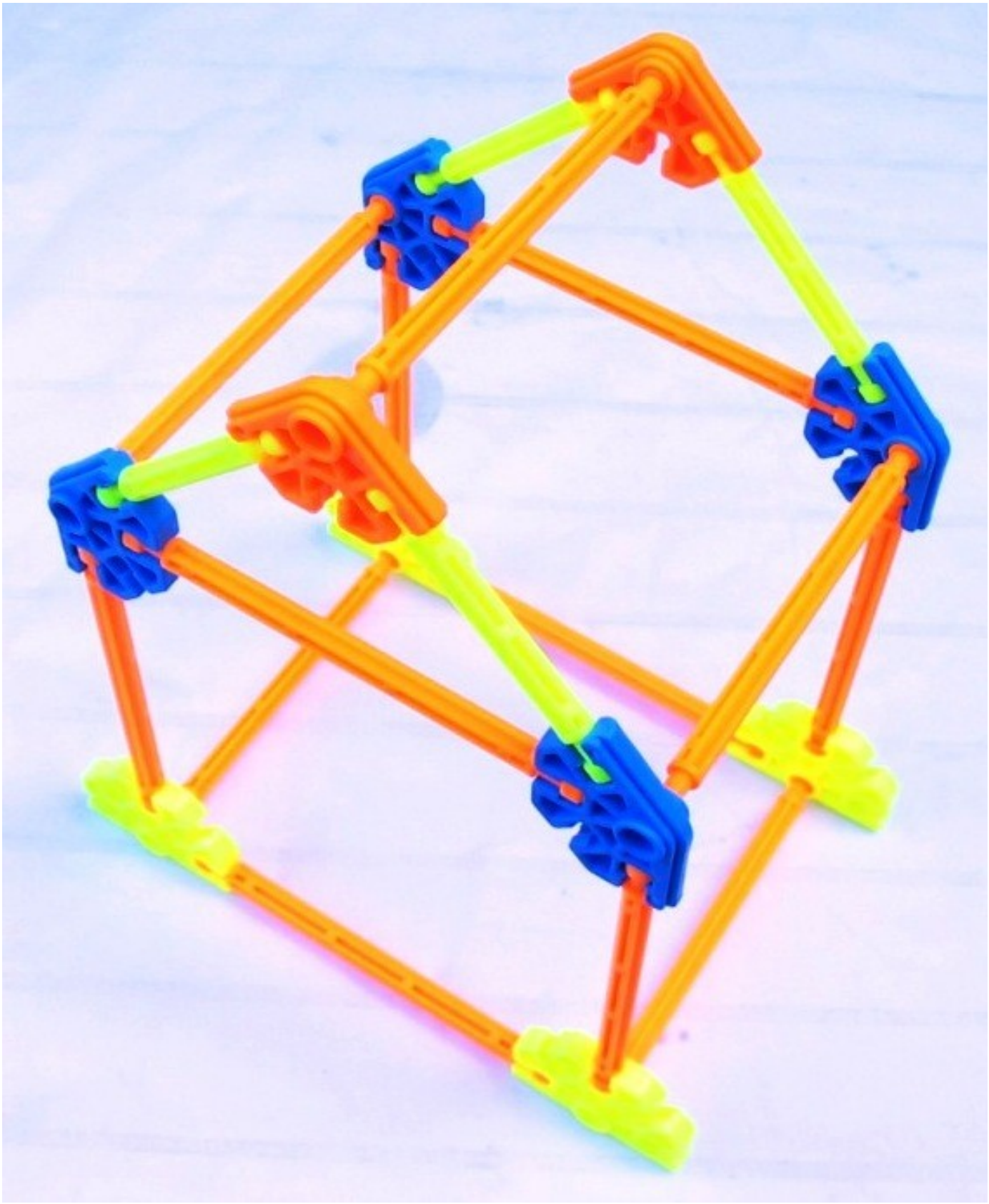


Go-kart Instruction Card

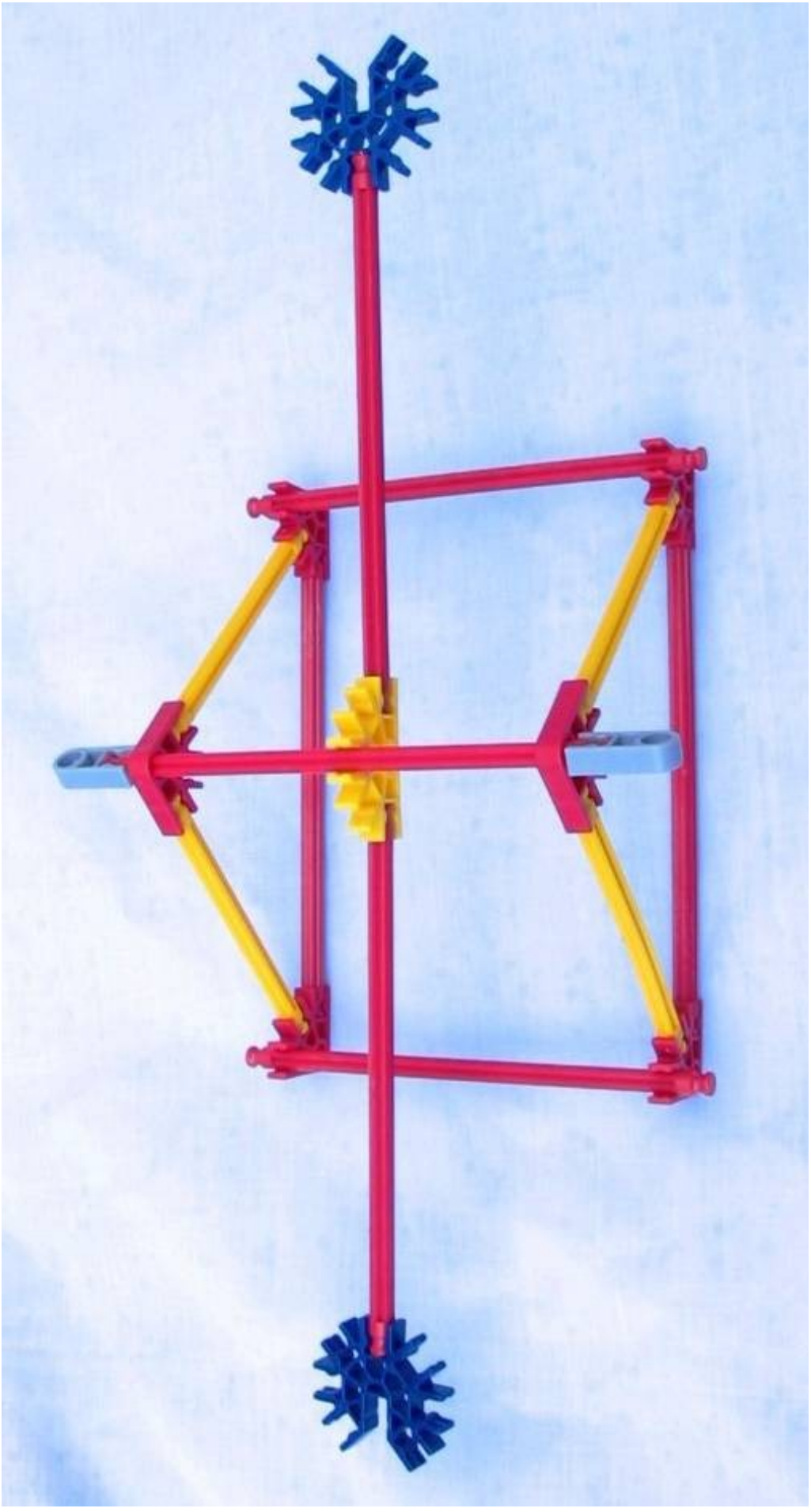
K’NEX House Instruction Card



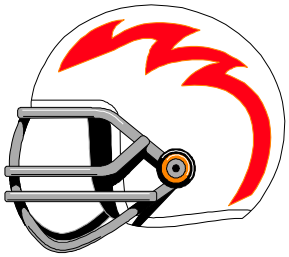
Kid K’NEX House Instruction Card



Weighing Scales Instruction Card



Crash helmet



Whether you're playing American Football, riding a bike or working on a building site, your head is in danger! Can you make a crash helmet that will protect it?

Levels of difficulty	
Level 1 ✓5	Make a simple hat or helmet
Level 2	As level 1, but the helmet does not break if you pat the top of your own head quite hard
Level 3	As level 2, and the helmet does not break if you stand on it (on the floor!)

✓5 = suitable for 5 year olds

How could you make a hat or helmet that is the right shape for your head? What K'NEX rods and connectors could you use to make it fit snugly? How can you make it as strong as possible?

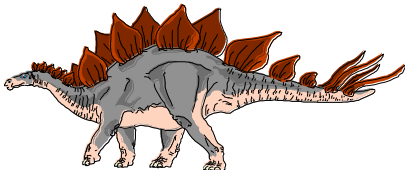
For level 2, test your helmet by putting it on your head and patting it. Did it bend or break? How could you improve the design, so it won't break? Don't be afraid to start again if you want to try a new design.

For level 3, put your hat on the floor, and put your foot on it gently. Does it bend or break? Keep improving your design, so eventually you can stand on it.

Equipment needed: K'NEX set

☺ Handy hints
L1 3 ways to connect rods and connectors
L3 Making corners with blue and purple connectors
L4 Strong 3-D structures

Dinosaur



Exploring with a friend, you discover that a recent earth slip has uncovered a cave, which you follow down for a long way until it opens up into a huge space deep underground. Many animals live in this 'Lost World' which have died out on the surface, including Dinosaurs, which have evolved into clever and friendly animals well adapted to living in the 21st Century. When you return home, though, no-one believes what you have found! You decide to build a working model of the dinosaur, to convince everyone that they exist.

Levels of difficulty	
Level 1 ✓5	Make a simple model of a dinosaur
Level 2	As level 1, plus a mouth which opens and closes
Level 3	As level 2, plus moveable legs, that allow the dinosaur to walk

✓5 = suitable for 5 year olds

Think about the different sorts of dinosaurs you have seen pictures of. Could you try and make a model of one of these out of K'NEX? How big will it be? Does it walk on two legs or four? Will a 21st Century dinosaur be different to one that lived millions of years ago?

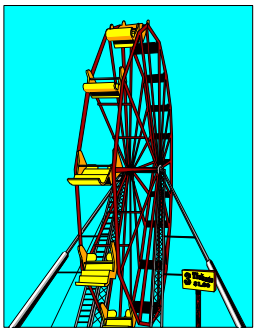
For level 2, think how you could make a mouth out of K'NEX, that can open and close.

For level 3, how could you fasten the dinosaurs to its body in such a way that the dinosaur can "walk"? Will your dinosaur be able to bend its knees?

Equipment needed: K'NEX set

☺ Handy hints
L1 3 ways to connect rods and connectors
L4 Strong 3-D structures

Ferris wheel



It is the school holidays, and a fair is being held near your school. Then a phone call comes - all the fairground rides have been damaged in a big storm and can't be used. The fair opens tomorrow, and we need your help - to build an exciting Ferris wheel for the children to ride on.

Levels of difficulty	
Level 1	Make a simple Ferris Wheel
Level 2	As level 1, with a motor that makes it turn
Level 3	As level 2, with seats that always hang downwards when the wheel turns

What does a Ferris wheel look like? How can you build a frame which is strong enough to hold the wheel up? What design will you use for the wheel? Where will the people sit?

For level 2, think about how you can attach your motor. Will you attach it to the frame or to the wheel?

For level 3, we do not want to have the people turning upside down as they go around the wheel! How can you ensure that the seats are always hanging downwards?

Equipment needed: K'NEX set

For level 2: Battery motor

☺ Handy hints

L1 3 ways to connect rods and connectors

L3 Making corners with blue and purple connectors

L4 Strong 3-D structures

L6 Making rods turn with wheels or connectors

M2 Battery motors

Shopping trolley

Whoever designs a shopping trolley that will always steer the way you want it to go will make a fortune. Could you become an inventor, and design the perfect shopping trolley?

Levels of difficulty	
Level 1 ✓5	Make a simple trolley with four wheels
Level 2 ✓5	As level 1, with a handle to push it by
Level 3	As level 2, with swivel wheels so that the trolley goes in whatever direction you wish

✓5 = suitable for 5 year olds

Have you ever pushed a shopping trolley, or sat in one? What shape was it? Where did the wheels fasten on? Could you make one out of K'NEX - the bigger the better?

For level 2, think how you could make a strong horizontal handle to push it by, just like on real shopping trolley.

For level 3, how could you make your front or rear wheels swivel? Will they swivel independently (as on a real shopping trolley), or will they swivel together? Can you push your trolley by the handle, and steer it in any direction?

Equipment needed: K'NEX set
K'NEX wheels

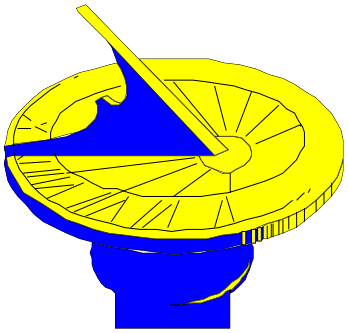
☺ Handy hints

L1 3 ways to connect rods and connectors

L3 Making corners with blue and purple connectors

L5 Wheels and tyres

Sundial



How did people know what time it was before clocks were invented? They sometimes used sundials, in which the sun cast a shadow on a dial marked out with the daylight hours. Could you make one?

First find a sunny day! Then think how you could make an octagon (an eight-sided 2-D shape) out of K'NEX. How can you make a rod stick up at or near the middle at an angle of 45 degrees?

For level 2, how can you make a stand that will hold the sundial about 1m up in air? Will it have feet to give it stability?

For level 3, cut your card to match the octagon shape, and attach it with Bluetac. See how the shadow falls. How can you mark out where the shadow will be for each daylight hour?

Levels of difficulty	
Level 1	Make an octagonal flat surface, with a K'NEX rod sticking out from the middle at a 45 degree angle
Level 2	As level 1, plus a stand to raise it about 1m from the ground
Level 3	As level 2, with a sheet of card on the flat surface marked out to show where the shadow is at each daylight hour

Equipment needed: K'NEX set

For level 3: Sheet of thin white card
Bluetac
Pencil

☺ Handy hints

L1 3 ways to connect rods and connectors

L3 Making corners with blue and purple connectors

L4 Strong 3-D structures

Suspension bridge

Suspension bridges are often used to cross rivers and sea channels which are too wide for any other sort of bridge. Could you make one out of K'NEX?

How can you make a 2-dimensional flat roadway for your bridge? What rods and connectors will you use? Will you need to reinforce the roadway with sideways diagonals to make it stronger?

For level 2, how will you make two strong towers? How tall do you think they should be? Can you make them stable, so they don't fall over easily?

For level 3, how many lengths of string will you need? Where will you fasten them onto the roadway and onto the tower? Will you need to 'anchor' the ends of the roadway?

Levels of difficulty	
Level 1	Make a 1m roadway out of a flat layer of K'NEX rods and connectors
Level 2	As level 1, plus two towers to support the bridge, and place them on either side of a 50cm gap
Level 3	As level 2, and support the roadway from the towers using string

Equipment needed: K'NEX set

For level 3: 5m of string
Blunt-nosed scissors

☺ Handy hints

L1 3 ways to connect rods and connectors

L3 Making corners with blue and purple connectors

L4 Strong 3-D structures

N1 String

Safety: Children should be supervised when using scissors

K’NEX Set reviews

The K’NEX User Group sells a full range of K’NEX education sets, guides and parts in its online shop at **www.knexusergroup.org.uk.** Three of the most popular K’NEX sets are described below, together with an Order Form overleaf.

K’NEX Discovery Building set

A general purpose K'NEX set that is equally effective in the home, schools, clubs, childcare schemes and family learning.

20 different models can be built from instructions, and the set is also a good base for setting simpler K'NEX challenges.

Suggested age range: **5 to 95**

Number that one set can support:

2-4 children, working in pairs

K'NEX Primary Education set

Large general-purpose K'NEX set, with a good mix of classic K'NEX parts. Ideal for use in the home, schools, clubs, childcare schemes and family learning, and excellent value for money.

All the models shown in the photo could be built **at the same time** with this set.

32-page Teacher's guide based on UK Primary curriculum, plus 12 double-sided activity cards, covering the topics: Flat shapes, Patterns, Symmetry, Cubes and cuboids, Designing and building, Working with pulleys and Balancing.

Suggested age range: **5 to 95**

Number that one set can support:

12 children, working in pairs

Kid K’NEX Creatures set

A large Kid K'NEX set that enables children to build a range of "creatures". Good for home, nursery, school and family learning.

Build any 8 of 13 different models simultaneously, from full colour building cards. Includes 14 eyes, 11 dorsal fins and 4 bird feet.

Suggested age range: **3 to 7**

Number that one set can support:

12 children working in pairs

Cardboard Automota

20

Activity Description:
Cardboard automata is a type of mechanical sculpture made of simple materials that lets you bring stories to life. As you build you can explore simple machine elements such as cams, levers, and linkages in a playful way. Making this version of automata lets you quickly get started in building functional mechanisms as your mechancal scupture ideas develop.

20

Cutting

Cu

Scissors

Measuring

Ms

Straws

Arts & Crafts

Ar

Craft Paper
Pipe Cleaners
Feathers
Patterned Paper

Brainstorm

Br

Markers
Colored Pencils

Joining

Jo

Tape

Joining

Jo

Glue
Glue Sticks
Hot Glue Gun

Other Materials
Washers and nuts for weight, skewer sticks,

Textiles Bin for cloth

You can also use the Makedo Cardboard Tools found in the Cr Bin!

CARDBOARD AUTOMATA

Cardboard automata is a type of mechanical sculpture made of simple materials that lets you bring stories to life. As you build you can explore simple machine elements such as cams, levers, and linkages in a playful way. Making this version of automata lets you quickly get started in building functional mechanisms as your mechanical sculpture ideas develop.

TRY IT!

Gather these materials for building your automata

Small cardboard box (approximately 6" x 6")

Thick foamie sheet - 6mm thick craft foamies for the cams and cam followers

Skewer sticks

Paper drinking straw

Masking tape

Scissors

Hot glue gun and glue stick

Washers and nuts (for weight)

Sharpened pencil

Nail or wood screw
(for poking holes in the cardboard)

the tinkering studio

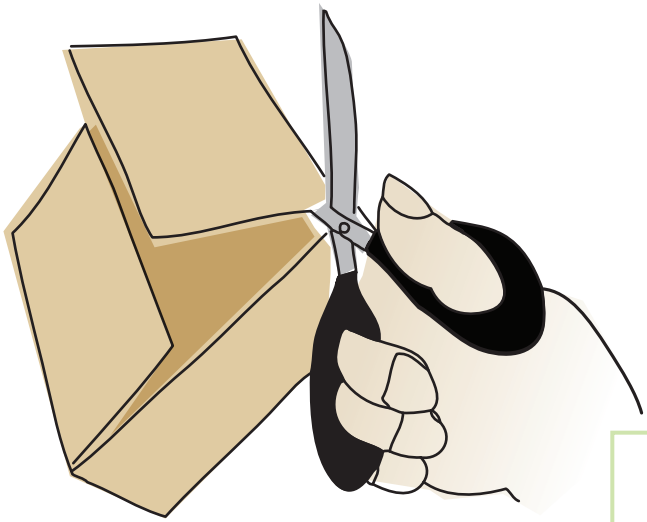
exploratorium

General materials:

Additionally, you will need materials to create the narrative on top of your construction. You can use thinner foam sheets to create this, and materials such as feathers, corks, googly eyes, colored felt, and pompons are other fun things that help tell a story or decorate it.

GETTING STARTED

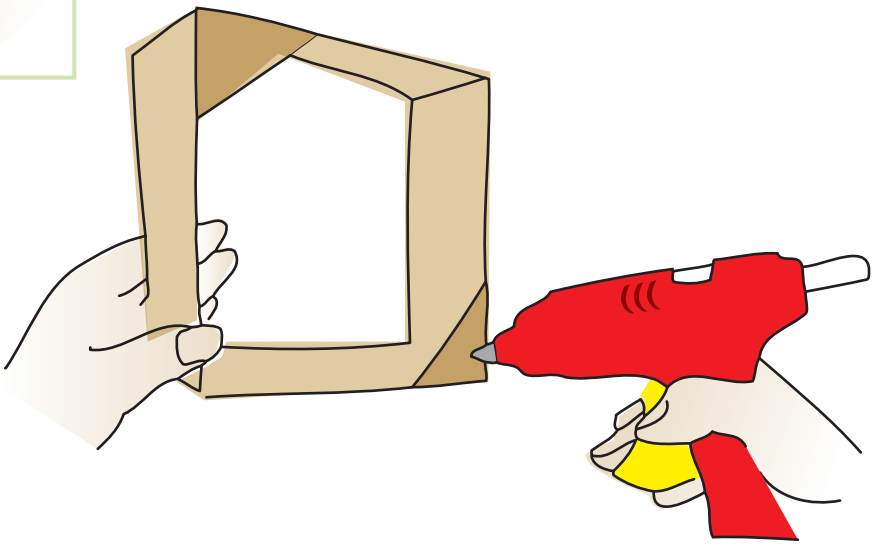
Make a frame:



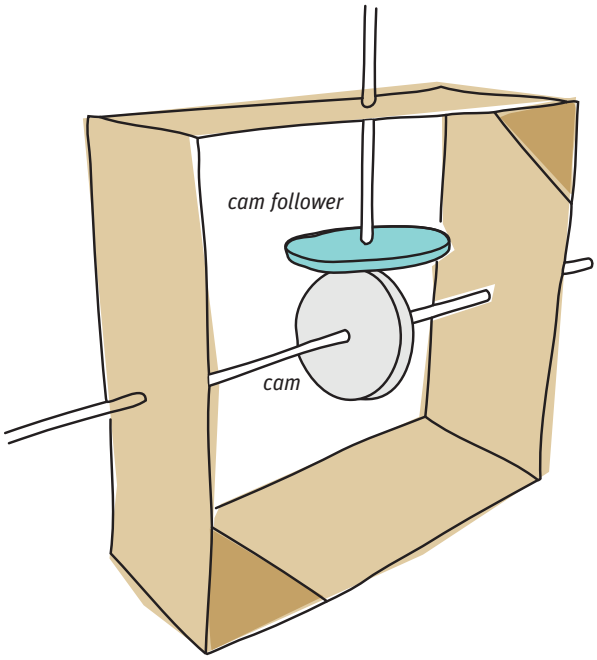
Remove the top and bottom flaps of the cardboard box to make an open square. Save these pieces of cardboard as they will be useful for other parts!

We usually cut a square box in half, creating two frames approximately 3" wide.

To stabilize your box cut four cardboard triangles and hot glue them in opposite corners of the box. Tape can substitute for hot glue but it won't be as permanent.



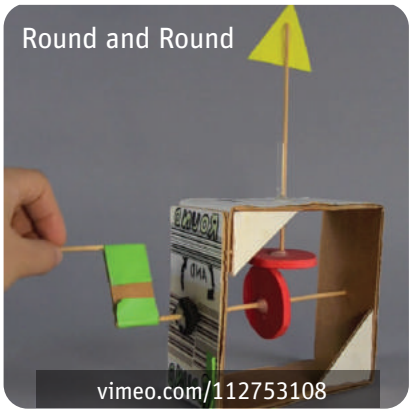
Choose a motion

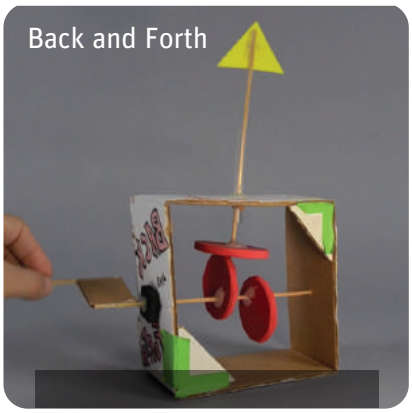


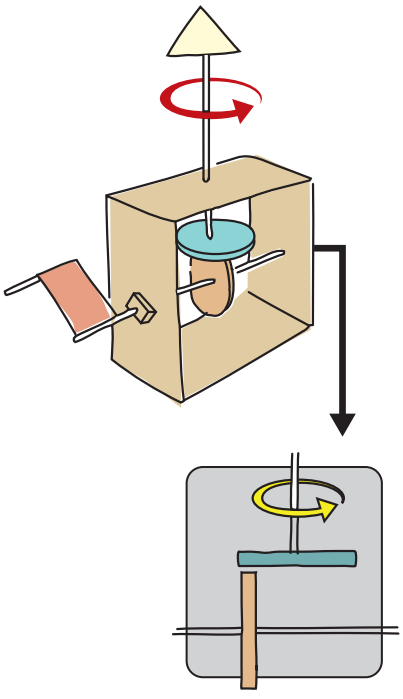
The spinning element that you turn with the handle is called a cam. The element that sits on top of the cam will move according to the shape and position of the cam, and is called a cam follower. The cam follower transmits its motion to the elements on top of the box to animate your sculpture.

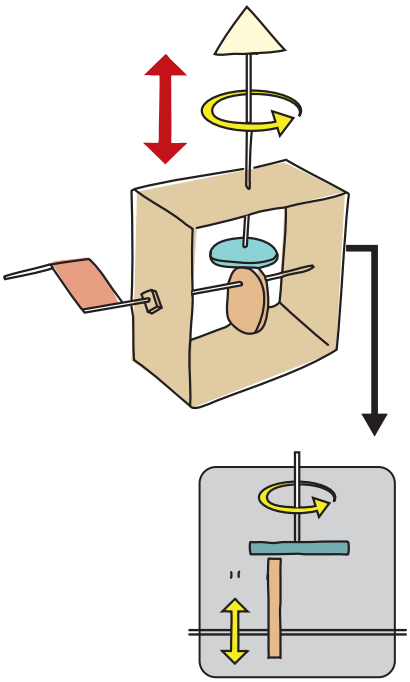
The way you align the cams and cam followers will affect the motion of your animated elements. Some simple to achieve movements are:

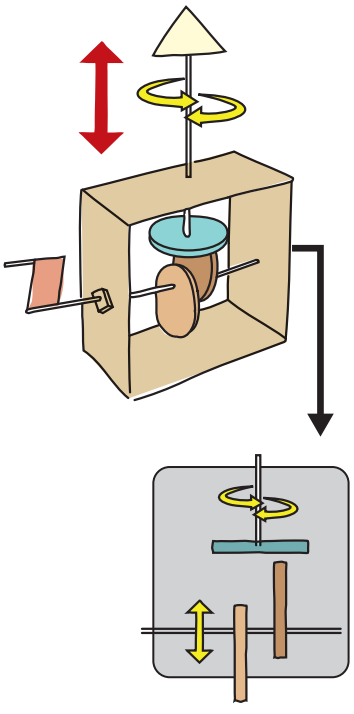
- Round and Round
- Up and Down + Round and Round
- Back and Forth





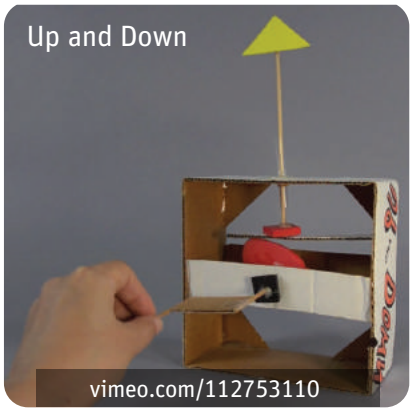


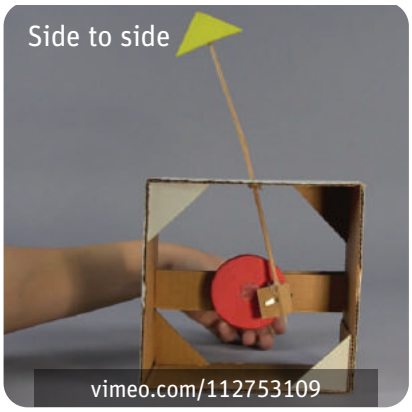


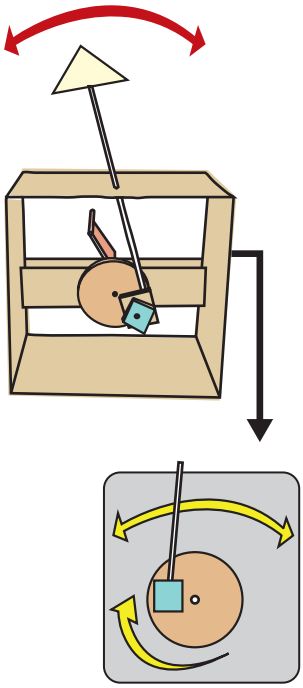


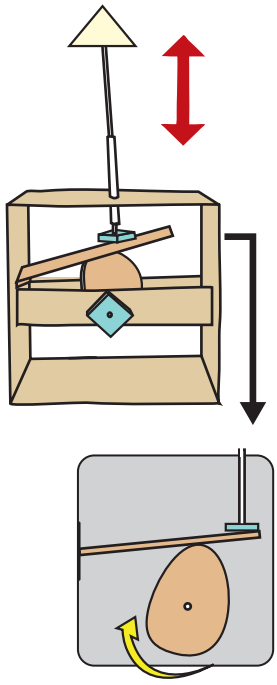
You can also try some more complex but satisfying motions:

- Up and Down
- Side to side



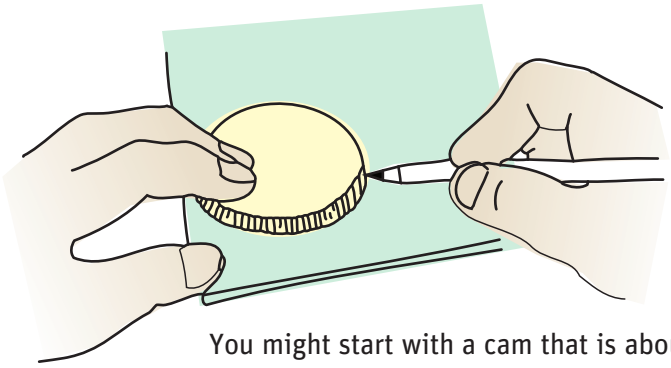




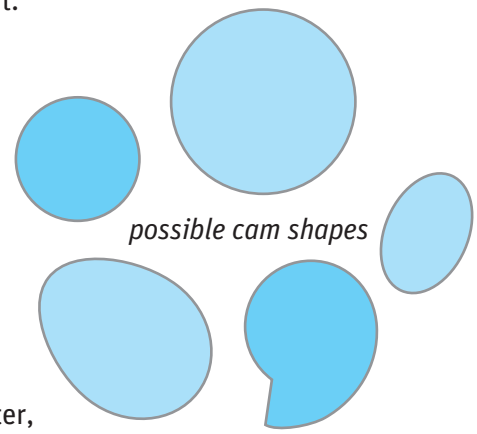


Make the mechanism

Draw your cam and cam follower on the thick foamie sheet and cut them out. (you can use a yogurt cup or a circular container to trace a circle.)



You might start with a cam that is about 2.5” in diameter, then experiment with other sizes based on your design.

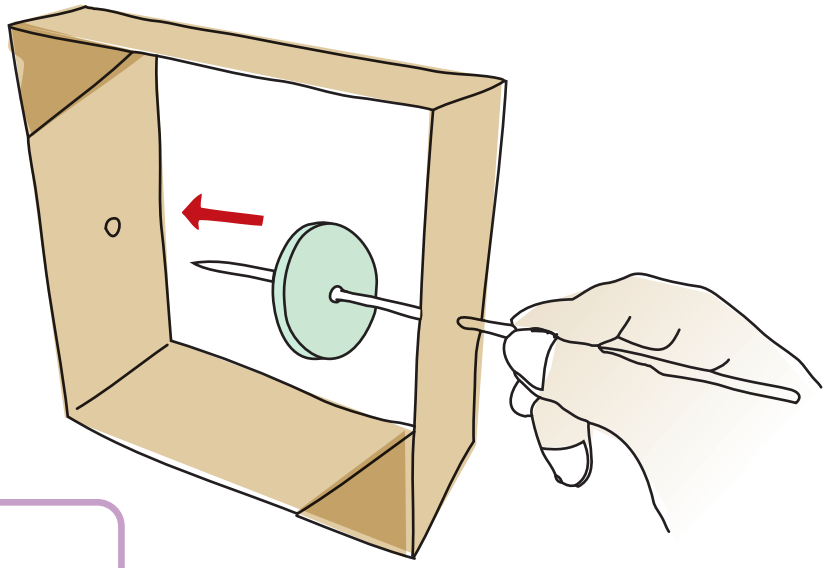


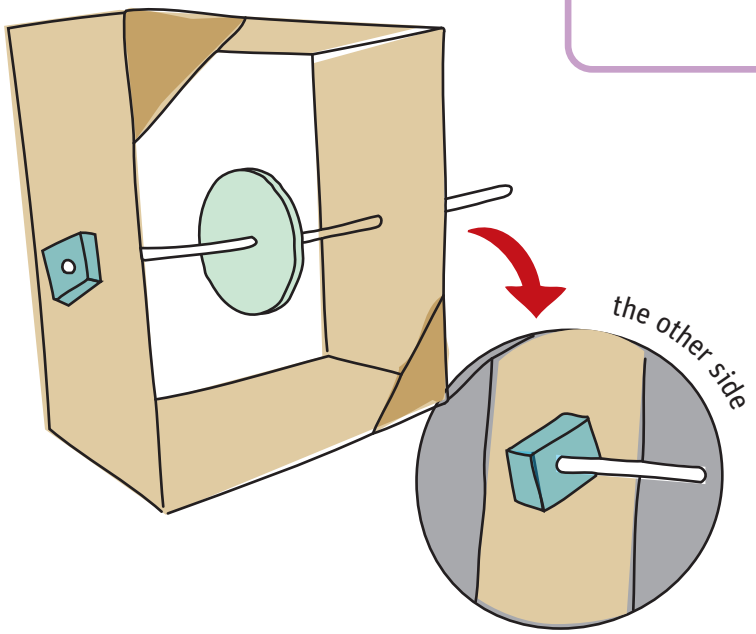
possible cam shapes

Tip: *Cut the cams smoothly and make sure the cam follower is a little bigger than the cam. As you make more automata, experiment with different shapes and sizes to see how they affect the automata motion.*

Put your cam on a skewer stick inside the frame.

Tip: *Start the holes in the frame using a nail or screw, and make sure the cam clears the top and bottom of the frame. Don't glue the cam yet!*



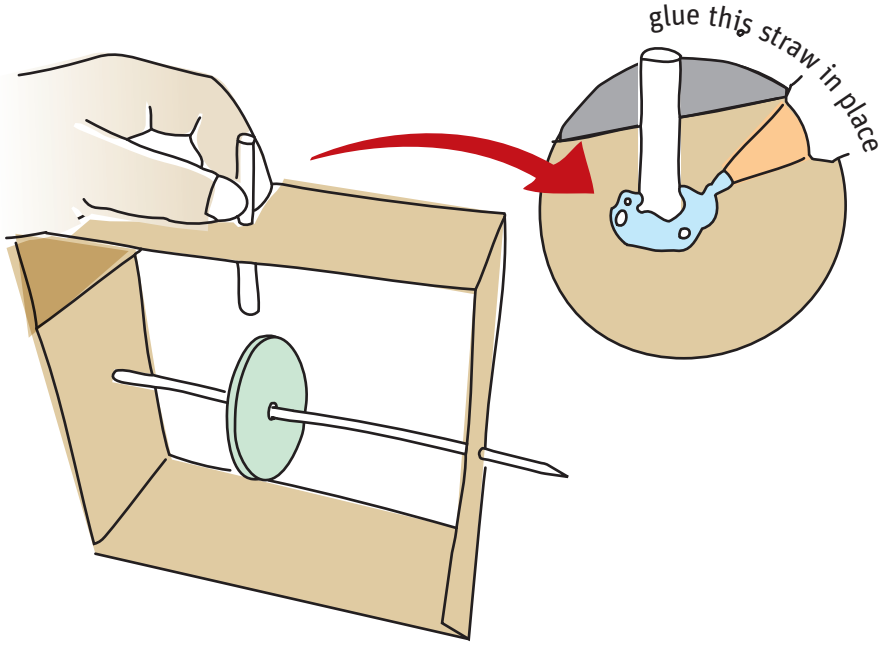


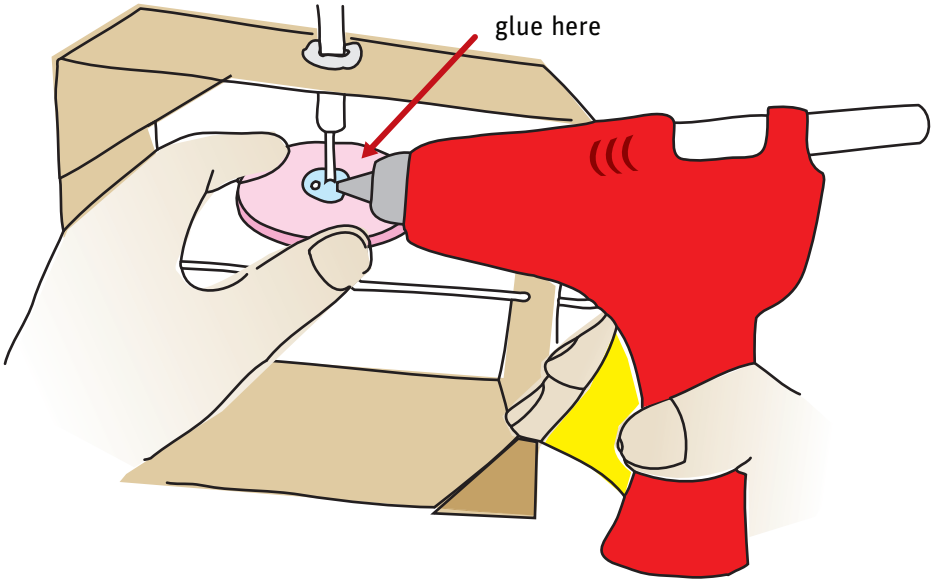
Cut small foam or cardboard squares and push them on each end of the skewer stick to hold your axle in place.

Tip: *Don't glue these in place yet!*

Poke a hole in the top of the frame where you want your cam follower to be located, and insert a piece of drinking straw. The straw should extend both above and below the frame, so it will stabilize the upright skewer stick. Carefully glue the drinking straw in place.

Tip: *The tip of a pencil is a good tool to gradually enlarge the hole so that the drinking straw just fits without falling through.*



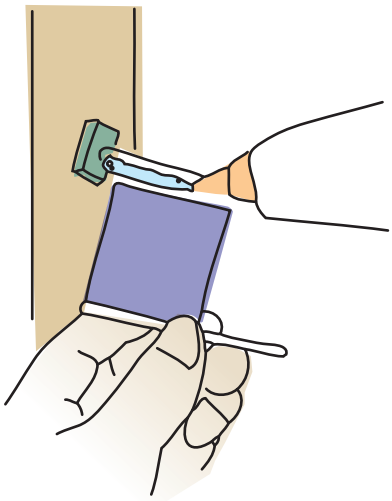


Insert a skewer stick through the straw, then glue your cam follower at the bottom end. Glue your cam follower on the end of a skewer stick and put it through the straw.

Tip: *If the cam follower does not fall down on the cam, attach a washer or nut to add a little weight before you glue it to the stick. Feel free to change the position of the cam under the skewer stick as this may change the motion.*

Test your mechanism

Adjust your cam under the cam follower until you get the motion you like, then GLUE the cam into place on the skewer stick axle.



Make the handle

Glue a small rectangle cut from the cardboard box flap to the skewer stick axle.

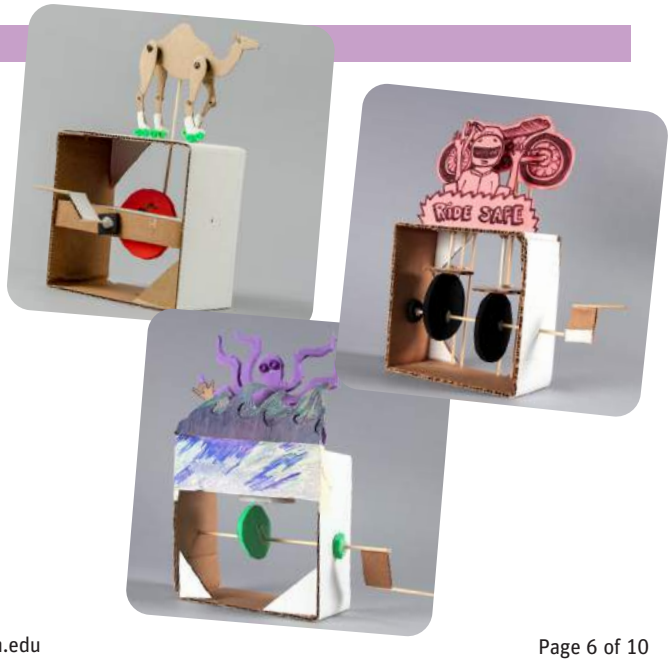
Glue a second piece of skewer stick to the end of the rectangle to make a handle.

Make your story

Once it's working, take another close look and imagine what might move on top of your box. Think of things that spin, bounce, or jump.

When you decide what it should be, make the sculpture out of the rest of your materials.

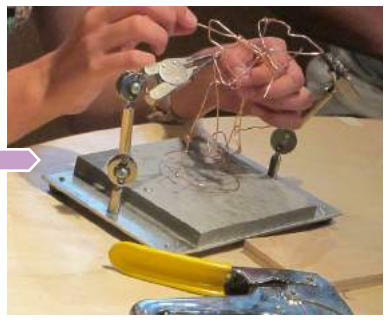
As you continue to experiment with different cardboard automata you can decide to start either by coming up with a new idea for a story on top and then figure out what mechanism can make that motion or continue to make the mechanism first and then decide what your sculpture will be.



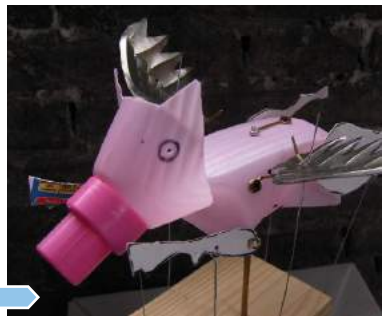
TAKE IT FURTHER

Wood is a great alternative to cardboard for building automata. For these automata, we use a wooden frame for the cardboard box, dowels for the sticks, and screws and nails instead of hot glue. Cutting circles and shapes in wood might be challenging, but you will build your woodworking skills while you make automata (or use pre-cut wooden shapes from craft stores).

Wire automata is another way to explore simple machine elements. Spend some time bending wire to make sculptures before diving into automata. Use copper wire so that you can solder wire joints if needed. You can learn how to make cranks, linkages, and handles out of wire then you can add decorative materials or wood pieces to your wire mechanism.



You can also scrounge for parts from recycling bins to make automata with. You might use old plastic bottles and aluminum cans, or walk around your house to find materials that you want to use for your automata. Making automata from found objects is a bit challenging but you will find that the techniques from cardboard, wire, wood automata come in handy and can be applied in many ways.



EDUCATOR ADDENDUM

A note on our philosophy:

The Tinkering Studio is based on a constructivist theory of learning, which asserts that knowledge is not simply transmitted from teacher to learner, but actively constructed by the mind of the learner. Constructionism suggests that learners are more likely to make new ideas while actively engaged in making an external artifact. The Tinkering Studio supports the construction of knowledge within the context of building personally meaningful artifacts. We design opportunities for people to "think with their hands" in order to construct meaning and understanding.

Decisions and designs that support a tinkering experience

Tinkering Studio activities and investigations are designed to encourage learners to complexify their thinking over time. The variety of materials and variables available for experimentation allow for learners to enter at a point where they are comfortable starting, and then alter and refine their designs as they develop new ideas. Tinkering activities are often fun, whimsical, inspired, and surprising, here are a few of the the goals that we have for Cardboard Automata activity:

STEM (science, technology, engineering, and mathematics) education is a means, not an end in itself
Building cardboard automata is a playful and inventive approach to learning about simple machines. Learners naturally explore levers, cams, cam followers, linkages, and other mechanisms, as a means to make their mechanisms work.

Science and art connections
This activity is a good example of integrating science and art into an activity. For learners, the narrative and decorative aspects of the automata are as important as the mechanical elements. Making automata takes a lot of time, but going back and forth between the narrative and the mechanism throughout the activity will make the automata very unique and personally meaningful for learners.

Activities and investigations encourage learners to complexify their thinking over time
The motion of automata depends on various factors such as the size and shape of the cams, the position of the axles, and number of cams and cam followers. Exploring in those factors is a good starting point to understanding simple mechanisms. Introducing other elements such as gears, linkages, and springs will add complexity to the activity and enable learners to explore endless possibilities for creating mechanical motions in automata.

Environment (the elements of the space that support tinkering)

In the Tinkering Studio there are many things that we keep in mind when setting up an environment for a successful tinkering activity.

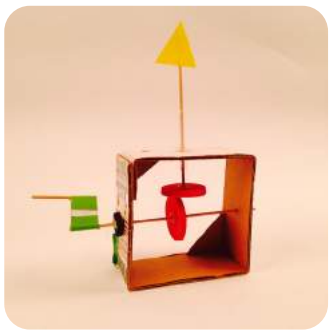
Create an Inviting Space
Since learners often work with us for an extended period of time, so we try to create a warm and welcoming workspace with comfortable seating, sturdy worktables, and good lighting. We often display exhibits, or examples from past projects and current activities throughout the space to seed ideas and provide an introduction to what is happening that day. Materials are easily accessible and in close proximity to the tinkerers, and we often work at large, communal activity stations to enable cross-talk and invite collaboration between participants, allowing them to look to each other for answers and solutions.

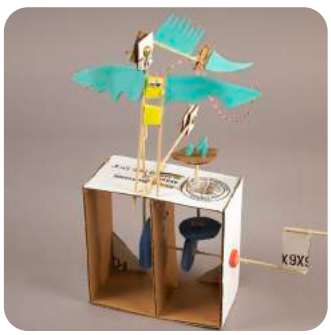
Automata examples in the space
In making Cardboard Automata, providing clear and easy to follow examples of different types of motion is crucial. We usually prepare five different examples that move in interesting ways:

- Round and round
- Up and down, and around
- Up and down, back and forth
- Straight up and down
- Side to side

It might be helpful for you to make each example with the same basic shape on top (like a circle or triangle), that way participants can focus on the differences in the motion. It also helps to name each motion for the purpose of better explanation like “Round and round” “Up and down” or “Side to side” on the frame of automata.

In addition, it’s helpful to have a selection of examples of completed automata that span the range of complexity and “achievability” with the same set of materials on the table. Be sure to set aside plenty of time for playing around and building cardboard automata before the activity so that you can display more inspiring examples that you create.





Facilitation (the things we say and do to support learning through tinkering)

Facilitation is a way of teaching where you support the learner's own investigations, questions, and ideas within the framework of an activity. In the Tinkering Studio, we strive to practice a kind of facilitation that respects the individual path of the learner. As facilitators, we watch and wait until the precise moment to jump in and offer a hint, a material, or a new way of looking at a problem. As educators, we allow learners to feel frustration and encounter moments of failure as they work with real materials to try to solve their own challenges.

There are many ways that the facilitator can influence the interactions with participants in an activity. We help people get started with the activity by giving a quick sense of the goals. We invite them into the space, and introduce the materials and tools they might use. We spark interest and sustain learner's engagement by asking questions about their work and responding to their answers. We support multiple outcomes of the activity and are open to the possibility of new ideas, different solutions, and changing goals of the individual learners. We try to practice a style of facilitation where we are not teachers who transmit knowledge to passive learners, but rather are guides and co-learners on a path to understanding.

For Cardboard Automata it is important that you try building your own a few times before sharing this activity with others. There are several small steps involved in building Cardboard Automata that will make a big difference later on if you know what to expect. By building automata yourself, you will encounter most of the frustrating points that participants are likely to run into, and you will know how to get unstuck. That way, you will be better able to help other people past these "sticking points".

A few common things to watch for:

The box got bent or squashed.

Make sure that learners add a triangle shape in the corners to make the box square. Making a sturdy box is a good start to make a functional mechanism.

The axle (a horizontal skewer stick) keeps sliding

Use little foamie bushings at the end of axles to keep the skewer from sliding out.

The sculpture doesn't go up and down

Try adding weights, such as a washer, to the cam follower to ensure a smooth motion. Using gravity helps.

The vertical skewer stick is wobbly

Maybe you've forgot to add a piece of straw? Cut a length of straw that will keep the vertical axle in place while still allowing for the full range of up and down motion of the automata.

Tip: *In order to make things move it is important to understand which parts must be attached firmly and which connections should be loose. You may want to leave gluing the cam and cam follower to the skewer for the last step, after many iterations of creating and adjusting motions.*

You may find that the most difficult thing to facilitate is the transition between the construction of the mechanical part and the creation of moving narrative part. Some people get the technical part down first and then think about what it does, while others have an idea of what they want it to do first and figure out the mechanism later. It's important to consider both strategies, and go back and forth between the mechanism and narrative throughout the activity to create the automata.

Making cardboard automata is one of the more step-by-step activities in the Tinkering Studio, but we like to focus on the process of rapid prototyping, so it is important to figure out each of these steps together with the participants.

Consider the layout of the Space

In contrast with many of our activities Cardboard Automata benefits from an initial step-by-step coaching on how to put together the structure of the box that sustains the cams and followers. In order to work well not only does the box need to be sturdy and fairly square, but the axles on the cams and followers need to be centered and at right angles with each other. There are several small steps like this that make a big difference.

RELATED TINKERING ACTIVITIES

Activity Connections
Try these related activities to develop your own repertoire of tinkering experiences.

Toy Take-Apart: Collect discarded mechanical stuffed toys and dissect them to find battery packs, switches, sensors, and motor-driven mechanical elements. You can test the things that you find inside, repair broken toys, or repurpose them using your imagination and a few tools to create new and original playthings.
https://tinkering.exploratorium.edu/toy-take-apart

Marble Machines: Create your own ball-run contraption made from familiar materials. Try experimenting with motion and build the contraption to send a rolling marble through tubes and funnels, across tracks and bumpers into a catch at the end.
https://tinkering.exploratorium.edu/marble-machines

Chain Reaction: Build a contraption in a domino-style chain reaction that will trigger the next contraption! Make your machine comical and whimsical using variety of materials such as bowling ball, pulleys, slow motors, mechanical toys, cowboy hats, balloons, ropes, mousetraps, gears, and more.
https://tinkering.exploratorium.edu/chain-reaction

ARTIST CONNECTIONS

inspiring connections to the Cardboard Automata activity

Cardboard Automata is inspired by the **Cabaret Mechanical Theater**, a group of automata builders based in England. Artists like Paul Spooner, Keith Newstead, and Carlos Zapata build beautiful narrative pieces using elegant mechanisms based on cams, gears, springs, and linkages.

http://www.cabaret.co.uk/

Arthur Ganson is a self-taught engineer, and the creator of intricate, whimsical machines. He makes mechanical art demonstrations and Rube Goldberg machines with existential themes. Ganson's work appeals to viewers of all ages, and has been featured in an animated children's television show. He has invented mass-produced children's toys, and hosts an annual competition to make Rube Goldberg chain reaction machines.

http://arthurganson.com/

Electro-magnetics

21

Activity Description:
Easy Electromagnet

Cutting

Cu

Scissors

Electronics

El

Copper Wire
9V Battery

21

Joining

Jo

Tape

Other Materials
Steel rod/ bolt or nail

Intro: Easy Electromagnet

Hey guys, havent been on recently, and i thought i would post. i used to do a bunch of LEGO stuff but im done with that now. so ill be showing you how to make a simple fairly powerful electromagnet with 5 simple things.

Step 1: Materials

Here's what you'll need:

An iron rod/bolt or nail (i think mine is steel though couldnt find an iron one)
Copper wire (mine is solid but i think you can use threaded)
Power source (C battery works great)
Tape

im afraid to hook it up to a 120V wall AC/DC adapter afraid it'll flip the breaker haha.

Step 2: Winding the wire

Start winding the wire tightly around your core. go most of the way down but dont completely cover it. I went down to the threads on my bolt and then put a nut on the end to keep the wire in place.

Step 3: Power Source

Okay now your soon to be electromagnet should look something like this. Now to add your power source. in my case, a C battery. Get your tape, and tape the battery in between the two ends of your wire. Have the positive end be on the shorter length of the wire thats sticking up and tape the wire to the contact. Do not tape the other end of the wire to the negative!

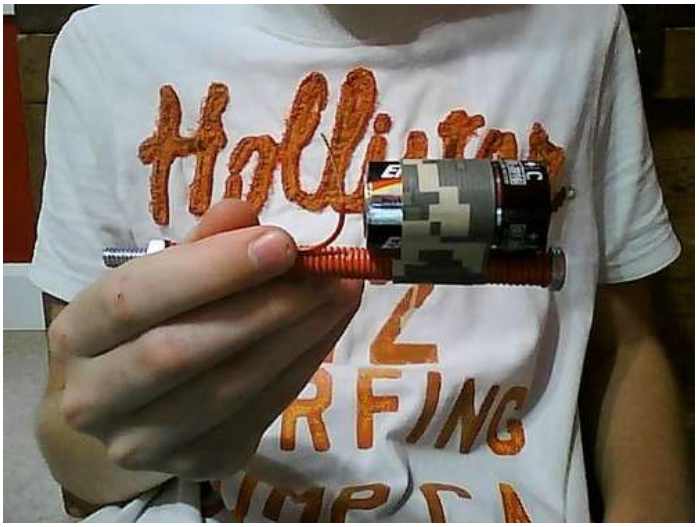


Image Notes
1. Positive end

Step 4: Switch

Okay here is how you will turn your magnet on and off. Cut a peice of ducttape about 1" by 1.5". Then cut a small sliver about 1" tall and a centimeter wide. put the small strip in the middle of the bigger peice like so. then put it on the negative contact with the open end facing down and at an angle towards either sideof your wrapped iron core.

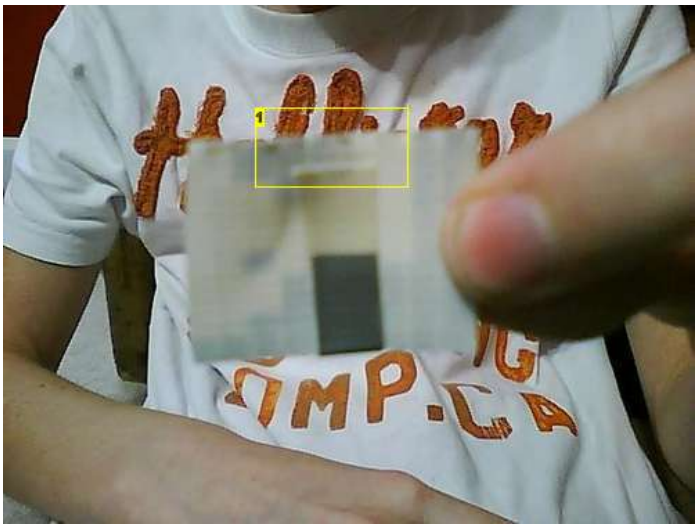
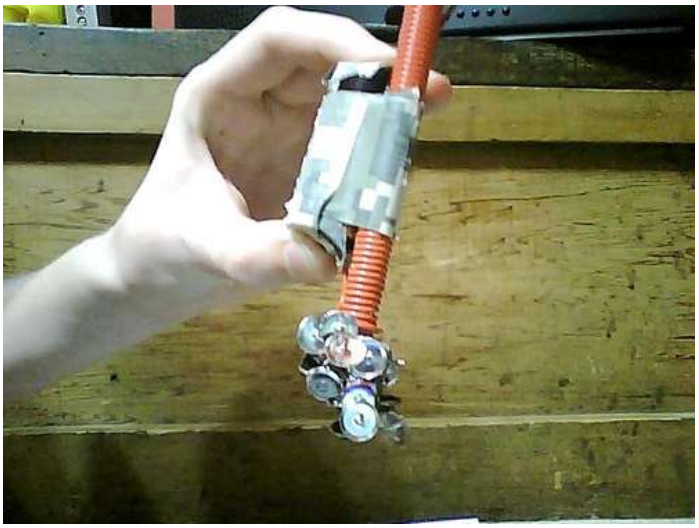


Image Notes
1. Note i didnt go all the way to the top

Step 5: Pick up stuff

There you go now you have a magnet to play around with or i used mine to find and pick up nails after we had a bonfire.



Related Instructables

Electro Magnet by Migacz

Electro-Graf by Q-Branch

Tongue Music(+The Sound of Kiss) (video) by hnam

Clap-Off Bra by randofo

Magnetic Cars by intoon

Anti-gravity Chamber (Photos) by cypherxax

Soda Bottle Airplanes

22

Activity Description:
Create airplanes with recycled goods. Decorate and customize!

22

Cutting

Cu

Scissors

Painting

Pa

Paints

Arts & Crafts

Ar

Craft Paper

Brainstorm

Br

Markers
Colored Pencils

Joining

Jo

Tape

Other Materials
Recycled plastic bottles, cardboard

Soda Bottle Airplanes

Supplies:
Recycled plastic bottles
Cardboard
Scissors, cardboard cutters
Paper (optional)
Paints (optional)
Tape
Markers,
permanent markers (for plastic)

Instructions:

1. draw wings onto cardboard and then cut cardboard wings out, decorate and design wings

2. Measure the length of cuts on the bottle needed for the wings

3. Cut two parallel slits on the sides of the bottle for the wings to slide into

4. Slide cardboard wings through the bottle

5. Decorate bottle (optional) with paper, paints, other craft supplies

Tower Build

23

Activity Description:
It is low cost, low stress and extremely easy to implement. Tower building can serve as a great icebreaker and team building exercise for any new faces that have joined in your program.

23

Cutting

Cu

Scissors

Measuring

Ms

30 Straws

Arts & Crafts

Ar

Craft Paper
Pipe Cleaners

Brainstorm

Br

Markers
Colored Pencils

Joining

Jo

3 Feet of Tape

Fixturing

Fx

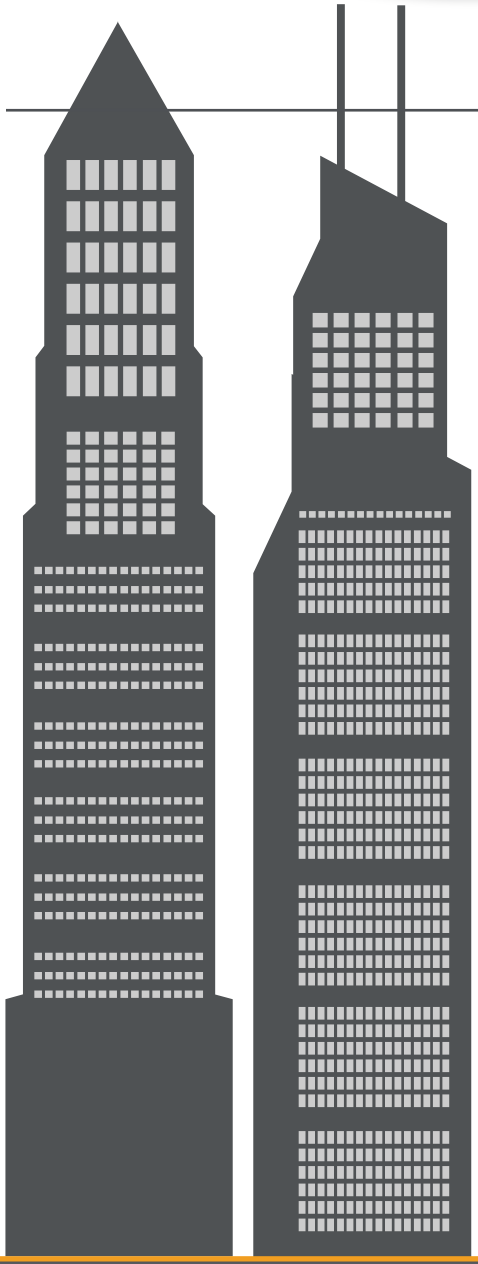
30 Paper Clips

Other Materials
Paper bag to hold materials for each group

STEM gems

Brought to you by the NATIONAL AFTERSCHOOL ASSOCIATION

TOWER ENGINEERING CHALLENGE



big IDEAS

THIS STEM GEM IS AN ENGINEERING CHALLENGE THAT IS PERFECT FOR THE HECTIC START OF A SCHOOL YEAR. It is low cost, low stress and extremely easy to implement. Tower building can serve as a great icebreaker and team building exercise for any new faces that have joined in your program.

WHAT IS A STRUCTURAL ENGINEER?

Structural engineers specialize in designing and constructing all types of structures. Along with towers, structural engineers help design bridges, tunnels, ships, airplanes, warehouses, and even houses. When structural engineers design something, they must take into account the technical aspects of construction, environmental concerns and limitations, as well as the aesthetic properties of design. Structural engineers often build small scale models to test their designs, in particular, to test the forces a structure will experience under different conditions. Structural engineers start with an idea, create a design, then organize and oversee the actual building of the project. Throughout the process, they work closely with other engineers who specialize in specific areas, such as electricity and plumbing and with the builders, architects and surveyors.

WHAT IS A TOWER?

A tower is a building or structure that is higher than its length or width. Towers can stand alone or be attached to adjacent structures. The earliest known towers were vertical stone structures without windows. When iron and steel were introduced during the Industrial Revolution, towers became much stronger and taller, and the term “skyscraper” was coined. In addition, the invention of the elevator in 1857 made tall towers more accessible and practical for everyday use.

WHAT FORCES DO STRUCTURAL ENGINEERS HAVE TO CONSIDER WHEN DESIGNING TOWERS?

Structural engineers must consider all the loads a building must bear. The dead load (the weight of the actual structure), the live load (the weight of the objects inside a structure, such as people and furniture), and environmental load (the natural conditions a structure must endure, such as extreme temperatures, high winds, and earthquakes). After all of these calculations have been made, the engineers create designs and select the materials that will support each type of load. When selecting designs and materials the engineers need to consider the balance between the forces of compression and tension. Tension is the pulling force created by stretching a material or pulling it apart. When materials are put under tension they become strong and inflexible. Compression is the opposite of tension. Compression is a pushing force created by pushing or squeezing a material together. Generally, in most structures compression supports most of the load in a building, as gravity is always pulling everything downward. Most materials can bear a lot of compression in one direction end to end but very little in another. If a straw is compressed end to end then it is very strong, but when squeezed on its side the straws cannot support much and folds flat. Engineers need to know how to use the building materials they are given so a balance of tension and compression can support the loads that the structure will be under.

What do engineers do? *Explain that engineers design and build things. (There are many different types of engineers. One type, a structural engineer, designs buildings, roads, bridges, and tall towers.)*

Have you ever been inside a tall tower of any kind? *If yes, where, and what was it like? (Children's choice. Children may have been in skyscrapers or in iconic towers such as the Space Needle in Seattle or the Empire State Building in New York City.)*

Have you ever built a model tower? *If yes, what building materials did you use? (Children's choice. Children may have built towers with unit blocks, Lego® bricks, rocks, K'Nex® building toys, or other building materials.)*

What things do you think engineers have to think about when they are designing and building a tower? *(Some examples include how to reach the required height, how to achieve balance, how to make the base wider than the top, how to make the tower sturdy enough to withstand wind, and what design to use so the tower is good to look at.)*

SCIENCE talk

COMPRESSION: The force of squeezing or pressing something together.

DEAD LOAD: The weight of structural components that remain relatively permanent over time, including the structure itself and immovable fixtures such as walls and carpet.

ENVIRONMENTAL LOAD: The impact of weather, topography, or other natural phenomena on a structure.

FORCE: A push or a pull.

GRAVITY: An invisible force that pulls objects toward the center of Earth.

LIVE LOAD: The weight of structural components that are temporary, of short duration, or movable. Furniture, planters, and people are examples of live loads.

STRUCTURAL ENGINEER: A trained professional who uses math and science to build structures that support or resist loads.

TENSION: The force of stretching or the condition of being stretched.

TOWER: A building or structure that is higher than its length or width.

what YOU WILL NEED & before YOU BEGIN

- **30 Straws per group**
- **30 Paperclips per group**
- **3 Feet of tape per group**
- **Paper bag to hold materials for each group**
- **Drawing paper**
- **Pencils**

Find a flat area for where small groups can build their towers. Bag the supplies each group will have to work with.

EXPLORE & EXPERIMENT

1. **Have the group split** into small engineering teams.

2. **Explain to the following to teams:**

   - ☐ They have just all become structural engineers for the day.
   - ☐ Their design challenge is to build the tallest tower they can with the building supplies that they are given.
   - ☐ The towers must be freestanding and must not use anything but the floor for support.
   - ☐ Each tower must be able to stand up on its own unsupported for at least ten seconds.

3. **Show each team the building supplies that they will have available:** 30 straws, 30 paper clips and 3 feet of tape. Invite the group members to pick up and examine a straw.

4. **Ask the kids what they think the strengths and weaknesses are** of using straws as a building material.

5. **Explain that any structure must support its load** by balancing the forces of tension and compression.

6. **Define and explain compression.** Tell the groups that straw can be compressed two different ways – on its ends and on its sides. Ask the groups which way the straw can hold more weight.

7. **Have the groups bend their straws into an arch and explain tension.** Explain how an arched straw can support more weight on its the sides than a straight straw, because when the sides are under tension they are harder to compress. When a straw is arched the tension in it redirects any downward force along the length of the straw and out to the ends.

8. **Ask the groups what they think is the best way to join their straws together for building?** The straws can simply be taped together, slid together or joined with a paper clip as shown below.

Open a paperclip up and push a straw on to each of its ends. The ends can be squeezed together or opened to ensure a tight fit.

Two straws can be joined together by pinching the end of one straw and sliding into the other one.

9. **Have each group retrieve** a piece of paper and pencil.

10. **Challenge each team to come up with a design** that they think will enable them to create the tallest tower.

11. **Promote discussion** by going around to each group and asking questions about their designs and how they are going to support the load with compression and tension.

(continued...)

12. **After each team has finalized a design** hand out the bags of building supplies and give an appropriate amount of time for the groups to build their towers. Remind everyone that designs can be tweaked and changed until they are successful.

13. **When time is up, have the engineering teams share their towers with the entire group.** The groups should explain their designs and whether they had to make any changes to their original designs in order for their towers to stand. After each groups shares, have the young people in the group count to ten to make sure the tower meets the freestanding requirement.

14. **Have a competition to determine:**

- ☐ Which tower will stay standing the longest?
- ☐ Which tower is the tallest?
- ☐ Which tower used the least amount of straws?
- ☐ Which tower is the most eye catching?

make THE CONNECTION

Bring in books or photos and description of towers or provide computer and internet access and invite young people to research different designs all over the world have been used to build tall towers. Each team can be challenged to pick a tower to present to the rest of the group.

THE EIFFEL TOWER, one of the most famous towers in the world, was designed by Gustave Eiffel (1832-1923), a French engineer who specialized in metal structures. Revolutionary for its time, the Eiffel Tower was built completely from iron. Eiffel wanted to demonstrate that iron was a viable building material, as strong and as stable as stone, but infinitely lighter. The Eiffel Tower was completed in 1889, and at 986 feet tall, it was the tallest building in the world until the completion of the Chrysler Building in New York City in 1930. For more information about the Eiffel Tower along with photos visit http://www.toureiffel.paris/en.html

The builders of the **LEANING TOWER OF PISA** Italy did not intend for the tower to lean. The tower started out on level ground when construction began in 1173, but by the time the builders reached the third floor in 1178 they realized the tower's foundation was sinking. The foundation's stones had been laid on soft ground containing clay, sand, and shells, which sunk as it was compressed by the tower's weight. Today, the eight-story tower is over five meters off perpendicular. For more information about the Tower of Pisa along with photos visit http://www.towerofpisa.org/

ONE WORLD TRADE CENTER (also known as the Freedom Tower) is the main building of the rebuilt World Trade Center complex in Lower Manhattan, New York City. It is the tallest building in the Western Hemisphere and the sixth-tallest in the world. The building reaches a total height of 1,776 feet. Its height is a deliberate reference to the year when the United States Declaration of Independence was signed. For more information about One World Trade Center along with photos visit https://www.wtc.com/about/buildings/1-world-trade-center

The world's tallest skyscraper is the **BURJ DUBAI** in Dubai, United Arab Emirates. It uses Y-shaped cross sections to support a central tower. This structural design makes the building very rigid. At approximately 2,716 feet tall and containing 162 floors, the building rises nearly one half mile into the sky. As a point of comparison, the Empire State Building in New York City is just over 1,200 feet tall. For more information about Burj Dubai along with photos, visit www.burjdubaiskyscraper.com.

EXTEND & EVALUATE

CHALLENGE THE KIDS TO USE PAPER AND DRAWING TOOLS TO DESIGN A NEW FUTURISTIC TOWER FOR YOUR HOME TOWN. HAVE THE CHILDREN THINK ABOUT NOT ONLY THE STRUCTURAL DESIGN, BUT THE USE FOR THE TOWER AND ITS AESTHETICS:

Is the tower going to be a tourist attraction or a practical building like a school? • How does the design make it strong? • How does light get in? • What is it made from? • How do people get in and out and around the tower? • What will be used to make the tower environmentally friendly? • What design elements could be added so people want to visit or work in the tower?

Arts & Crafts

Cardboard Organizer

24

Activity Description:
Scribbling machines are motorized contraptions that move in unusual ways and leave a mark to trace their paths. They are made from simple materials and set in motion by a vibrating offset motor causing them to bounce, spin, bump and move in interesting ways.

24

Cutting

Cu

Scissors

Sewing

Sw

Yarn

Arts & Crafts

Ar

Construction Paper
Colored Paper
Deorative Paper

Brainstorm

Br

Markers
Colored Pencils

Joining

Jo

Tape

Joining

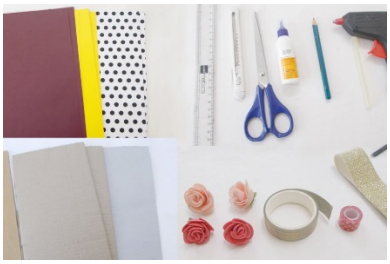
Jo

Glue
Glue Sticks
Hot Glue Gun

Other Materials
Yarn, gems, lace etc...

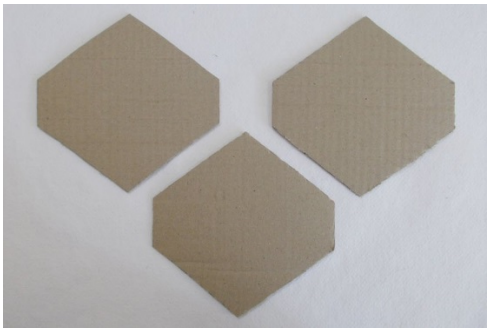
RECYCLED CRAFTS: CARDBOARD ORGANIZER

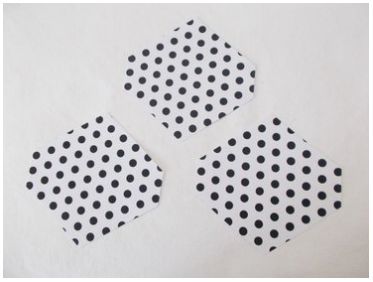
Step 1: Supplies

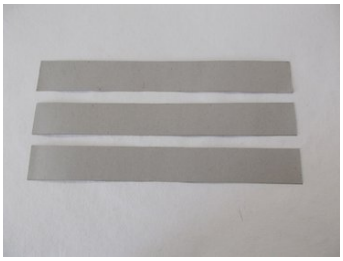


Construction/colored/white papers
cardboard
Printed/Decorative paper
Scissors
Tape
Pencil
Glue gun and stick
Decorative items: lace, yarn, gems, etc…

Step 2: Make the Boxes.

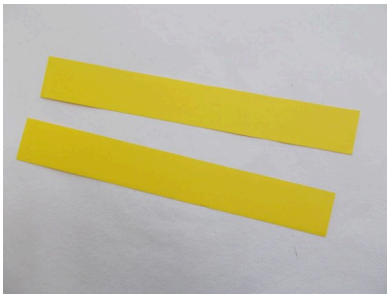


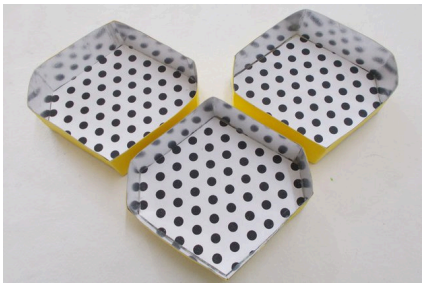




1. Take a 15 cm thick cardboard cut out and make markings on the opposite sides of 5.5 cm , 4 cm and 5.5 cm respectively.
2. Draw lines and cut along them to get hexagon shaped base like this.
3. Cover the base with printed papers.
4. Cut out 4 cm wide strips using thin cardboard and paste them with glue gun to make the walls of the box.

Step 3: Add Color to the Boxes.





Cut out 4 cm wide yellow strips and paste them on the outer side of the walls to give it a colored look.

Step 4: Build Up Your Organizer

1. Take a 28 cm long thick cardboard strip and cover it with brown paper.
2. Mark the height of the boxes on the strips and also make markings to ensure equal placement of the boxes.
3. Paste the boxes to the strips with a glue gun.

Step 5: Decorate Your Organizer

1. Take a thin cardboard paper strip measuring 30x4 cm and cover it in brown paper.
2. Paste it as the handle of the organizer.
3. Add some decorative items (yarn, lace, stickers, gems, etc).

Egg Carton Animals

25

Activity Description:
Encourage students to be creative---create animals out of egg cartons!

25

Cutting

Cu

Scissors

Painting

Pa

Paints

Arts & Crafts

Ar

Craft Paper
Popsicle Sticks
Pipe Cleaners
Craft Decorations

Brainstorm

Br

Markers

Sewing

Sw

Yarn

Joining

Jo

Glue
Glue Sticks

Other Materials
Egg cartons

Egg Carton Animals

Encourage students to be creative---create animals out of egg cartons!

SUPPLIES
Tempera Paint
Construction Paper
Egg Cartons
Yarn
Markers
Craft Decorations: Pipe cleaners, Googly Eyes, Feathers, Etc

Flowers from Mars

26

Activity Description:
Students will transform ordinary paper towel and toilet paper rolls into unique expressions of what "flowers from mars" might look like!

Cutting

Cu

Scissors

Joining

Jo

Clear Tape

26

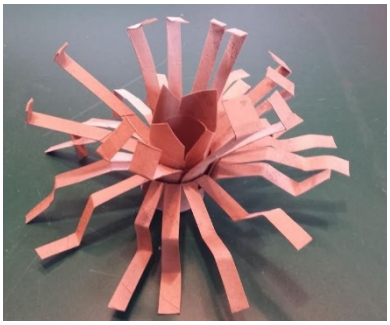
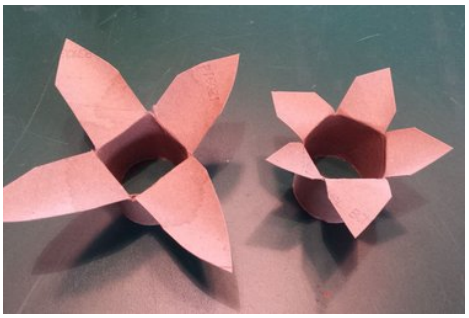
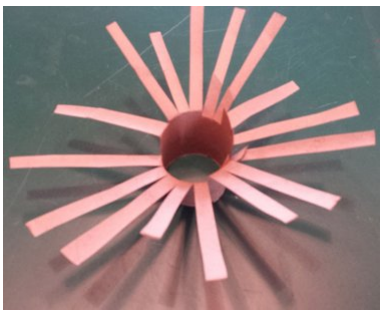
Arts & Crafts

Ar

Craft Paper

Other Materials
Paper towel and toilet paper rolls

FLOWERS FROM MARS

"FLOWERS FROM MARS" Students will transform ordinary paper towel and toilet paper rolls into unique expressions of what “flowers from mars” might look like!

Step 1: Gather Materials / Introduction

Materials:
Paper towel and toilet paper rolls, Scissors, Tape

STEP 2—TINKER AND CREATE!



For the first 10 minutes, let students design independently, exploring the materials on their own. **After 10 minutes,** stop and get the children's attention to issue a new challenge. "I now challenge you to see if you can connect what you've created with the flower of the student sitting beside you—challenge them to make an even larger flower by joining flowers together. **At the last 5-10 minutes,** give a 5 minute warning to clean up time and say, "I challenge you to take it even further. Can you connect even more together? Can you cut or fold it in a way that it hasn't been done yet? "

Origami Corner Bookmark

27

Activity Description:
Create functional bookmarks using beautiful origami design techniques.

27

Cutting

Cu

Scissors

Joining

Jo

Glue

Arts & Crafts

Ar

Craft Paper
Printer Paper

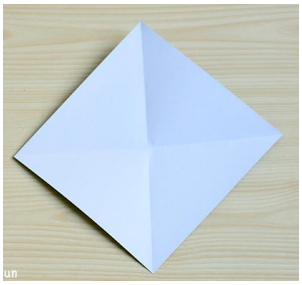
Other Materials
If available find origami paper.

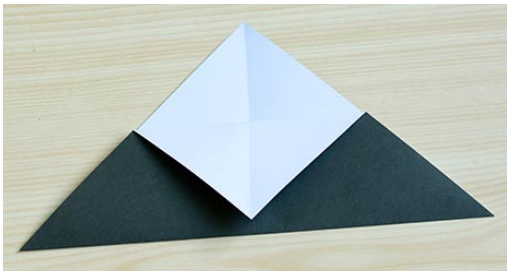
Origami Corner Bookmark

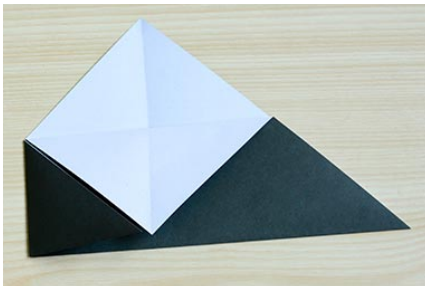
Materials:

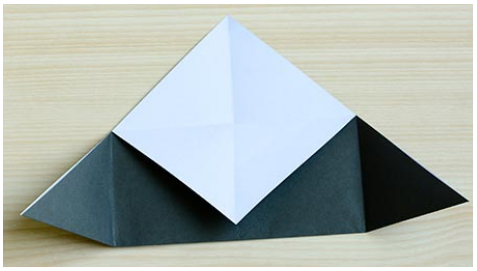
- White paper
- Construction paper
- craft supplies: googly eyes, feathers, sequins, stickers, etc
- scissors
- glue
- *if available, utilize origami paper instead of white paper

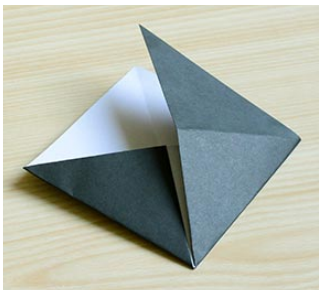
Origami--Create the bookmark:

 Fold the paper diagonally. Unfold.

 Fold into a triangle (colored side on the outside). Grab hold of the top of the triangle (one sheet only) and fold it toward the bottom of the triangle.

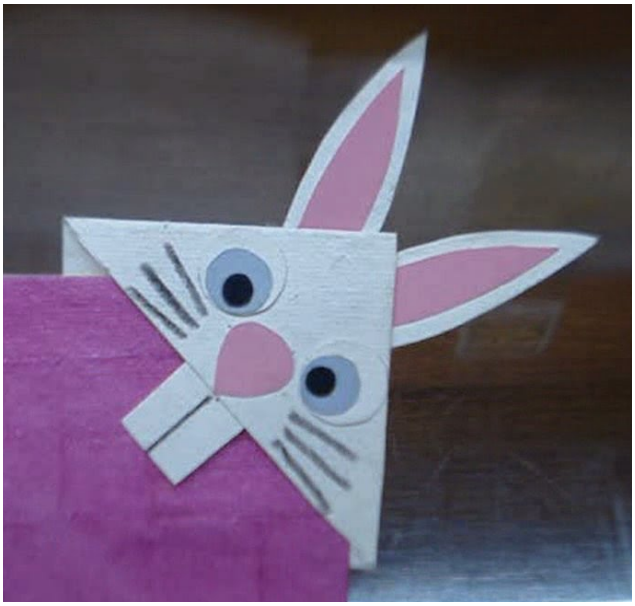
 Fold the left and right corner towards the bottom centre of the triangle. Crease and unfold.

 again grab the corner, this time folding it towards the top of the triangle. Crease well. Do the same with the other side.

 Now tuck both tops inside the pocket.


You now have your corner bookmark. If you so choose, you can also tuck the “white triangle” inside the pocket.

DESIGN and DECORATE YOUR BOOKMARK




ss down the front and
of your toilet roll to create
and two pointy ears.
ue on the googly eyes, and use y
s and pieces of craft material to add
ipes, spots, hair – whatever takes
ur fancy. You could also make a
nail hole on either side and thread
pipe cleaner through to make arms.
27

Perler Bead Activities

28

Activity Description:
Perler beads, also called Hama beads (in Japan) or melty beads, are small, plastic beads. You arrange them on a special pegboard to form a design. Then, using an iron and wax paper, you melt the beads together. When they cool off, you have a solid piece of plastic in your design.

Perler Beads

Pb

Perler Beads
Tweezers
Pegboard

28

Recycled Book Art

29

Activity Description:
A bristlebot or brushbot is an extremely simple form of walking robot. It is one of the simplest of all mobile robots, both in its function and its construction. (Wikipedia)

29

Cutting

Cu

Scissors

Painting

Pa

Paints

Arts & Crafts

Ar

Glitter
Stickers
Sequins

Brainstorm

Br

Markers
Pens

Joining

Jo

Tape

Joining

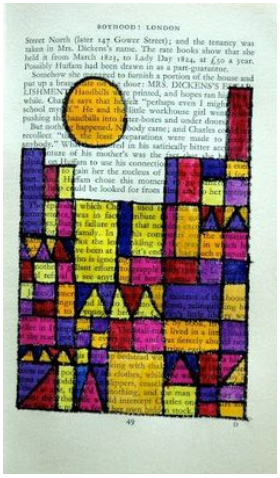
Jo

Glue
Glue Sticks

Other Materials
Recyled books

Recycled Book Art

We all have damaged or out-of-date books that we've weeded from our library. Instead of tossing them out, why not transform them into recycled art?



Materials:

Recycled Books
Glue
Tape
Scissors
Paint
Markers
Pens
Craft supplies: glitter, stickers, sequins, etc

Provide students with a variety of arts and crafts supplies, including glue, tape, paint, scissors, glitter, etc. Teach the students about what an artist's statement is, and have them write one up once their project is done.

Design prompt: Working alone or in pairs, transform a used book into a work of art. You can use any arts and crafts materials, including paint, scissors, glue, tape, etc. Write an artist's statement explaining how you came up with your idea and how you created your art.

Cardboard Printmaking

30

Activity Description:
Make stamps and different kinds of shapes with cardboard to print onto paper.

30

Cutting

Cu

Scissors
Hole Punchers

Painting

Pa

Paints
Brushes
Rollers

Arts & Crafts

Ar

Craft Paper

Brainstorm

Br

Markers
Pencils

Joining

Jo

Glue
Glue Sticks

Other Materials
Cardboard

Cardboard Printmaking

Materials:
Cardboard
Scissors
Glue
Paint (tempura or acrylic)
White paper
Paint sponges, brushes, or rollers
Optional—cardboard rolls

Directions:

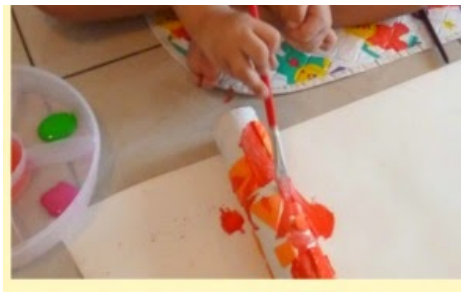
Cut your cardboard up into shapes/designs. Glue them to a larger piece of cardboard.

After shapes are dry, spread paint evenly over them with paint sponge, brush or roller.

Place white paper over the cardboard shapes. It will probably take 2-3 paint applications and test prints before you get a good print- the paint needs to saturate the cardboard enough so it doesn't dry out too quickly. Just keep rolling/brushing paint on and printing until you get some good prints.

Mix colors, get creative!

Get creative and tape designs/shapes to a cardboard roll and then roll that over plain paper!



Tin Foil Art

31

Activity Description:
This project engages students in an open ended activity exploring art and circuitry. Students learn about electrical circuits by creating an illuminating art object out of pipe cleaners. They are invited to design an off/on mechanism for their creation. An extension project could be to invite students to create a scale model of a public space light feature or a paper and pipe cleaner model of a hand held illumination device.

31

Cutting

Cu

Scissors

Measuring

Ms

Tin Foil

Joining

Jo

Glue Stick
Glue Gun

Brainstorm

Br

Markers
Colored Pencils

Other Materials

Cardboard

Foil Art

Supplies:

Recycled cardboard
Glue gun with extra glue refills
Tin Foil
Glue stick
Permanent Markers
Scissors

Instructions –

(1) Cut a piece of cardboard to make your frame.
(2) draw a simple design on the carboard
(3) carefully go over the drawn lines with the glue gun and allow to dry

(4) Cover the cardboard with tin foil and gently rub to expose the textured outlines of the drawing

(5) then color the tin foil using the permanent markers.

Music/ Rain Stick

32

Activity Description:
Rain sticks that actually sound like rain!

32

Cutting

Cu

Scissors

Measuring

Ms

Tin Foil

Arts & Crafts

Ar

Colored Paper

Joining

Jo

Glue
Glue Sticks

Joining

Jo

Tape

Fixturing

Fx

Rubber Bands

Other Materials
Funnel, wooden spoon, paper towel roll, rice

RAIN STICKS

SUPPLIES:
Paper towel roll
Aluminum foil
Rice
Clear tape
Wooden spoon
Colored paper
Optional: Funnel, Broom Handle

Instructions:

(1) Start by tearing a sheet of foil about 10″ long.

(2) twist the foil into a stick-like shape.

(3) wrap it around the handle of a broom to make a spiral.

(4) tear a small piece of foil about 7″ long.

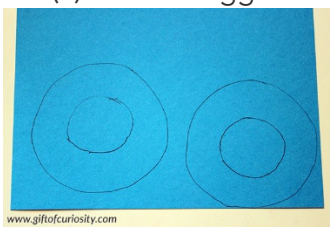
(5) twist this piece of foil into a skinny, wire-like shape.

(6) Wrap this thin piece of foil around the handle of a wooden spoon in order to make a tight spiral.

(7) then insert the smaller spiral into the larger spiral. Note: This is the key step that makes the rain stick work.

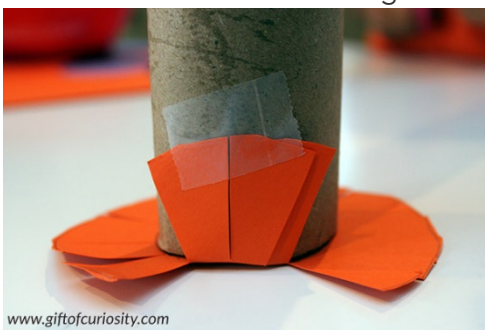
(8) place the end of the paper towel roll onto a sheet of paper and traced a circle around it. do this twice (once for each end).

(9) draw a bigger circle around the small circles that were just drawn.



(10) cut out the larger circles, and use scissors to make a lot of cuts from the edge of the paper to the inner circle.

(11) tape the paper to the end of the paper towel roll, wrapping the flaps we had cut up the sides of the tube and securing them with clear tape.



(12) Once one end of the tube is secured, insert the two foil spirals we had created.

(13) Add about 1/4 cup of dried rice to the tube.

(14) secure the other end of the tube with the other circle of paper that was cut.

(15)use lots of tape to make sure everything stayed together.

(16) wrap a sheet of colored paper around the outside of the tube to make it bright and colorful.

(17) decorated the rain sticks with markers and rubber bands.

https://www.giftofcuriosity.com/diy-rain-stick-craft/#respond

Paper Kites

33

Activity Description:
Robots from recycled materials!

33

Cutting

Cu

Scissors

Arts & Crafts

Ar

Stickers
Sequins
Stencils
Stamps

Sewing

Sw

Yarn

Brainstorm

Br

Markers
Crayons

Joining

Jo

Tape

Joining

Jo

Glue
Glue Sticks

Other Materials
Brown paper sack

PAPER KITE

Supplies:

Brown paper sack
Crayons/Markers
Craft supplies: stickers, sequins, stencils, stamps, etc
String/Yarn
Popsicle sticks
Streamers (optional)

Instructions:

1. Decorate both sides of the brown paper sack. ENCOURAGE CREATIVITY IN THEIR DESIGNS!
2. Add streamers with tape to the opening of the bag (optional).
3. Cut a small hole in the middle of the bottom of the bag.
4. Tie the string or yarn to a craft stick. Put the string through the hole in the bottom of the bag, from the inside. The craft stick should be inside the bag, stabalizing the string.
5. Let it fly! Hold onto the string and run! Tie them onto fixed objects to watch them fly.

Textiles

Knitting Loom Wall Hanging

34

Activity Description:
Create a knitting loom you can actually knit with.

34

Cutting

Cu

Scissors

Joining

Jo

Tape

Arts & Crafts

Ar

Craft Paper
Popsicle Sticks

Sewing

Sw

Yarn

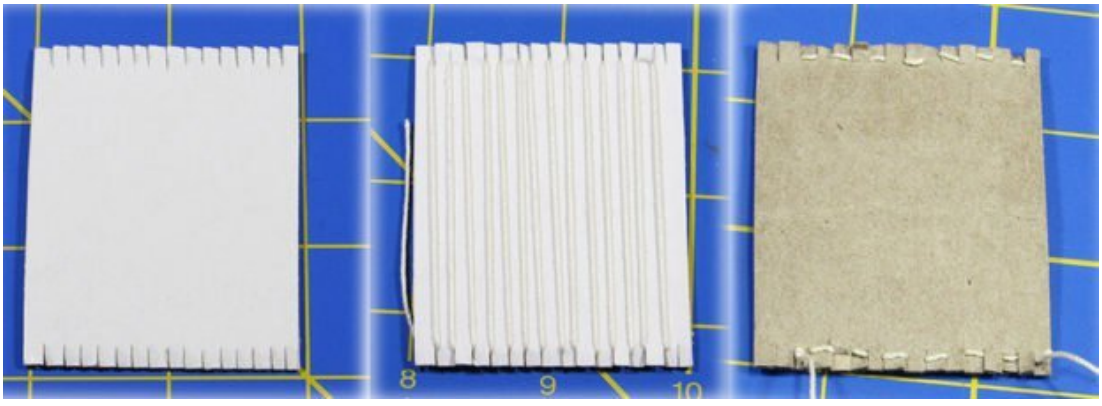
Other Materials
Toilet paper rolls

Mini-Loom Wall Hanging

Students create their own weaving loom and then design and weave their own wall hanging!

MATERIALS:
Cardboard
String
Yarn
Scissors
Small Dowels or Tree twigs
Optional: (LED, coin battery)

Make the Loom



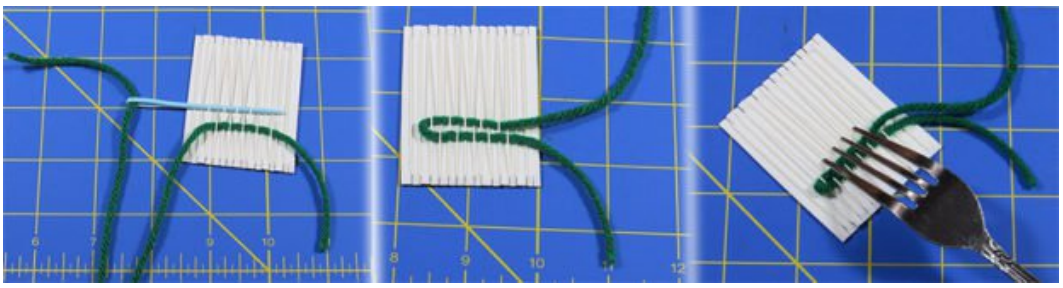
Cut a piece of cardboard a little larger than the size of your finished weaving. Then mark and cut notches along the top and bottom of the loom. You will use an odd number of notches; the more you have, the more detail you can put in your design. Think of it as having a bigger number of pixels to play with!
I used a loom that was 2 inches square, with notches about 1/8 inch apart. For younger makers, a 3X3-inch loom with notches 1/4 inch apart will be easier to manage. The notches hold your

warp thread in place. These were too close to use regular yarn, so I used a thinner thread meant for crocheting lace.

To string up the loom:

- take the warp thread and make a knot a few inches from the end.
- Slide the thread through the first notch on the bottom, with the knot in the back of the loom.
- Bring the thread up and through the first notch at the top, keeping it fairly tight. Then wrap it around the back of the tab and around to the front through the next notch over.
- Bring the thread down to the next notch on the bottom and repeat, ending with the thread at the bottom.
- Make a knot as close to the back of the loom as you can, and cut the thread leaving a tail of a few inches. You can tape the loose ends to the back of the loom to keep them in place while you work.

Weave the Design



To make the tree design shown, weave the tree separately first, then fill in with the background color. To weave, thread the yarn through a large-eyed needle. Insert the needle wherever you want to start your design, then bring it over and under the warp threads, coming out at the end of that row. leave a tail on your yarn. For the next row, leave a space and then repeat, going under where you went over on the row before. Use a fork to push the rows tightly together, then continue for as many rows as you want.

Weave the Background

When you're done with the tree, insert the needle through a few stitches to anchor it. Clip the end close so you can't see it. Next, thread your background color on the needle and weave as you did before, working your way around the center design. Where your new color meets the original color, you can insert the needle through one stitch of the design color to connect them.

Remove the Weaving from the Loom

- Keep weaving until the loom is packed with stitches, to hide the warp threads.
- Then untape the ends of the warp threads and pull them out of the loom. You should now be able to remove all the warp threads by pulling the loops off the tabs.
- Bend the tabs if necessary. Slide the weaving down so the loops on the bottom disappear and all the slack is at the top.
- Choose the side that looks best to be the front. Insert a skewer, dowel, or stick through the loops at the top.
- To hang your wall hanging, you can insert a cord through the loops as well (which helps with any remaining slack) or tie it to the ends of the dowel.

Optional — Add a Light!

To add an LED to your design, poke the wires right through the weaving, making sure they are separated by a stitch or two. Slide a battery between them, throwie-style. Then just tape the battery on. If you have kids or pets around, make sure the battery won't come loose, as it's dangerous if swallowed. You can secure it by crisscrossing it with some yarn that you sew so it is only visible from the back. Then hang your mini-weaving and enjoy!

Nature Weave

35

Activity Description:
This can be made with items found in nature or a mixture of hand made and nature.

Cutting

Cu

Scissors

Sewing

Sw

Yarn

35

Other Materials
4 sticks, flowers, leaves, green

Intro: Nature Weave

This can be made with items found in nature or a mixture of hand made and nature (see example).

You will need:

4 sticks
Yarn
Flowers, leaves, greenery

Step 1: Collect Nature Items

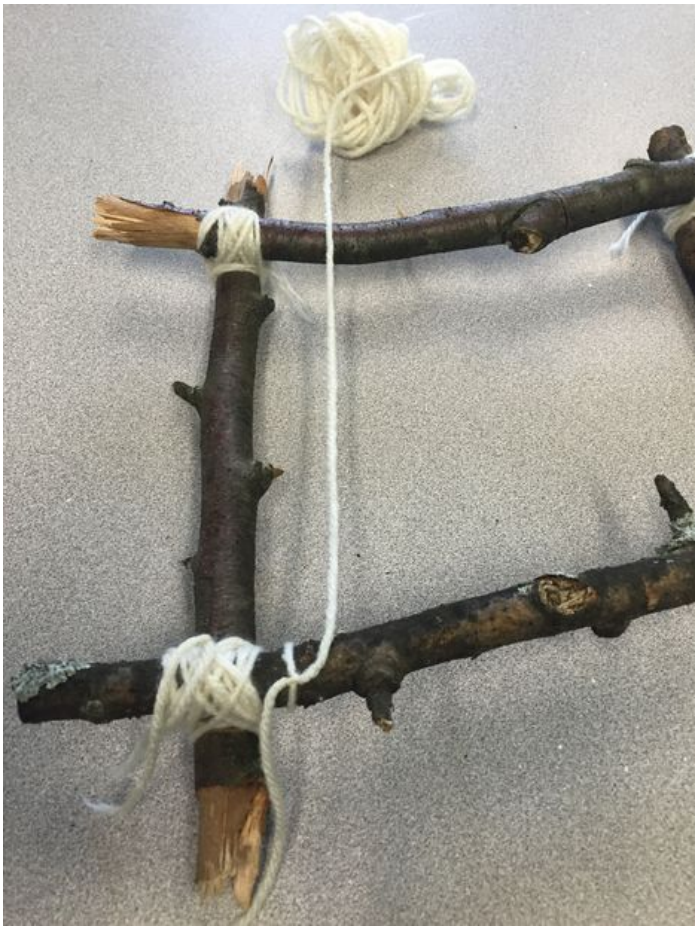
Collect sticks. Collect flowers, leaves and greenery. For longer lasting art work, either hand make or purchase flowers and greenery. If no access to sticks, can purchase dowels as well.

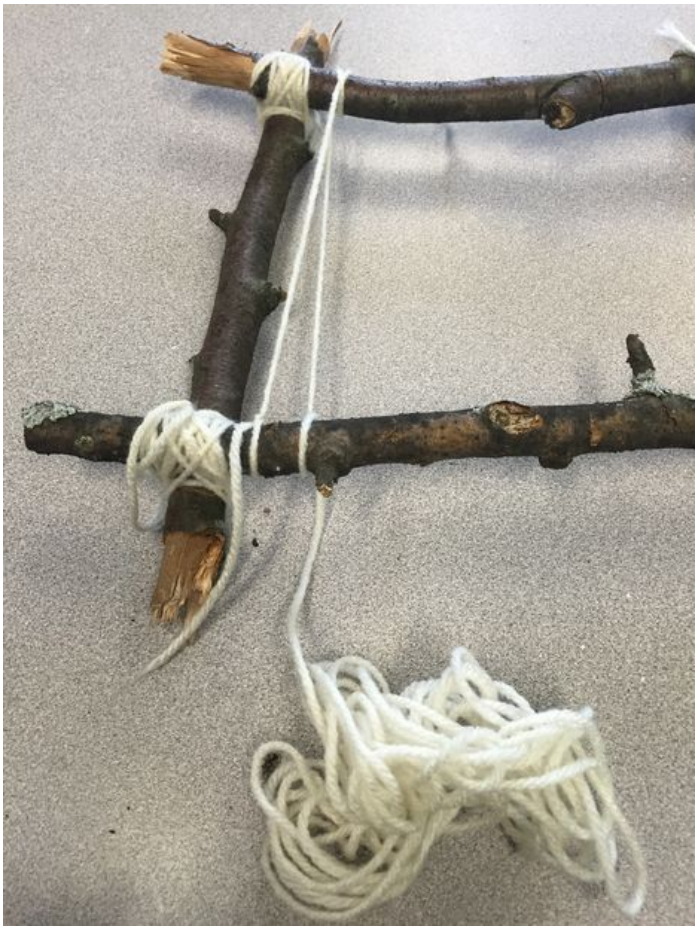
Step 2: Start Making The Frame

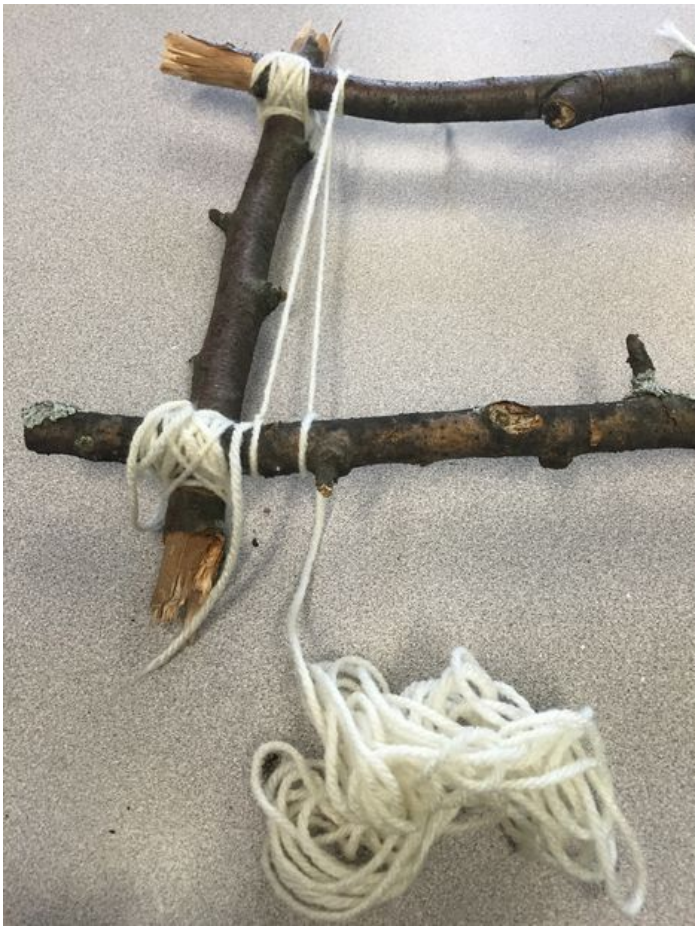
Take 2 of the sticks and start winding yarn to hold them perpendicular to each other. Repeat until you have a rectangle.

Step 3: Add Woven Area

Tie a piece of yarn to one stick and then wrap it around the stick parallel. Continue wrapping back and forth. The more times the yarn is wrapped, the more options there are for weaving in items.

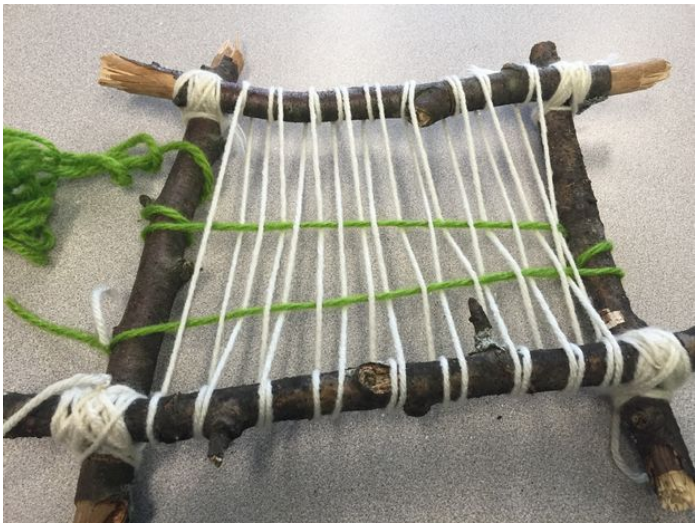






Step 4: Other Colors

Wanted a bit more color. Wove this color perpendicular to the last color. Can be creative and weave in different directions.



Step 5: Add Items

Weave items into the yarn. (If want to know how to make the origami flowers see other Instructable)

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Tea Cup Bird Feeder by CyberJaws

Yarn Art

36

Activity Description:
Use simple materials to create beautiful compositions and shapes out of yarn. End up looking like a painting made out of yarn.

36

Cutting

Cu

Scissors

Sewing

Sw

Yarn

Joining

Jo

Glue
Glue Sticks
Hot Glue Gun

Brainstorm

Br

Pencils

Arts & Crafts

Ar

Craft Paper

(/member/Muhaiminah%20Faiz/)
By **Muhaiminah Faiz (/member/Muhaiminah%20Faiz/)**
The Craftaholic Witch (http://www.thecraftaholicwitch.com/)
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More by the author:

About: Hey, I'm Muhaimina! A crazy craft addict! Obsessed with swirls and polka dots... Love green craft and rustic home decors... and Instructables is pretty much my second home! More About Muhaiminah Faiz » (/member/Muhaiminah%20Faiz/)

I bought yarns to learn how to crochet and knit but it didn't work that way! I think I'm too lazy for crocheting and knitting. But the yarns had to be useful so I though of doing some yarn art. I've seen fiber art, yarn art before but didn't know much about it. I had fun doing yarn art and loved how they turned out :)

Step 1: Materials Needed

To make yarn art you'll need:

1) Yarns (different colors),
2) White paper,
3) White glue or hot glue (I used white glue),
4) Cotton swab (for applying glue on paper),
5) Scissor,
6) Pen or pencil.

Step 2: Basics

If you're not familiar with yarn art then you should try out these easy shapes or patterns. Once you get handy with these patterns you can do yarn art easily and create different designs.
I've selected 9 different (easy) shapes for yarn art, I hope the step-by-step tutorial is helpful.

I used white glue for sticking the yarn on paper and cotton swab for applying glue on paper (over the design).

*Don't apply glue over the whole paper at once. Apply glue only on the pattern on which you'll be sticking yarn and after completing that pattern go for another one.

*Don't forget to carefully tap the glued yarn on paper with your finger to flatten it.

*Glue yarn from the middle or corner of any pattern.

*To create perfect corners you'll have to cut the yarn every time the yarn reaches a corner

rather than folding the yarn (see triangle, square, lens, tear drop...).

*To fill small blanks or patterns cut the yarn into small manageable pieces.

*Last but not the least, make sure the color combination is good.

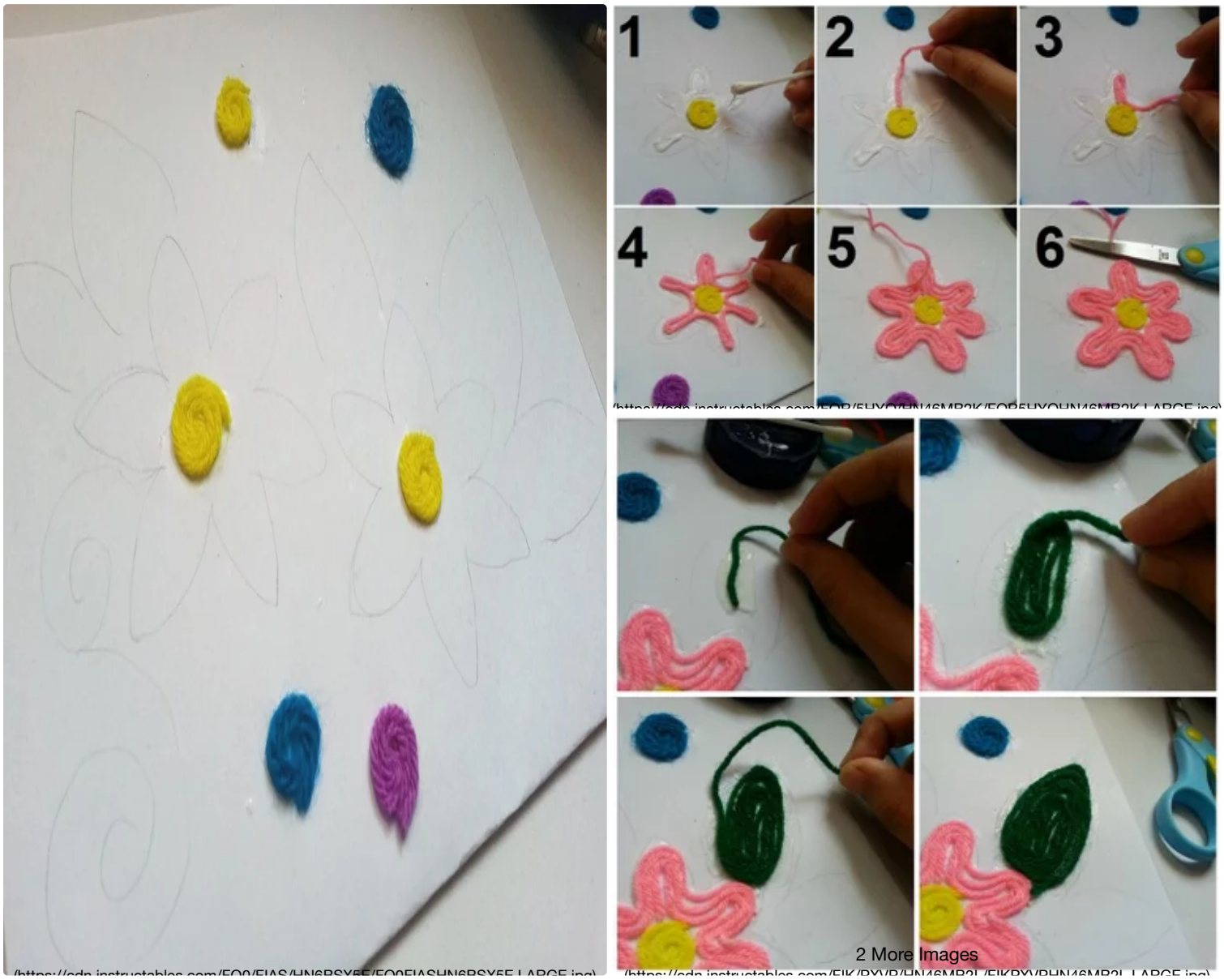
In few easy words, all you need to do is- draw a design and stick yarn over the design :p
You may come up with your own technique for yarn art while you're working.

Step 3: Select a Design

Start your yarn art with a simple design.
Select a design for the art and draw it on a paper. It's easier to do yarn art once you draw the design on the paper and simply glue the yarn over the design.

These are the 3 designs I've drew for my yarn art.
Design-1 for yarn art-1,
Design-2 for yarn art-2,
Design-3 for yarn art-3.

Step 4: Yarn Art-1



Start with the basic shapes, like- circle, square, triangle, lens etc but in this design there's only circles.

After you're done sticking yarn over the circles go for the other patterns or design (I've done- flowers, leaves and swirly vines),

After you complete the main design it's time to fill the blank areas. Stick yarn on the blank areas to make sure the white background is covered with yarn (see the last picture of this step).
If it becomes difficult to fill the blank area by using a single yarn string then you should cut the yarn. To fill the small blank areas it's better to cut the yarn into small pieces and then glue them to fill the small blanks.

Follow the pictures of this step to see how I filled the flowers, leaves and blank area with yarn.

Step 5: Yarn Art-2

First I glued yarn over the basic shapes (circle, square, triangle, lens, tear drop).

Then I glued navy blue yarn over the paisley, zigzag, flower and waves to highlight them.

I filled the blank areas of this art with different colored yarns.
You won't be able to fill some particular patterns by using a single yarn string, in that case cut the yarn into small manageable pieces. I had to cut red yarn into small pieces to fill the flower.
Sticking yarn on the blank areas of this art was fun!

Step 6: Yarn Art-3

Cardboard Billfold

37

Activity Description:
Students get to make something they can use everyday!

37

Cutting

Cu

Scissors

Arts & Crafts

Ar

Craft Paper
Heavy Cardstock

Fixturing

Fx

Binder Clips (Clamps)

Brainstorm

Br

Markers
Crayons

Painting

Pa

Paints

Joining

Jo

Glue
Glue Sticks

Other Materials
Thin cardboard and for drivers license compartment use plastic from recycled goods (3, 7/8" x 2, 7/8")

CARDBOARD BILLFOLD OR WALLET


Step 1: Tools and Materials

One piece of thin cardboard.
Scissors
Glue
Clamps
Kraft paper
Heavy cardstock
Optional: Paint brushes and high gloss polyurethane varnish, water based. For the driver's license compartment, I used a piece of plastic,3 and 7/8ths by 2 and 7/8ths in.

Step 2: Cut the Cardboard

Cut a thin piece of corrugated cardboard to 4x9 and 3/8ths inch

Step 3: Cover Edges With Kraft Paper




This would be leather on a typical billfold, but for our purpose, strips of kraft paper are used. Fold the pieces in half, lengthway, then glue to the cardboard. Use a liberal amount of glue so that the entire strip of paper is covered and will adhere to the billfold.

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Step 4: Make Credit/Debit Card Pockets



Use a colored cardstock here to hold down total bulk of the bill fold. To have space for three cards, you will need three pieces of cardstock. See pictures for descriptions on how to glue these and leave enough space for the cards.

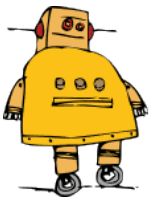
Step 5: Make Driver License Compartment

cut cardstock into 3/4 inch strip and long enough to make a border completely around the compartment. Optional—use plastic from recycled packages. cut to the dimensions of 3 and 7/8ths x 2 7/8ths in.

Optional Step 7: Paint



Utilize high gloss polyurethane varnish, water based paint for leather finish.



instructables

Embroidery

38

Activity Description:
Learn to embroider your own designs.

Cutting

Cu

Scissors

Textiles

Tx

Emroidery Floss
Plastic Needles
Embroidery Cloth

Brainstorm

Br

Markers
Crayons

38

Author:jessyratfink Making Jiggy.
I enjoy cats, Nicolas Cage, sewing, cooking, books, learning, and making.

I've had my work featured on Jezebel, BoingBoing, Gizmodo, LifeHacker, ohdeeoh, CRAFT, and in Theme and Adbusters magazines. If you came here from there, hello! Hope you stick around!

Intro: Embroidery 101!

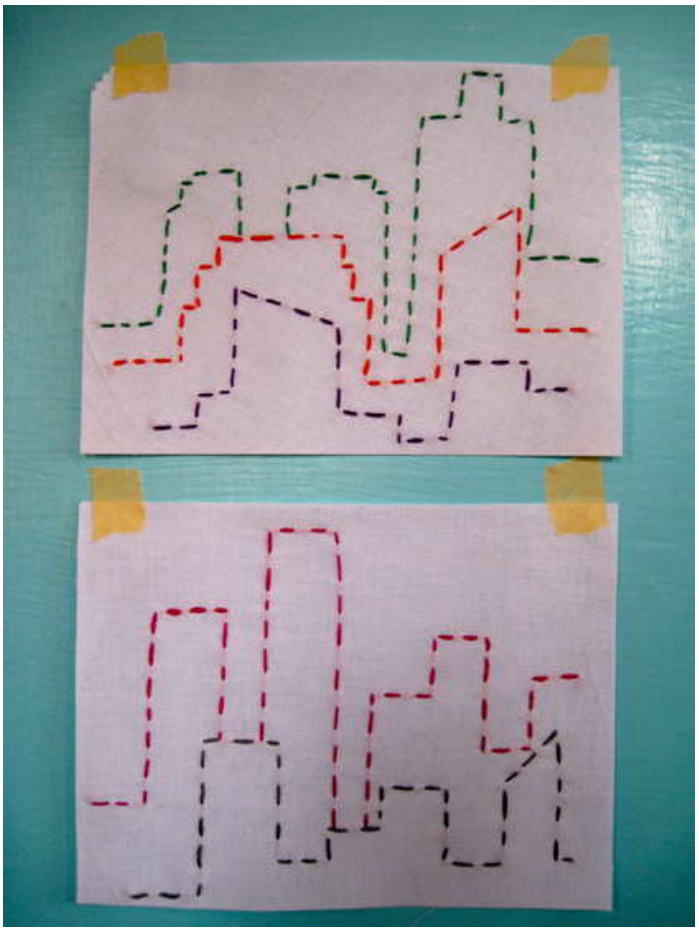
In this instructable I'll go over the basic stitches that I use the most and the basic tools you'll need to begin embroidering.

This will help with building yourself a Robot plushie. ;)

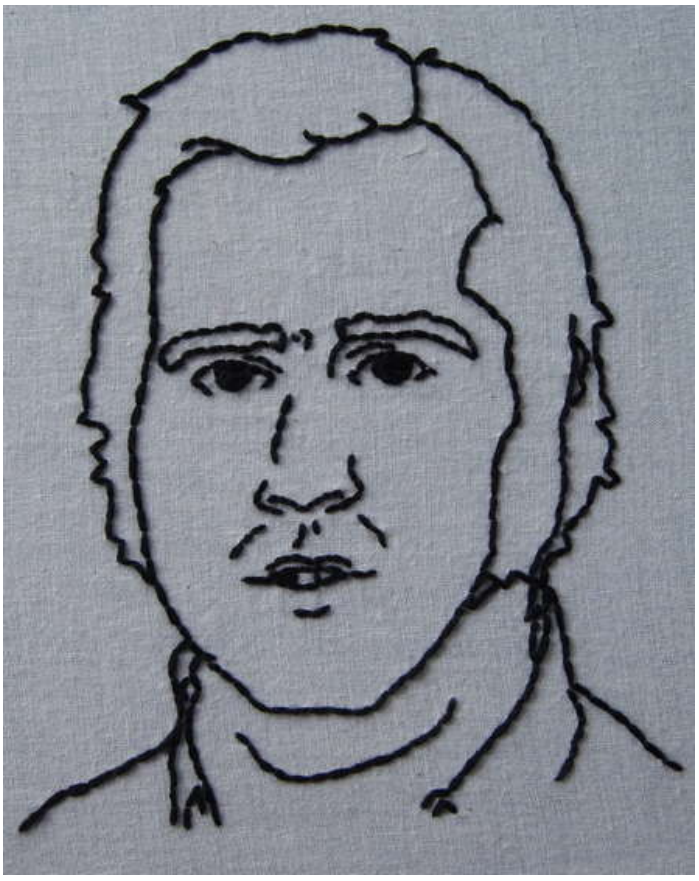
Also: for additional help with the basic stitches and general handsewing, check out my other crafty instructable at http://www.instructables.com/id/How-to-Sew./

If you have any stitch requests, or you're confused about something, let me know! :D

The measuring cups and cupcakes are patterns from Sublime Stitching! The rest of the embroideries are my own design.




the truth
is
out there



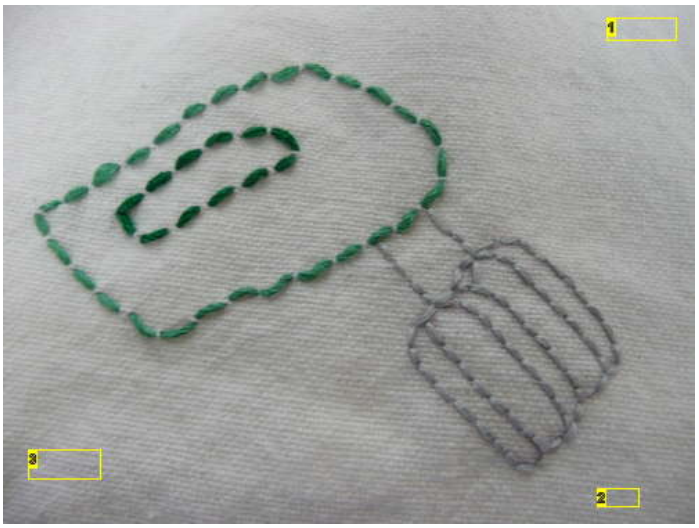


Image Notes
1. The mixer body is 6 strands, the whisks are 3.
2. Completely done in backstitching!
3. From sublimestitching.com

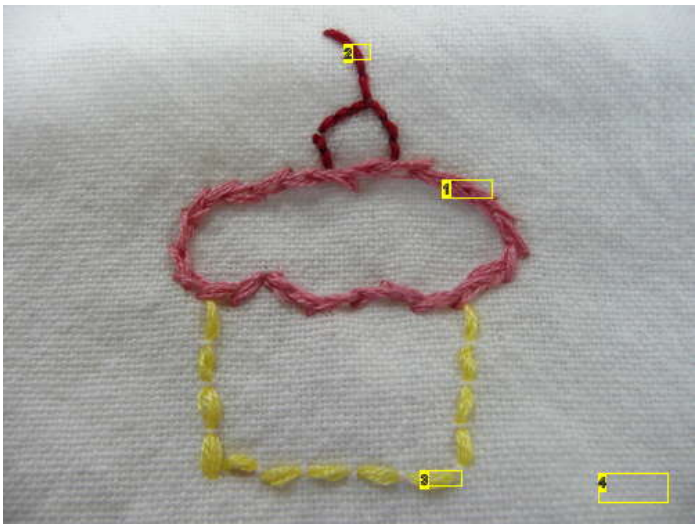


Image Notes
1. Split stitch to give texture.
2. Backstitch!
3. Backstitch!
4. From sublimestitching.com

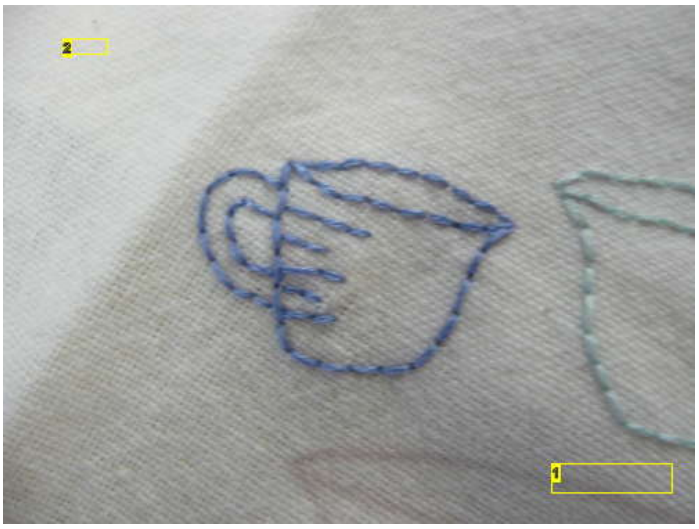


Image Notes
1. 3 strands, backstitching for both cups.
2. From sublimestitching.com

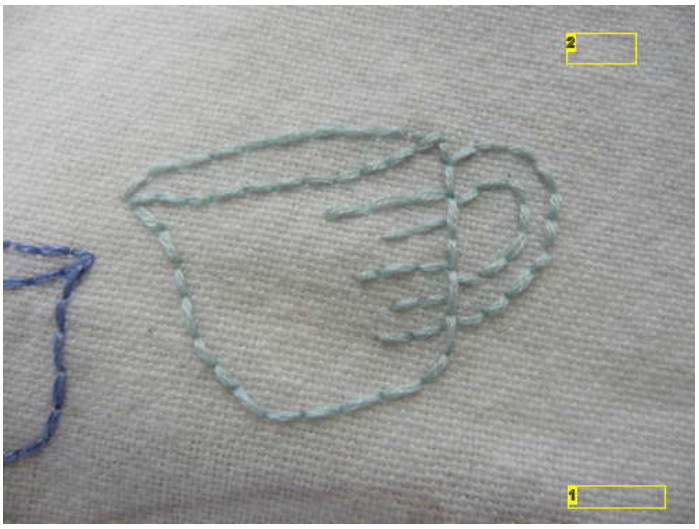


Image Notes
1. Backstitching, 3 strands for both cups.
2. From sublimestitching.com

Step 1: Tools or hardware, if you prefer.

To start embroidering, you'll need the following items:

- embroidery hoop - this is a ring consisting of two parts. You put the fabric in between the hoops - this helps keep it taut, making the embroidering easier.
- small, sharp scissors. You can find these under many names.
- your fabric of choice! In most cases, this shouldn't be loosely woven or too stretchy. Simple quilting cotton will work fine.
- embroidery floss. This is cheap and comes in TONS of colors.
- embroidery needles. These have bigger eyes than normal needles to accommodate the size of the floss.

Image Notes
1. Embroidery scissors.
2. Embroidery needle.
3. Embroidery floss.
4. Fabric.
5. Embroidery hoop.

Step 2: Using the embroidery hoop.

Embroidery hoops come in many flavors, though the basic circular wood and plastic ones are the most common. You can find them at most craft stores. :)

To start, loosen the nut at the top of the hoop. You'll then separate the hoops. Put the one that has the nut and bolt to the side, you don't have to worry about it just yet.

The other part of the hoop is the part you'll drape the fabric you're using over. In this case, I'm using an old cotton t-shirt because there was a whole bag of them at Instructables. :P

After you have the fabric over the bottom hoop, push the top hoop down over the bottom one. This will sandwich the fabric between them. Now you'll want to tighten the nut a bit and begin pulling the fabric taut. The fabric floating between the hoops should not give very much - this will make the embroidering much more complicated than it should be.

After the fabric is taut, keep tightening the nut until it feels secure to you.

Also note that this is the best time to trim the fabric if you need to. If you trim before you put it into the hoops you'll often find that it doesn't work as you think it will! :P

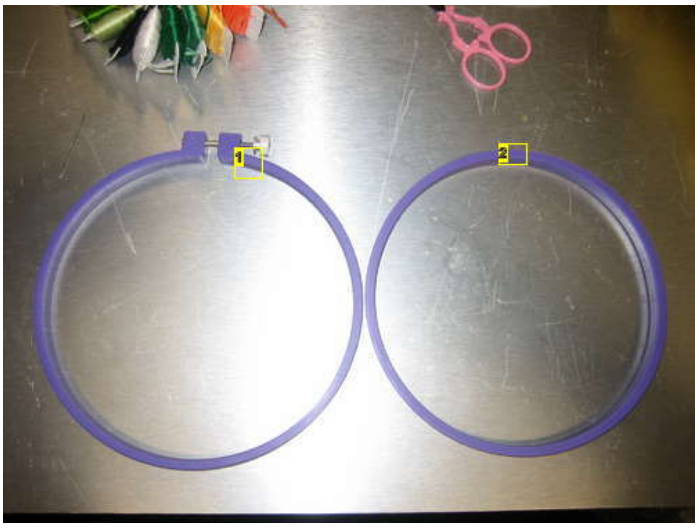


Image Notes
1. Top hoop!
2. Bottom hoop!

Image Notes
1. Place the fabric over the bottom hoop.

Image Notes
1. Put the top hoop over the bottom!

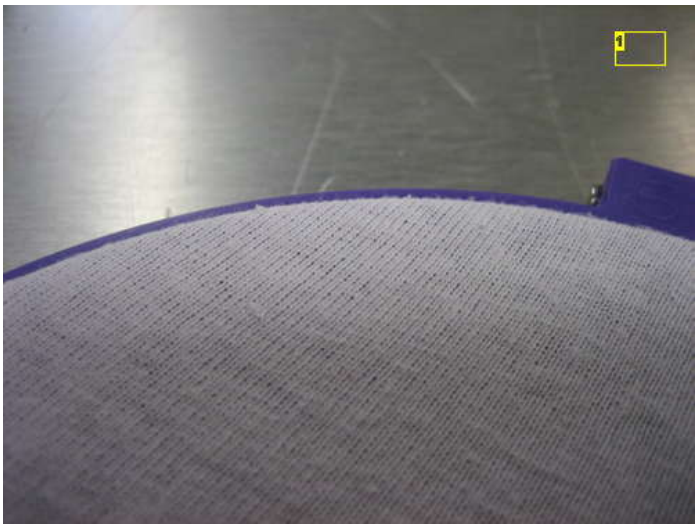


Image Notes
1. Nice and taut!

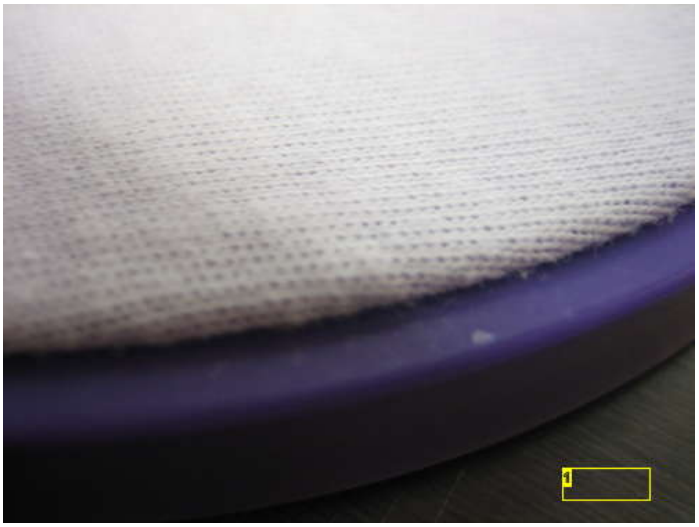


Image Notes
1. When using bottom hoops with lips, the lip should go over the top hoop. :)

Step 3: Threading the needle and all about floss.

Needle threading can be a little complicated at times. I've found the easiest way to do it is to wet the floss (yes, put it in your mouth.) and squish it between your thumb and forefinger. This will flatten it out and allow it to pass through the eye of the needle with less fuss.

Also: keep in mind that you do not double the floss as you sometimes do with thread. You're simply going to pull the thread through the eye and let a few inches hang loose. You'll knot the other end as usual. (And make sure to cut off the loose stuff after the knot - it'll make your work neater!)

Most floss is multi strand. The most common is six strands. You can divide the floss for more detailed work. The best way to do this it to use your fingernails to separate the strands and then pull is apart slowly. :)

(Plus, if you get addicted to embroidery as I have, you will find so many neat little gadgets. You can see my little organization system in the pictures of the floss. I simply wrap my floss around the plastic cards and write the color number on them!)

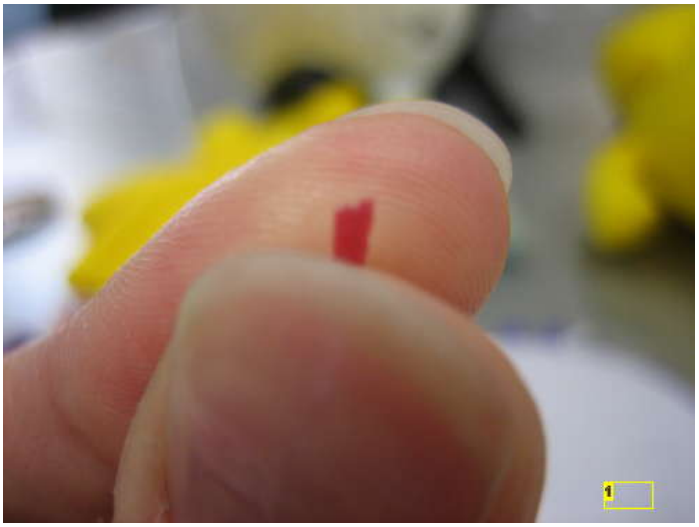


Image Notes
1. Squish the floss!

Image Notes
1. See? Nice and thin!

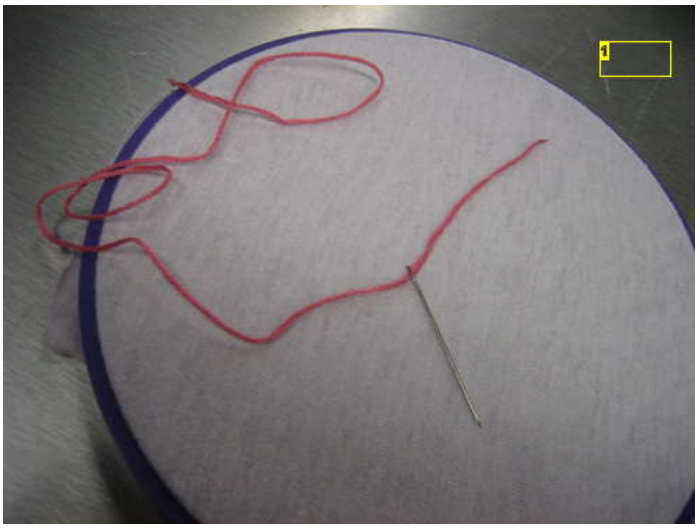


Image Notes
1. Pull the thread a few inches through the eye and let it hang.

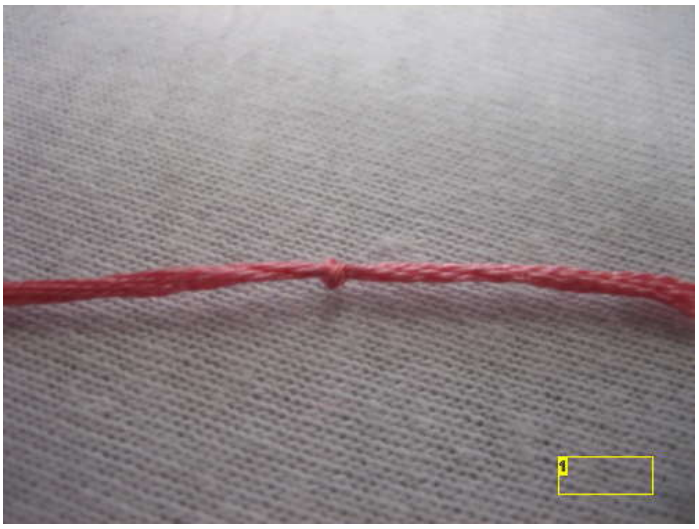


Image Notes
1. Knot as normal!

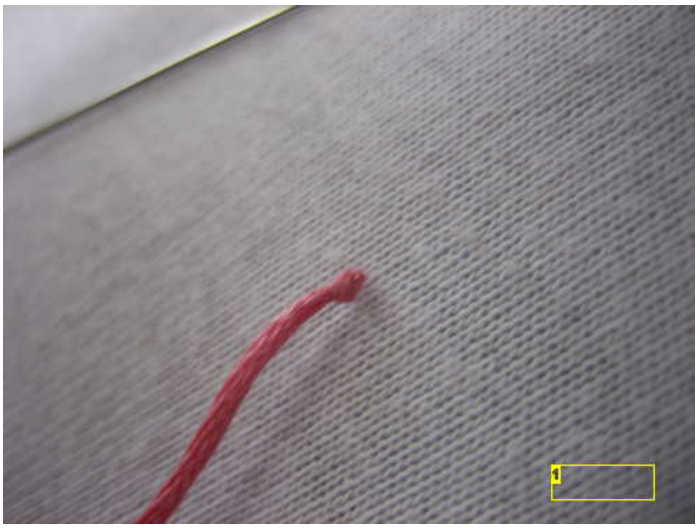


Image Notes
1. Cut the thread right past the knot to keep things cleaner. :D

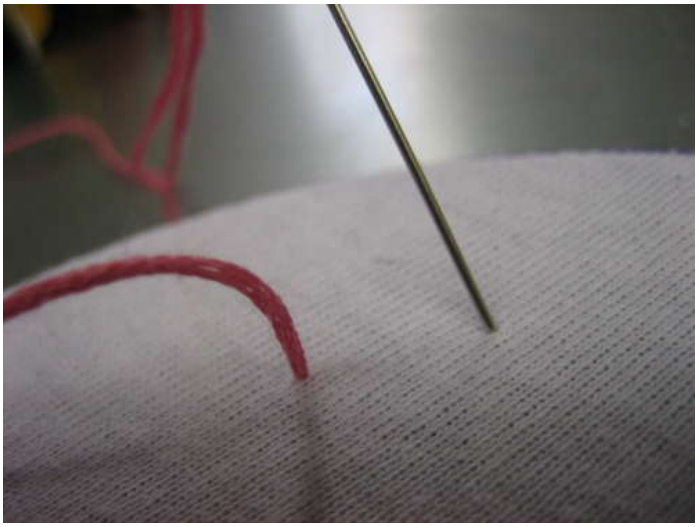
Step 4: The running stitch.

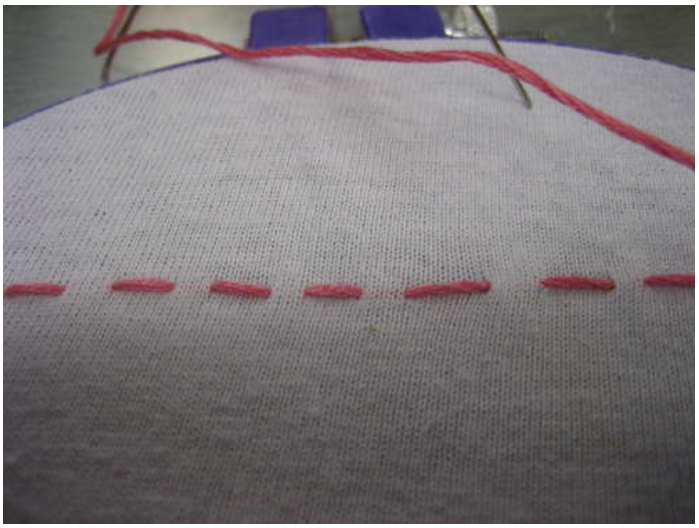
Done just as it is in regular sewing. You can make the stitches long or short or randomly placed depending on your design.

I use this stitch for framing and embroidery design, or for things that I want to seem open and airy. (See the Will Smith speech bubble for examples. I'll have a picture of another Will Smith shirt I made once I see the friend I gave it to. :P)

I don't recommend this as much for text, because it can be a little too spacey.

You can either do the standard up and down, or push the needle through and make several stitches at once. Both types are pictured below. :)





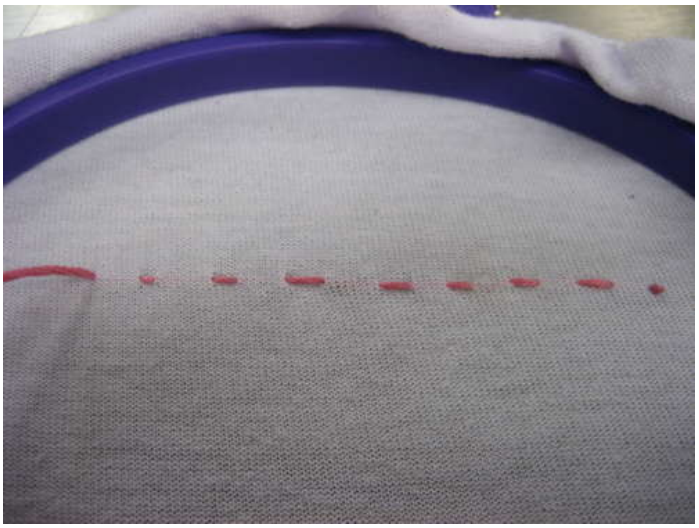


Image Notes
1. Knot it on the back!

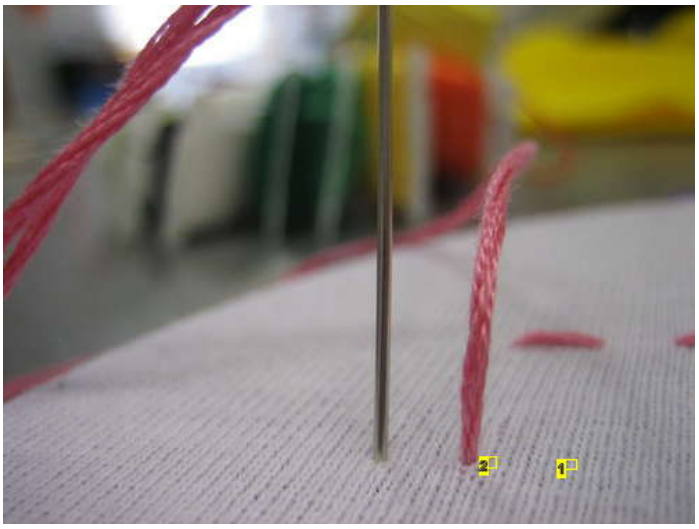
Image Notes
1. Yes, I did make this shirt for Hancock.

Step 5: Backstitch.

I use this stitch all the time for text. It makes the text easier to read and it's more uniform.

You basically just pull the thread up through the fabric, and make a stitch to the left or right, depending on which way you'll be going. (Left if you'll be going right, right if you'll be going left.) You'll then bring the thread up again a stitch length from the original. You'll then take the thread back down right next to the original stitch.

The pictures below will probably help make more sense of this! ;)



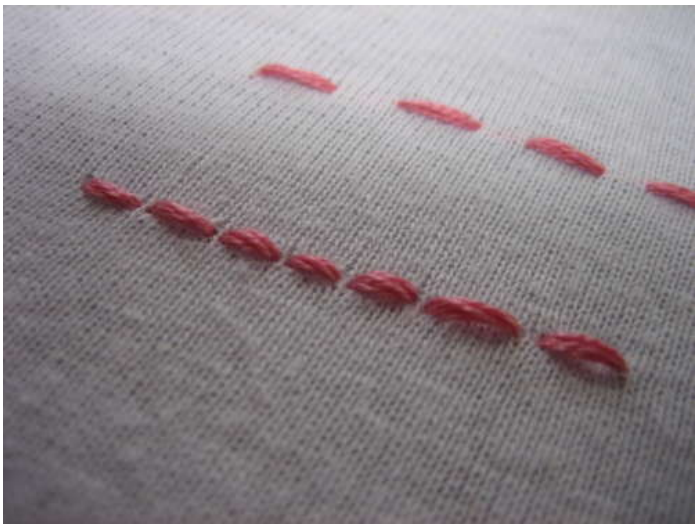


Image Notes
1. Bring the needle back up over here...
2. ...then bring it down right here!

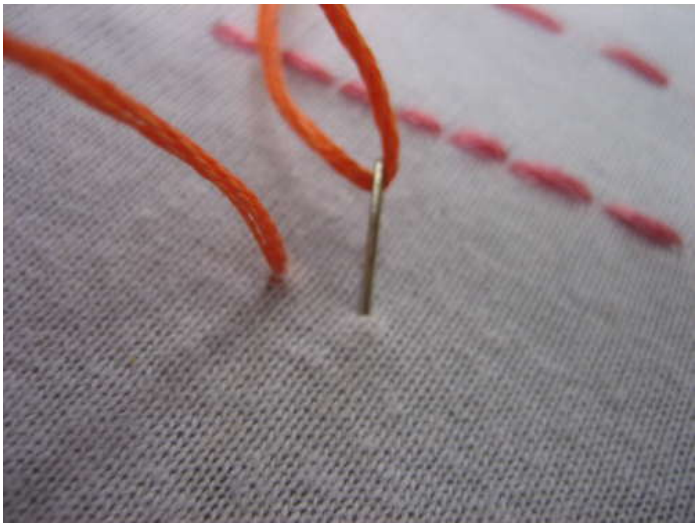
Step 6: Split stitch.

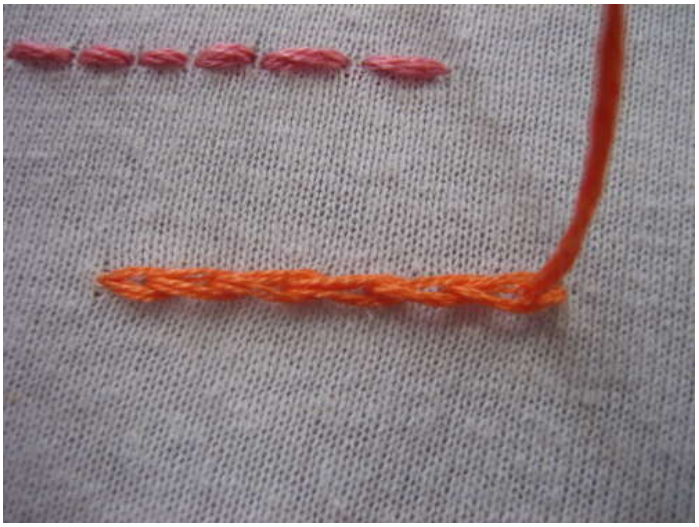
This is a great raised decorative stitch. It can be used much like a backstitch and works much like one.

I use this when I want things to have a little bit of texture. For example: the frosting on a cupcake, tree tops.

For this stitch you'll pull the thread up and make a small stitch. You'll then come back up through the middle of that stitch and take it back down through the fabric a short distance away in the direction you're going in. It's best to keep your stitches pretty short (1/8 of an inch to 1/4 of an inch.) when doing this - otherwise your stitches look messy and they won't conform to curves as much as you'd like.

See the pictures below for extra help! :D





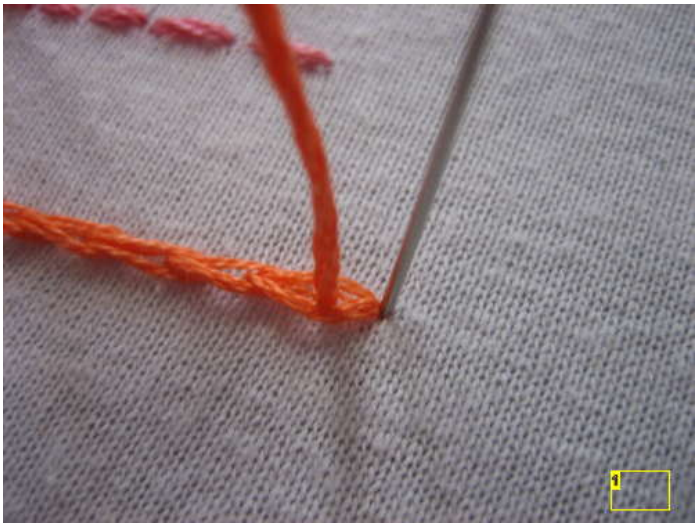


Image Notes
1. End by going to the back right next to the last stitch!

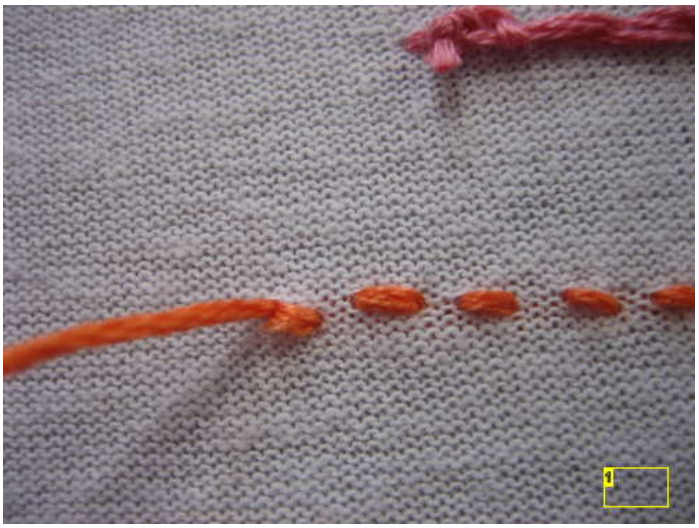


Image Notes
1. Knot at the back as normal!

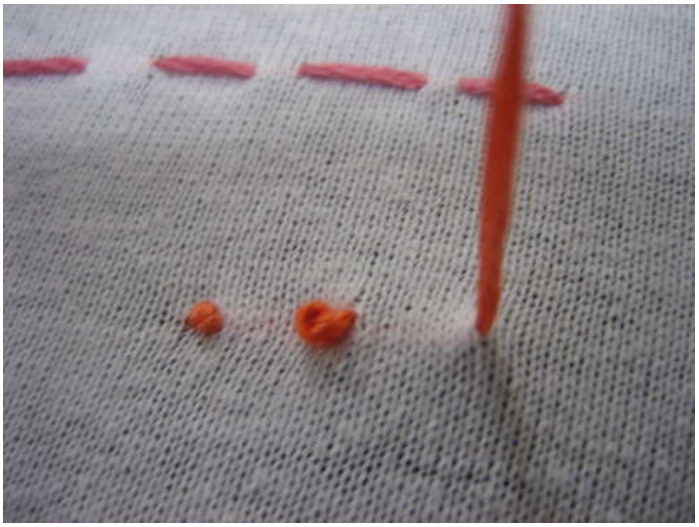
Step 7: French knots!

These are considered to be a nightmare for most embroiders, but I love them. They're very delicate and cute and they never look the same.

Their size can also vary greatly, so you can use them in a ton of ways. You can use them for the center of flowers, as eyes, for polka dots, and even as lines if you're feeling patient. :D

To pull off a french knot successfully, you'll need to follow these steps:

- pull the floss through to the front of the fabric.
- wrap the floss that's between the fabric and the needle around the needle 1, 2, or 3 times. (One time is a small knot, 2 is medium, 3 is large.)
- hold the floss tightly so that it is wrapped tightly around the needle.
- with your other hand, push the needle through to the back of the fabric very close to where the floss emerged.
- keep holding the floss taut and pull the needle all the way through.
- practice this a few hundred times until it becomes second nature. :D



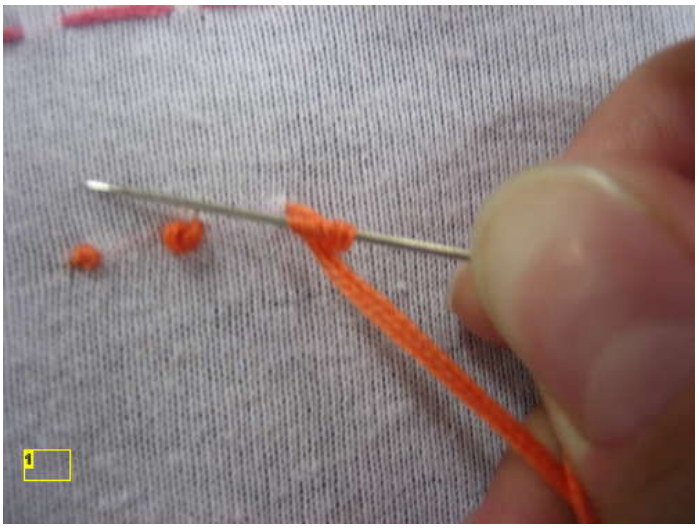


Image Notes
1. Wrap it around a couple times, hold the floss taut.

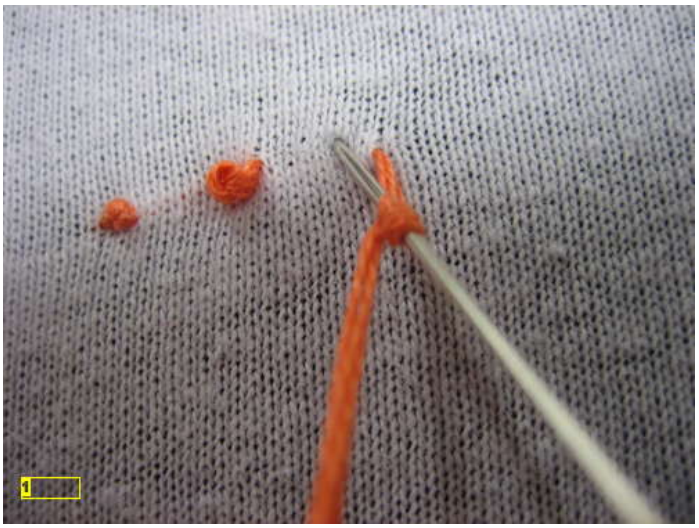


Image Notes
1. Insert the needle into the fabric next to where the floss came out!

Image Notes
1. Pull the floss through and you'll be left with a french knot!

Step 8: Blanket stitch!

This can be used for borders and thicker lines. You can also vary the spacing of these quite a bit. :D

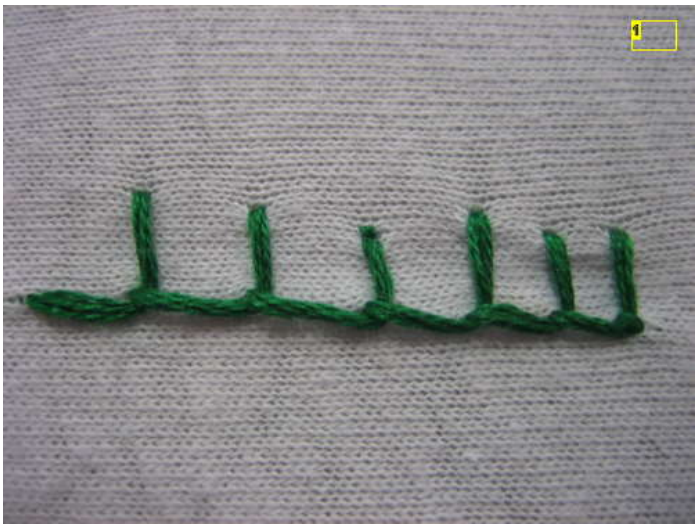
This is often used to "edge" materials - things like blankets, towels, hems on clothing, etc.

Also: note to self and possibly to you - don't use blanket stitch on a cotton t-shirt because it looks awful. Or, best case scenario, use stabilizer. It pulls too much and things become awfully uneven. :P

How to do the blanketstitch:

- insert the needle where you'll want the bottom of the backstitch to be and pull it up through the fabric.
- reinsert the needle up and right of your current position. Where you insert it will depend on how tall and far apart you want the stitches to be.
- have the needle reemerge so that it lines up with where you put the needle through the last time.
- make sure the floss between the fabric and thread is under the needle.
- pull the floss through!
- to end, simply take the needle down right next to the curve of the last stitch. This will secure the stitch.
- Make sure to knot on the backside. You can separate the floss into equal parts and knot it normally, if you like!

See the pictures below for extra help. :)



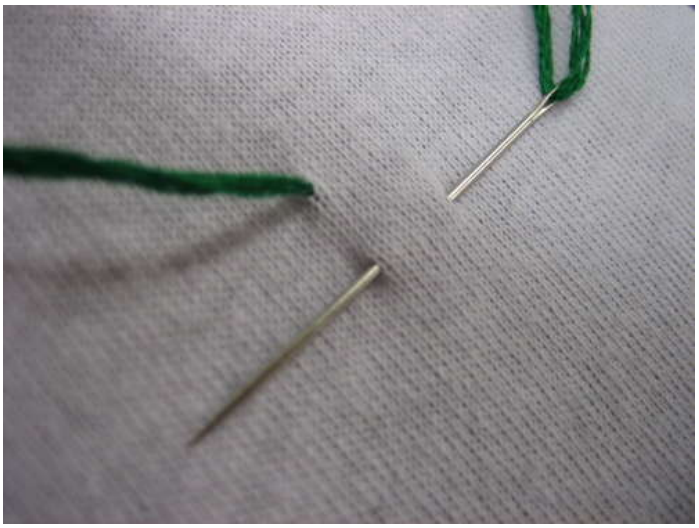
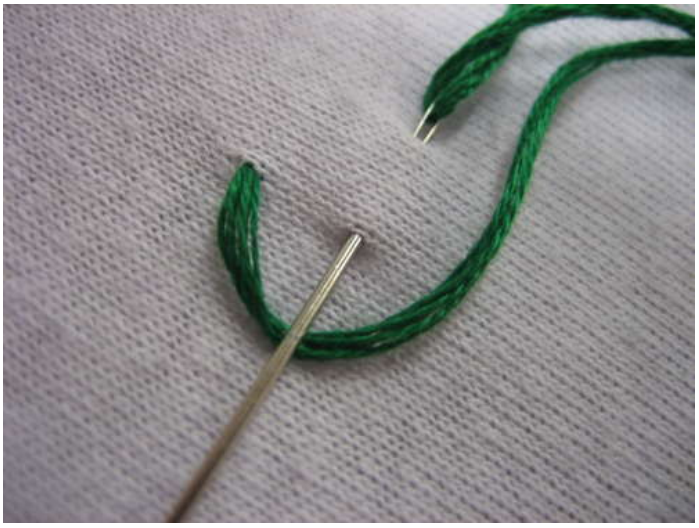
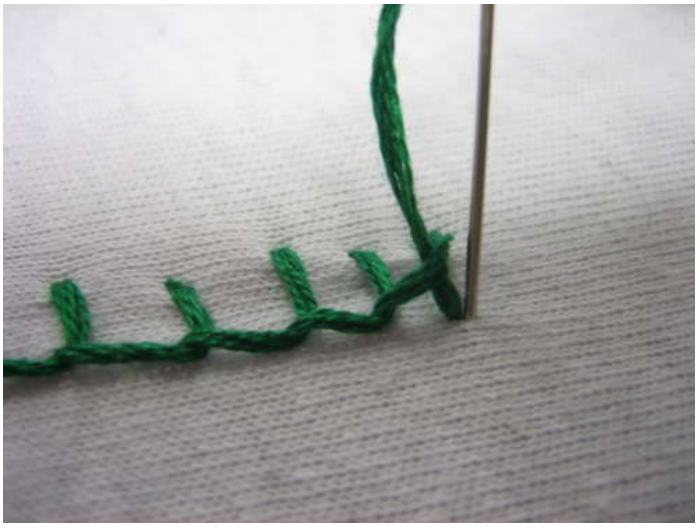
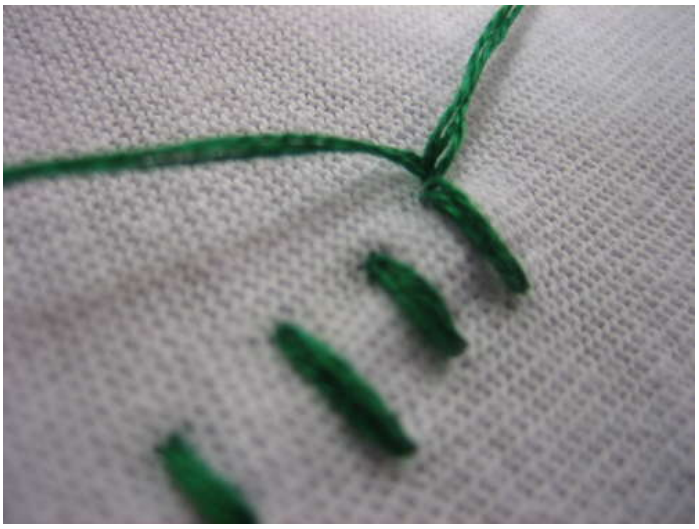
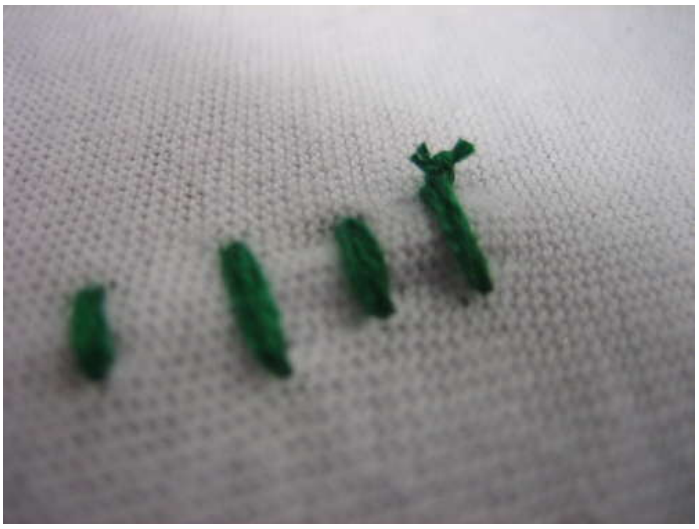


Image Notes
1. Examples of different sizing and spacing.







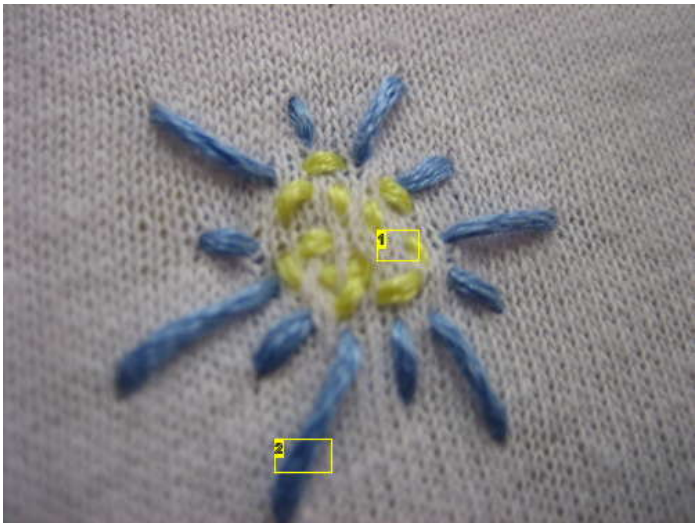


Step 9: Straight and seed stitches.

These are similar to running stitch - you're just not following a line! The placement is very random.

Straight stitches can vary in length. Seed stitches are very tiny - you'll be catching just a few threads with these! Seed stitches are most often used to fill areas in. Straight stitches can be used for a ton of different things - filling things in, adding detail, shading, etc.

See below for a quick example.



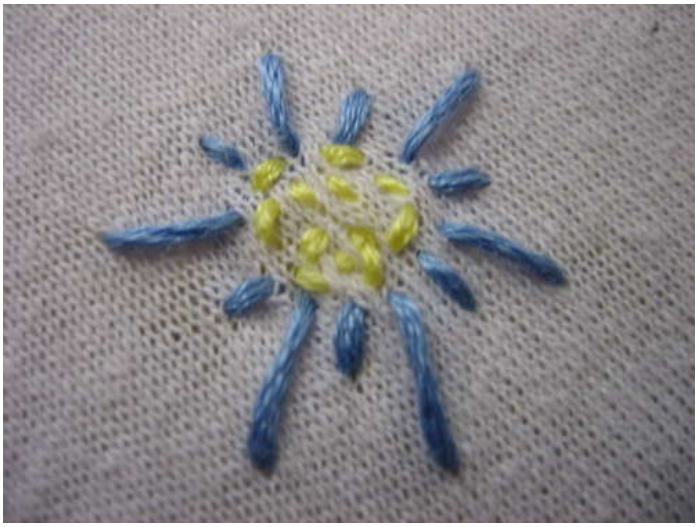


Image Notes
1. Seed stitches.
2. Straight stitches.

Step 10: Additional information and recommendations.

Everything in this instructable was freehanded on an old t-shirt, and therefore not as impressive as I'd like! ;) Things will look much better if you're following a pattern. To create a pattern, you can draw on the fabric, use iron on transfers or carbon paper to copy a design onto the fabric. (There are two examples of iron on transfer patterns below - they're from Sublime Stitching. :D)

You can get many free patterns online - I use http://blog.craftzine.com/ because they link to a lot of them!

As far as shopping for supplies and patterns, you can check your local craft/sewing retailer or try these websites:
http://pimpstitch.com/
http://www.sublimestitching.com/ - They have great beginners kits!
http://www.etsy.com/

Image Notes
1. Embroidery scissors.
2. Embroidery needle.
3. Embroidery floss.
4. Fabric.
5. Embroidery hoop.

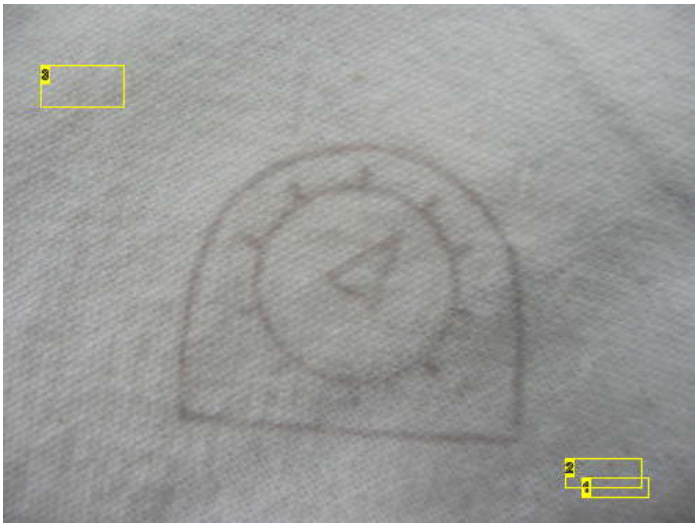


Image Notes
1. This is an example of an iron-on transfer.
2. This is an example of an iron-on transfer.
3. From sublimestitching.com

Rainbow Plate

39

Activity Description:
Weaving and painting project.

39

Cutting

Cu

Assorted Scissors

Sewing

Sw

Yarn

Painting

Pa

Tempura Paints

Other Materials

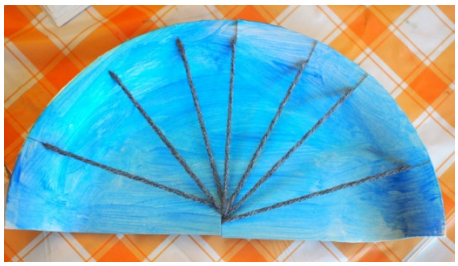
Pape plate

Rainbow Paper Plate Weaving Project

Supplies:
Paper Plate
Paint
Yarn—assorted colors
Scissors

Instructions:

(1) 
cut a paper plate in half and paint it with tempera paint to look like the sky and clouds.

(2) 

cut out 7 slits on top of the plate and 1 slit on the bottom.
Then, create your loom with **yarn**. (tie the two ends in the back.)

3. 

Start weaving the rainbow, starting from bottom of the plate (rainbow) first. Tie on the blue strand (see pic) to a grey one. Then, wrap **masking tape** around the other end of blue yarn to help weave faster. To weave, simply go over, under, over, under, etc... To change colors, tie on the next color yarn.

4. 

Once finished, tie on the red strand (or whatever color you end with) to a grey one.

Mosaics

40

Activity Description:
Challenge students to be creative and create a mosaic with fabric scraps and any additional textiles (buttons, yarn, etc). These mosaics could be abstract or an actual picture…be creative!

40

Cutting

Cu

Scissors

Sewing

Sw

Yarn

Arts & Crafts

Ar

Construction Paper

Brainstorm

Br

Markers
Colored Pencils

Joining

Jo

Glue Bottles
Glue Sticks

Textiles

Tx

Buttons

Other Materials
Cardboard, Fabrics

Fabric Mosaics

Supplies:
Recycled cardboard
Construction Paper
Glue bottles, glue sticks, glue guns
Larger fabric pieces
Fabric scraps
Additional textiles: buttons, yarn, etc
Markers

Instructions:

(1) Choose to have a fabric or construction paper background for the mosaic
(2) Cut cardboard to the dimensions of the construction paper or fabric

(3) Glue construction paper or fabric to the cardboard—the cardboard will serve as the backing to the mosaic
(4) Challenge students to be creative and create a mosaic with fabric scraps and any additional textiles (buttons, yarn, etc). These mosaics could be abstract or an actual picture…be creative!

Design Challenge

Skyglider

41

Activity Description:
The challenge is to design and build a blimp that flies as straight and far as possible.

41

Cutting

Cu

Scissors

Arts & Crafts

Ar

Craft Paper

Measuring

Ms

Bag of Ballons

Brainstorm

Br

Markers

Joining

Jo

Tape

Joining

Jo

Glue
Glue Sticks

SKY GLIDER

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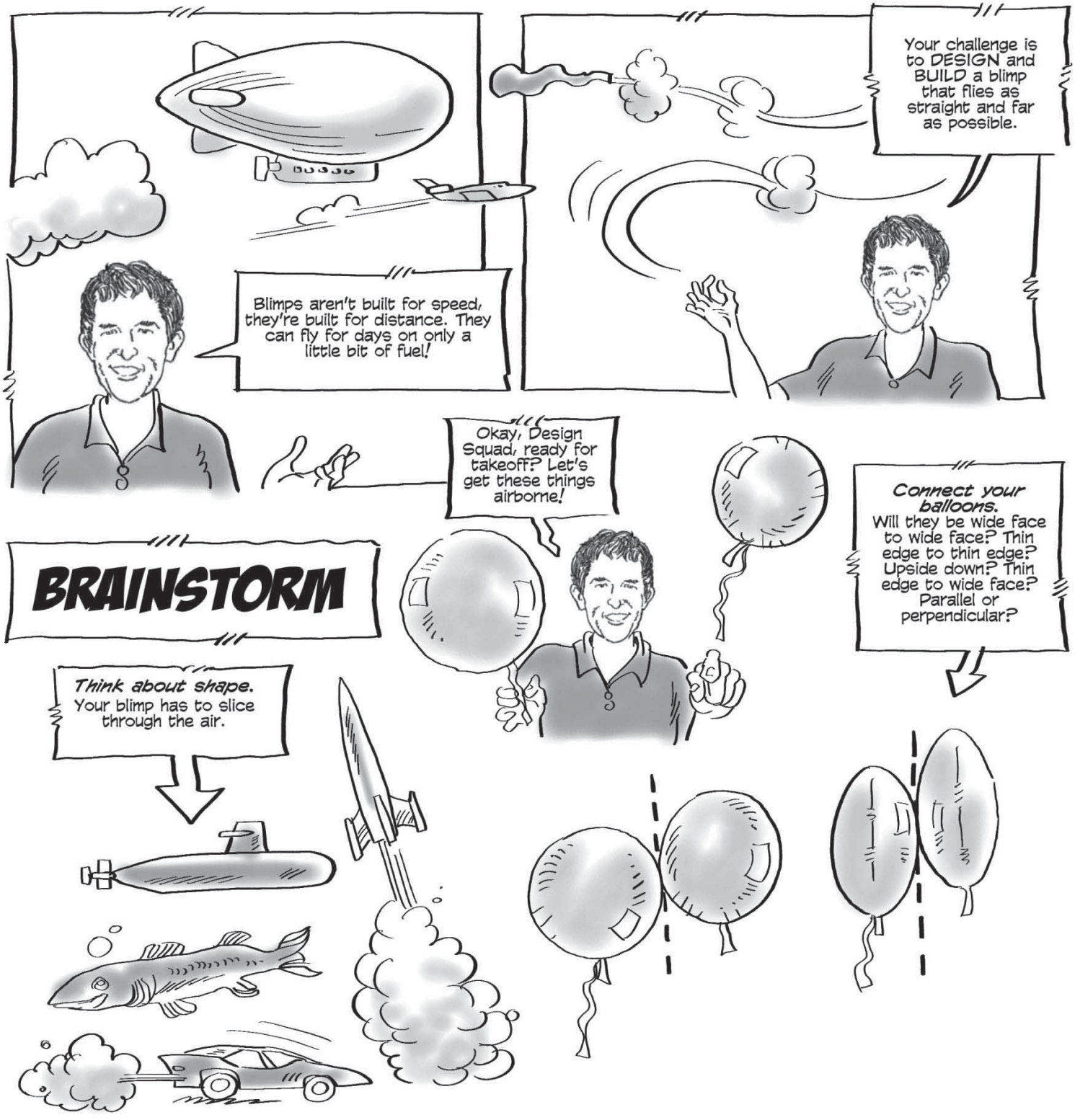
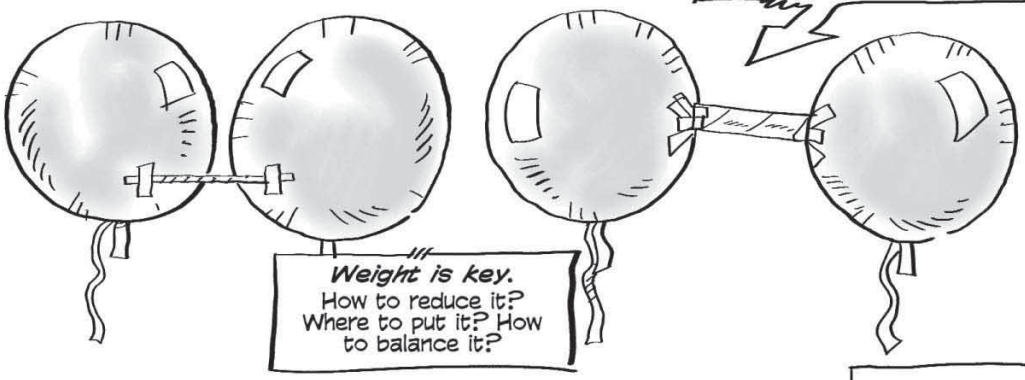
pbs.org/designsquad



DESIGN AND BUILD

How wide apart?
What's a good distance between balloons so your blimp tracks straight? Look at the skaters for a hint.



Weight is key.
How to reduce it? Where to put it? How to balance it?

TEST AND REDESIGN

Launch the same way
Use the same launcher, start the blimp at the same position, and use the same launch technique every time.

Measure and record
Record the distance of each test flight and how straight the blimp went.

Farther! Straighter!
After each test, think about ways to improve your design. Record the changes you made and their effects.

1. _____
2. _____
3. _____

DESIGN SQUAD PBS. **Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.**

Major funding for *Design Squad* provided by

NSF intel Education the Lemelson foundation improving lives through invention

Additional funding for *Design Squad* provided by

NOYCE FOUNDATION NCEES National Council of Examiners for Engineering and Surveying ASME IEEE Celebrating 125 Years NORTHROP GRUMMAN Foundation

Helping Hand

42

Activity Description:
Design and build a device that lets you grab different objects and drop them into a container that's at least two feet away from you.

42

Cutting

Cu

Scissors
Hole Punch

Arts & Crafts

Ar

Craft Paper
Heavy Cardstock
Wooden Craft Sticks

Fixturing

Fx

Rubber Bands
Binder Clips
Clothes Pins
Paper Clips

Brainstorm

Br

Markers
Crayons

Sewing

Sw

Yarn

Joining

Jo

Duct Tape

Other Materials
Cardboard, objects to pick up (e.g., tennis balls, cotton balls, soda bottles, and paper cups), yardstick or paint stirrers, brass fastners

HELPING HAND

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pbs.org/designsquad

YOUR CHALLENGE

Design and build a device that lets you grab different objects and drop them into a container that's at least two feet away from you.

BRAINSTORM & DESIGN

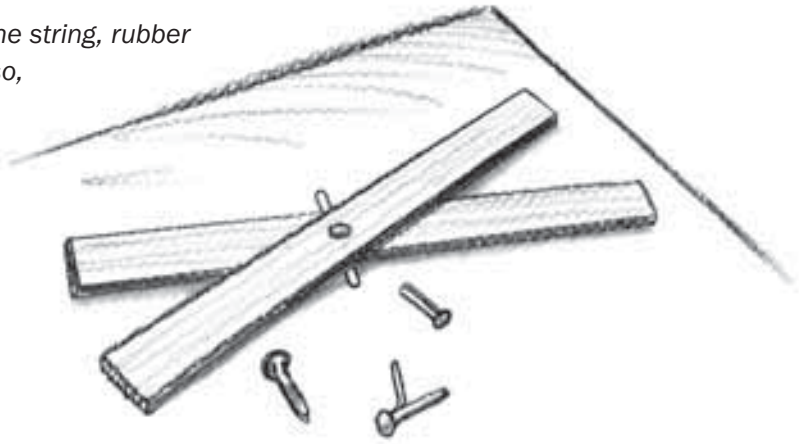
Look at your materials and think about the questions below. Then sketch your ideas on a piece of paper or in your design notebook.

1. Using these materials, what can you build to grab objects that are two feet away from you?
2. How will your grabbing device open and close so it can grip an object and let it go?
3. How will you attach your grabber to the end of the stick?
4. How will you control your grabber when it's at the end of the stick?

BUILD, TEST, EVALUATE & REDESIGN

Use the materials to build your grabber. Then test it by trying to pick up different objects. When you test, your design may not work as planned. When engineers solve a problem, their first solution is rarely their best. Instead, they try different ideas, learn from mistakes, and try again. Study the problems and then redesign. For example, if your grabber's jaws:

- have a weak grip—*Increase their force. Each arm of the jaw is a* **lever***—a bar that pivots around a* **fulcrum***. In this case, the fulcrum is the brass fastener. Change the strength of your jaw's grip by adjusting the length of the arms and the fulcrum's position. (See illustration.)*
- keep dropping things—*Make sure that the jaws close enough to actually hold something. Also see if the jaw's gripping surface is big enough and shaped right to have a firm grip.*
- bend or twist—*Reinforce them with something stiff. Also, check if the jaw's arms are longer than necessary—short arms don't bend as easily as long ones.*
- don't work at the end of the stick—*Make sure the string, rubber bands, and moving parts aren't getting stuck. Also, move the jaws with your hands. If they don't work the way they should, readjust the parts.*



MATERIALS (per person)

- 4 brass fasteners
- corrugated cardboard
- hole punch
- objects to pick up (e.g., tennis balls, cotton balls, plastic soda bottles, and paper cups)
- 2 rubber bands
- sandpaper
- scissors
- string
- tape (duct or masking)
- 4 toothpicks
- 4 wooden skewers
- yardstick (or long paint stirrers for 5-gallon buckets, a thin wooden slat, or lath 2–3 feet long)

TAKE IT TO THE NEXT LEVEL

- Supersize me! Build a grabber that can pick up two objects at once.
- Smooth moves! Add a second motion to your grabber, such as making the stick that holds the jaws able to bend like an elbow or extend another two feet and then retract.

MAKE IT ONLINE

Blast me a marshmallow, would ya?
Build an air-powered marshmallow launcher out of plastic pipe and marshmallows. See how on Make Magazine's project page at makezine.com/designsquad.

ENGINEERING IN ACTION

There's something unique about four-year-old Michael—he has four hands! Born with six inches of his left arm missing, Michael wears a standard prosthetic (i.e., artificial) hand. It has some limitations—Michael can pick up and hold things but can't squeeze or press very hard. Michael's father wanted him to be able to do more with his prosthetic hand and have some fun in the process. With this in mind, he contacted engineers at the Open Prosthetics Project. Together, they built Michael two more hands—hands unlike any you've seen! One is a dinosaur puppet. Michael grips things by controlling its jaws. The other is a fishing rod. Michael uses it to catch fish as well as to reel in stray toys. Michael's father continues to think up and build more hands for Michael. "Once you have the training," he says, "you can conceive, design, and build whatever your imagination pictures."

DESIGN SQUAD PBS

Watch the DESIGN SQUAD Water Dancing episode on PBS or online at pbs.org/designsquad.

cpb intel Education NCEES National Council of Examiners for Engineering and Surveying NOYCE FOUNDATION NORTHROP GRUMMAN Foundation IEEE

Major funding for *Design Squad* is provided by the Corporation for Public Broadcasting and the Intel Foundation. Additional funding is provided by the National Council of Examiners for Engineering and Surveying, United Engineering Foundation (ASCE, ASME, AIChE, IEEE, AIME), Noyce Foundation, Northrop Grumman Foundation, the IEEE, and the Intel Corporation.

Design Squad is produced by WGBH Boston. WGBH

Speedy Shelter

43

Activity Description:
Invent an emergency shelter that can fi t a person and is sturdy and quick to build. In this challenge, kids: (1) think about a familiar shape in new ways; (2) learn about an injured hiker who survived by building a makeshift shelter; (3) brainstorm shelter designs; (4) follow the design process to invent a solution to the challenge.

43

Cutting

Cu

Scissors
Hole Punch

Joining

Jo

Duct Tape

Sewing

Sw

Yarn

Other Materials
Cardboard, garbage bags, 16 3ft bamboo plant stakes

CHALLENGE 4
SPEEDY SHELTER

The invention challenge
Invent an emergency shelter that can fit a person and is sturdy and quick to build.

In this challenge, kids: (1) think about a familiar shape in new ways; (2) learn about an injured hiker who survived by building a makeshift shelter; (3) brainstorm shelter designs; (4) follow the design process to invent a solution to the challenge.

1 Prepare ahead of time

- Read the leader notes and the challenge sheet.
- Get paper and pencils for the warm-up activity.
- Gather the materials (per team):
  - 2 cardboard sheets (approx. 8.5x11 in.)
  - 16 3-ft. bamboo plant stakes
  - 3 33- or 42-gal. garbage bags, cut open into sheets
  - scissors
  - duct tape
  - string

NOTE #1: The bamboo plant stakes (available at garden centers and hardware stores) come in various lengths. The 3-foot length is the best for this challenge.

NOTE #2: Don't use fiberglass stakes. If a kid lets go of a bent fiberglass stake, it will immediately straighten. Kids could be hurt if an end that's whipping through the air hits them.

NOTE #3: As a safety measure, cut the garbage bags open into sheets before the session. This way, kids can't get stuck inside a bag and risk suffocation.

2 Warm up: Spark kids' imaginative thinking (10 minutes)

Draw a triangle on a board and show kids how it can be turned into an object (see examples at right). Next, have kids draw eight triangles on a sheet of paper, leaving some space around each one. Challenge them to turn their triangles (or pairs of triangles) into objects. After a minute or two, have kids share their ideas. Tell them inventors think about things in new ways and see interesting possibilities.

3 Introduce the challenge (5 minutes)

Put today's challenge in context by reading the following news story.

It started as a pleasant hike. But soon John Balgrano was in trouble. While hiking alone in the mountains of New Zealand, he slipped and fell down a mountainside, injuring his leg so badly he couldn't walk. Plus he'd lost his camping gear in the fall. That night, a storm blew in, bringing high winds, freezing temperatures, rain, and hail. Balgrano needed shelter—fast. He grabbed branches, strips of bark, and leaves and did his best to turn them into a weatherproof roof. Then he waited, growing colder and weaker throughout the stormy night. Twelve hours later, just as he was slipping into what he called the "jaws of death," a search party rescued him.

DESIGN SQUAD

SHOW KIDS THE RELATED TV EPISODE

Photo: Mika Tomczak

The Design Squad *teams take a crash course in pre-industrial building techniques as they compete to build 20-foot bridges without the aid of power tools, forklifts, or flushable toilets. Watch the "DS Unplugged" episode at* **pbs.org/designsquad**.

In this challenge, kids explore how shapes, such as triangles, can be used to make a stable structure. As a warm-up, kids stretch their imaginations by turning triangles into something different.

LEMELSON-MIT InvenTeams

SHOW KIDS A RELATED INVENTEAM PROJECT

Norfolk Technical Vocational Center's InvenTeam invented an ergonomic backpack that reduces the strain on a person's back. Check out this project and others at **web.mit.edu/inventeams**.

Inventors think about things in new ways and see interesting possibilities.

4 Brainstorm design ideas (10 minutes)

To help the kids brainstorm design ideas, tell them today's challenge and ask:

- How could you use different parts of plants to make a shelter that would be strong enough to withstand the wind and rain? *(Use long, sturdy branches and large leaves to block the wind and rain. Weave them together or layer them.)*
- Besides hikers, who else might use such a shelter? *(People who are homeless, stranded at sea, shipwrecked, or affected by natural disasters, such as hurricanes and earthquakes)*
- Buildings have to resist forces like the pushes and pulls caused by gravity and wind. What are some ways engineers help create sturdy buildings? *(They make sure that the structure has a solid base, the materials are strong enough, and the parts are securely fastened together.)*
- In addition to triangles, what shapes are good when building structures and why? *(Cubes, squares, rectangles, pyramids, domes, cylinders, and arches. They distribute force, such as the weight of the roof, among different parts of the frame. Triangles, domes, and arches are particularly strong shapes because they spread the force to nearly every other part of a frame.)*
- How can you make a wobbly frame more stable? *(Make sure each part is connected to, and supported by, two or more other parts.)*
- Tents have three basic parts: a frame, a cover, and connectors to hold the parts together. Look at the materials and sketch at least three shelter designs. *(An effective design will be similar to "skin and skeleton" structures, such as a tent or skyscraper. The skeleton is the frame [e.g., the pole or steel frame] and the skin is the covering material [e.g., fabric or glass]. Some structures, such as large tents and radio towers, use wires for added stability.)*

During testing, we ended up with a variety of designs. These pictures show several possible solutions. But don't show them to kids—they're likely to copy the ideas they see.

5 Build, test, and redesign (25 minutes)
During testing, we encountered some problems that your kids might also face:

- **Connecting parts together is hard**—Make strong, flexible joints with duct tape (see illustration).
- **The frame tilts or twists**—One way to strengthen a frame is to connect each part to one or more other parts. Also, kids can brace the corners of their frame with cardboard. Or, they can run a bamboo stake at an angle between two parts of the frame. This creates a triangular brace, which adds rigidity to a frame.
- **The frame wobbles**—To increase stability, anchor the frame to the floor with tape, or secure it by running lengths of string from the frame to the floor and taping them down.
- **The roof collapses the frame**—Remind kids that the plastic roof will push down on the top of the frame. Have them simulate this force by pushing down gently on the top of the frame. Reinforce the frame as necessary.
- **The plastic slides off**—Have kids tape two or three plastic sheets together before draping it over the frame. Once in place, they can secure the cover with tape or string.

6 Discuss what happened (10 minutes)
Ask kids to present, compare, and discuss their designs.

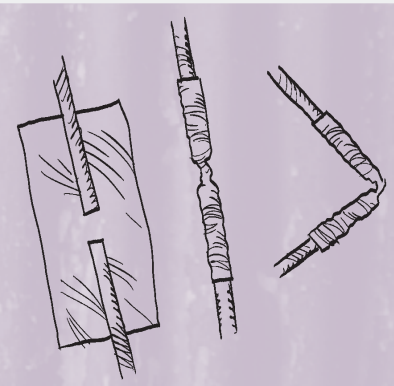
- What force affected your shelter the most? *(Gravity—including the weight of the frame, plastic, and any objects placed on the tent)*
- What tent shapes seemed to be the strongest? *(Triangles and domes are particularly strong shapes because they spread the force to nearly every other part of a frame.)*
- What were some successful strategies for making your shelter more stable? *(The base was securely attached or weighted down to the ground, the frame is a stable shape, and the parts were reinforced where they join together.)*
- What design changes would make your shelter easier to use or more useful in an emergency? *(Making it more portable by reducing the size and weight; making it easier to put up and take down; and making it a bright color so rescuers can see it.)*

TINKER SOME MORE

(1) Show kids the D-Squad ProFile of engineer Connie Yang who designs tents and talks about how engineering lets her combine a passion for sports with a love of solving interesting problems. Watch it online at **pbs.org/designsquad/profiles/connie_yang.html**.

(2) Challenge kids to make a shelter that:

- is small enough to fit in a backpack,
- takes only one person to set up,
- doesn't require tools to put together,
- can be collapsed and used again.



To connect two plant stakes, lay a 3-inch length of duct tape on the floor, sticky side up. Lay the ends of the plant stakes on the tape, keeping a ½-inch gap between them. Close the tape over the ends of the two stakes. Now the tape can act like a hinge.

CHALLENGE THE STEREOTYPE

Tell kids that inventors and engineers enjoy solving problems about things that really matter to people. For example, they develop handy, inexpensive, weatherproof shelters for hikers and for people who are homeless, stranded at sea, or affected by natural disasters, such as hurricanes and earthquakes. Also show kids videos in which young engineers describe how engineering lets them lead interesting, exciting lives and do cool things. See them online at:

- **pbs.org/designsquad/profiles**
- **web.mit.edu/inventeams/videos.html**

Seismic Shake-Up

44

Activity Description:
Design a structure that can survive an earthquake-then put it to the test!

44

Cutting

Cu

Scissors

Measuring

Ms

Straws

Fixturing

Fx

Rubber Bands
2 Large Binder Clips

Arts & Crafts

Ar

Wooden Craft Sticks

Joining

Jo

Tape

Joining

Jo

Play Dough

Other Materials
Cardboard or cardboard bin tools, tennis bins, rulers

SEISMIC SHAKE-UP!

CHALLENGE SHEET

DESIGN squad Global

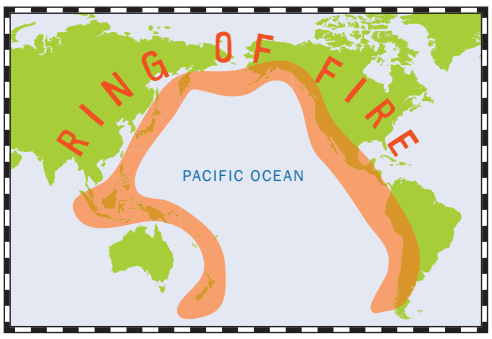
FOR MORE GREAT ACTIVITIES:
PBSKIDS.ORG/DESIGNSQUAD

YOUR CHALLENGE

Design a structure that can survive an earthquake—then put it to the test!

DEFINE THE NEED

Hundreds of millions of people live in places around the world where earthquakes are common. Most of the destruction earthquakes cause is the result of collapsing structures, like skyscrapers, hospitals, and bridges. That's why earthquake engineering is so important. By designing buildings and other structures that can withstand the violent shaking of an earthquake, engineers save lives.



About 90% of all earthquakes take place along the Ring of Fire—a zone stretching around the rim of the Pacific Ocean.

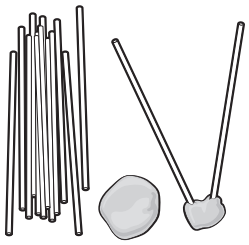
MATERIALS

Structure (per person)

- 20–30 wooden or plastic coffee stirrers (5–6 in long, or about 14 cm)
- ¼ lb (100+ grams) modeling clay (about half the size of a fist); non-hardening Plasticine® preferred
- manila file folder or thin piece of cardboard (8½ x 11 in or A4), as the base of your structure
- ruler

Shake Table

- 2 pieces sturdy cardboard (about 8½ x 11 in or A4)
- 2 thick rubber bands
- 2 tennis balls
- 2 large binder clips
- ruler or paint stirrer to make a handle
- masking tape



BRAINSTORM & DESIGN

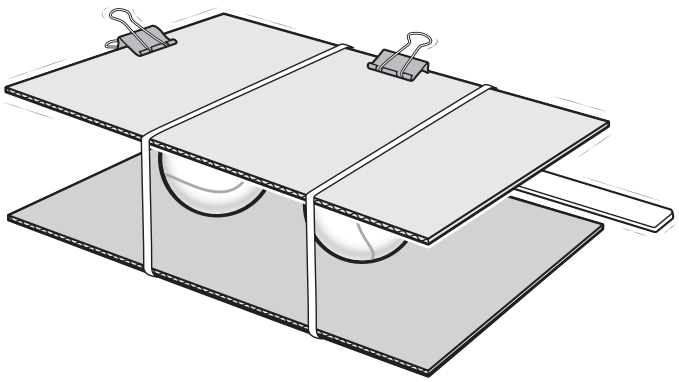
Using coffee stirrers and clay, can you design a structure that's stable and sturdy enough to survive an earthquake's vibrations? It must be **at least 8 inches tall.** Sketch your ideas on a piece of paper.

BUILD

Build your structure directly on top of the file folder, fixing the base of it to the surface of the folder. Use the ruler to make sure it's the minimum height.

Build a shake table, which is a device engineers use to simulate the back-and-forth shaking of an earthquake.

1. Wrap the rubber bands around the width of both pieces of cardboard. Space them about 4 inches apart.



2. Slide the two tennis balls in between the pieces of cardboard, and position them underneath each rubber band.

3. Tape the ruler (or paint stirrer) under the top piece of cardboard to make a handle.

TEST, EVALUATE, & REDESIGN

- Test your structure using the shake table. Attach the file folder with your structure on top of it to the table with the binder clips.
- Use one hand to hold the bottom of the shake table against a surface, pull the handle with the other, and let go! Earthquake!
- How did your structure hold up during the seismic shake-up? If it wobbled, swayed, tipped over, or collapsed, it's time to redesign. You want your structure to be as strong and stable as possible.
- Success? Take it to the next level and build an even taller structure!

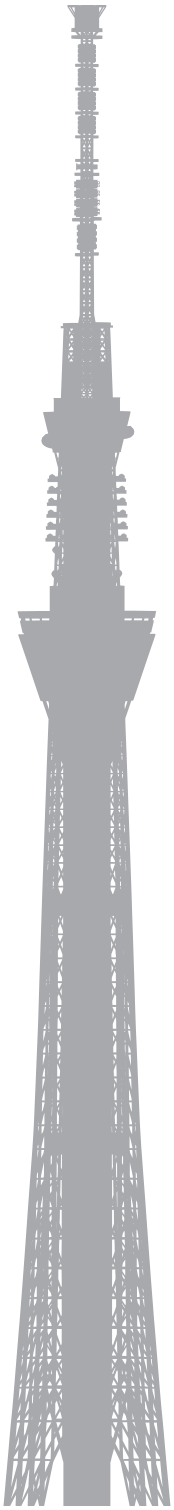
Problem-Solving Tips

WHAT IF YOUR STRUCTURE . . .

- **tips over?** Maybe your base is too small. Make it wider and sturdier.
- **collapses?** Add triangular shapes. Triangles are stronger than squares or rectangles because all three sides of a triangle carry some of the load (weight).
- **wobbles?** Try cross-braces. Turn squares into triangles by adding diagonal supports that go from one corner of the square to the other.

ENGINEERING AND INVENTION IN ACTION

Tokyo Sky Tree is the tallest tower in the world (634 m; 2,080 ft). It's also located right in the heart of an earthquake zone. So its engineers and architects needed to build a tower with the latest anti-earthquake technology. One way they did this was by standing the tower on a triangular, pyramid-shaped base. Another was by including massive dampers—shock absorbers that cushion the building during an earthquake. In March 2011, while still under construction, the tower was put to the test when a tremendous 9.0-magnitude earthquake struck Tokyo. Sky Tree's earthquake-resistant features worked beautifully—there was no structural damage and none of the construction workers caught in the building during the quake were injured.



Tokyo Sky Tree

PBS KIDS WGBH DESIGN SQUAD GLOBAL is produced by WGBH Boston

MAJOR FUNDING NSF PROJECT FUNDING the Lemelson foundation improving lives through invention

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Build a Band

45

Activity Description:
Challenge is to design and build a four stringed instrument. Partners will then tune instruments and play a song together.

45

Cutting

Cu

Scissors

Arts & Crafts

Ar

Craft Paper

Fixturing

Fx

Rubber Bands

Brainstorm

Br

Markers

Joining

Jo

Tape

Other Materials

Cardboard box, recycled goods, etc...

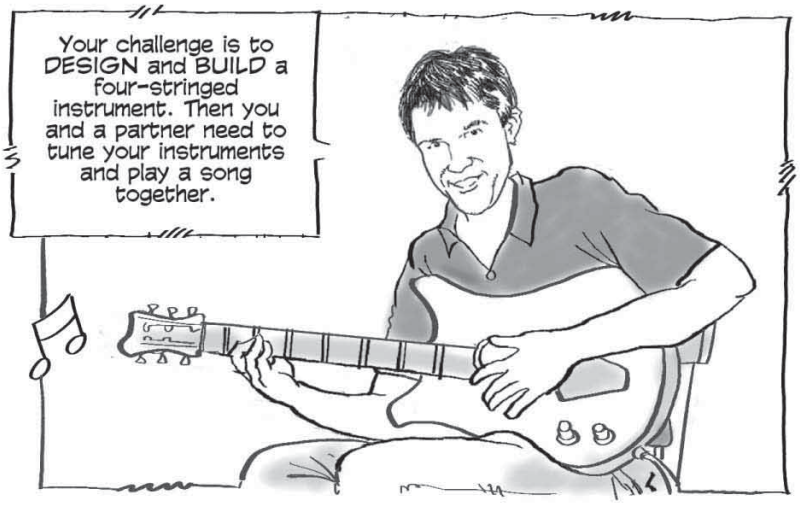
BUILD A BAND

DESIGN SQUAD™ PBS®

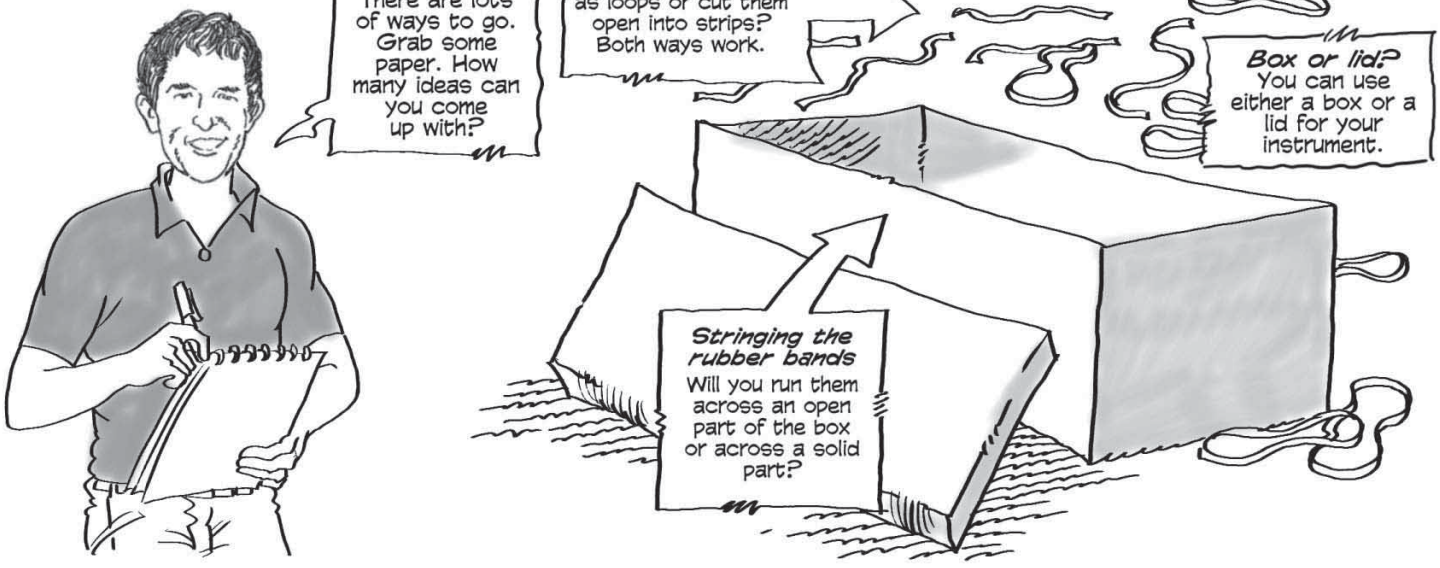
as built on TV™

pbs.org/designsquad

BRAINSTORM



DESIGN AND BUILD



DESIGN AND BUILD

Tip: Taping down rubber bands
Put tape over the end of a rubber band. Then run your fingernail along the rubber band to firmly connect the tape and rubber band.

Attach your strings
- Wrap one end over a box edge and tape it. This way it pulls on the box, not just on the tape.
- Stretch the other end to where you want it, and tape it.

Find 4 pitches you like
- Low pitch = Long, thick, or loose strings
- High pitch = Short, thin, or tight strings

TEST AND REDESIGN

Tip: Get extra notes
Press fingers along a string or pinch it. That changes its length. Mark the notes you like.

Free to move
How can you keep strings away from things that will stop them from vibrating, like the solid part of the box?

the bridge

More vibrations = louder!
Get the string's vibrations to go cleanly from the strings to the box material. Too much tape, loose parts, or a bulky bridge will reduce the vibrations.

Music is important to almost everyone, so there will always be a demand for musicians, not to mention the instruments and sound equipment they need! Rock on!

SHARE

Find a partner, tune both instruments, and play a song.

DESIGN SQUAD

PBS. **Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.**

Major funding for *Design Squad* provided by

NSF · intel Education · the Lemelson foundation improving lives through invention

Additional funding for *Design Squad* provided by

NOYCE FOUNDATION · NCEES National Council of Examiners for Engineering and Surveying · ASME · IEEE Celebrating 125 Years · NORTHROP GRUMMAN Foundation

Dance Pad Mania

46

Activity Description:
Build a dance pad that lets you use your feet to sound a buzzer or flash a light.

46

Cutting

Cu

Scissors

Electronics

El

AA Battery Holder
AA Batteries
Electrical Wire

Arts & Crafts

Ar

Craft Paper

Brainstorm

Br

Markers

Joining

Jo

Duct Tape

Measuring

Ms

Foil

Other Materials
Light bulbs, plastic wrap, wire strippers, buzzers, bulb holders

CHALLENGE 2

DANCE PAD MANIA

YOUR CHALLENGE

Build a dance pad that lets you use your feet to sound a buzzer or flash a light.

MATERIALS*

- 1.5-volt AA battery
- AA battery holder (optional)
- Aluminum foil
- Bulb holders for light bulbs (enough for half the group)
- Buzzers (enough for half the group)
- 2 11 x 17-inch sheets of corrugated cardboard (per team)
- Duct tape
- Electrical wire (22-gauge works well)
- Light bulbs that can run on a 1.5-volt AA battery
- Plastic wrap
- Scissors
- Wire strippers

* For information on where to get these materials, see page 6 or visit pbskidsgo.org/designsquad/engineers.

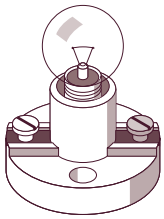
BRAINSTORM AND DESIGN

Divide your group into teams of two. Half the teams will make floor pads that flash a light, and the other half will make floor pads that sound a buzzer. When you work as a team, you can often solve design challenges more quickly. For example, you can share knowledge, get new ideas, and brainstorm solutions to problems. You can also learn a lot by looking at how other teams made their pads and seeing how they solved problems.

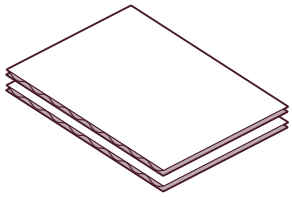
Your dance pad is basically a super-sized version of the alarm you built in Challenge 1. Like Hidden Alarm, the dance pad has a power source (the battery), materials for conducting electricity (the wires and foil), and something that uses the electricity (the buzzer or light). Yup, that's right, it's an electrical circuit. Before you begin designing, brainstorm answers to the following questions and record your ideas in your design notebook.

- Will my pad turn on a buzzer or a light?
- How will I build a switch into my pad to turn the buzzer or light on and off?
- How big will my pad be?
- How can I make it sturdy enough to withstand constant stomping?
- Where will I put the battery? Inside the pad? Outside the pad?

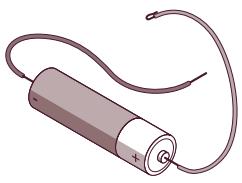
Buzzer



Light bulb and bulb holder



Corrugated cardboard



1.5-volt AA battery

BUILD, TEST, AND REDESIGN

As you build, make sure the circuit works and that it will be able to stand up to some rugged treatment! Once you've built your pad, test it. Step on it several times in a row to turn the buzzer or light on and off. How well did it work? When we made ours, we had to debug some problems. For example, our wires sometimes got loose and our pad stopped working. Also, our switch didn't always work. If things like this happen to you, figure out a way to fix the problem so that your pad works every time.

TAKE IT TO THE NEXT LEVEL

- Make a pad that has both a light and a buzzer.
- Make a pad that uses two batteries, two lights, or two buzzers.

INSIDE THE ENGINEERING

TECHNO GYM

Bust a move! Break it on down and get a good workout at Overtime Fitness™, a revolutionary fitness arcade for teens. Forget what you know about gyms, this is the gym of the future. Get your heart pumping with *In the Groove 2*®, a dance game that works like *Cyber Groove*™, *Dance Dance Revolution*®, *Feet of Fury*™, and *"Pump it Up"*®. Just try keeping up with those moving arrows! How about putting your one-two punch to the test with *MoCap Boxing*®, a virtual game complete with boxing gloves, a 3D virtual opponent, and infrared sensors that track your movements? Or try a game that has you jump, duck, and lunge to avoid virtual dodge balls. You can even hook yourself up to a video game box and become a human joystick to move an on-screen player. Note: The sensors, computers, sound systems, and software that make these games work were all brought to you by engineers. What will those ingenious engineers come up with next!?

Overtime Fitness is a trademark of Overtime Fitness, Inc. *In the Groove* is a registered trademark of Konami Digital Entertainment Co., Ltd. *Cyber Groove* is a trademark of Front Fareast Industrial Corp. *Dance Dance Revolution* is a registered trademark of Konami Digital Entertainment Co., Ltd. *Feet of Fury* is a trademark of Cryptic Allusion Games. *"Pump it Up"* is a registered trademark of Andamiro U.S.A. Corp. *MoCap Boxing* is a registered trademark of Konami Corporation

Watch *Design Squad* on PBS (check local listings). Download more challenges at **pbskidsgo.org/designsquad.**

PBS

TAKE IT ONLINE

Want something electrifying? Build a switch and wire up some different kinds of circuits! Download *Turn It On and Off* from Intel's *Design and Discovery* hands-on engineering program.

intel.com/education/designanddiscovery

The *Design Squad* cast moves and grooves. They built a floor sensor that used thin foam and metal to make switches that turned sound clips on as they danced.

Major funding for *Design Squad* is provided by the National Science Foundation and the Intel Foundation. Additional funding is provided by Tyco Electronics, National Council of Examiners for Engineering and Surveying, The Harold and Esther Edgerton Family Foundation, Noyce Foundation, Intel Corporation, American Society of Civil Engineers, and the IEEE.

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Design Squad is produced by WGBH Boston. Design and engineering consulting services provided by Continuum.

Soft Landing

47

Activity Description:
Spacecraft use airbags, cars use airbags, packages use airbags. Air makes a great cushion. THree rovers have landed safely on Mars using an air bag system. The challenge is to design and build an airabg system that can safely land an egg dropped onto the floor.

47

Cutting

Cu

Scissors

Measuring

Ms

Straws
Balloons
Cups

Arts & Crafts

Ar

Craft Sticks
Craft Paper

Sewing

Sw

Yarn

Joining

Jo

Tape

Fixturing

Fx

Binder Clips
Rubber Bands

Other Materials
Hardboiled eggs

SOFT LANDING

Spacecraft use airbags. Cars use airbags. Packages use airbags. Air makes a great cushion. Three rovers have landed safely on Mars using an airbag system.

WE CHALLENGE YOU TO...

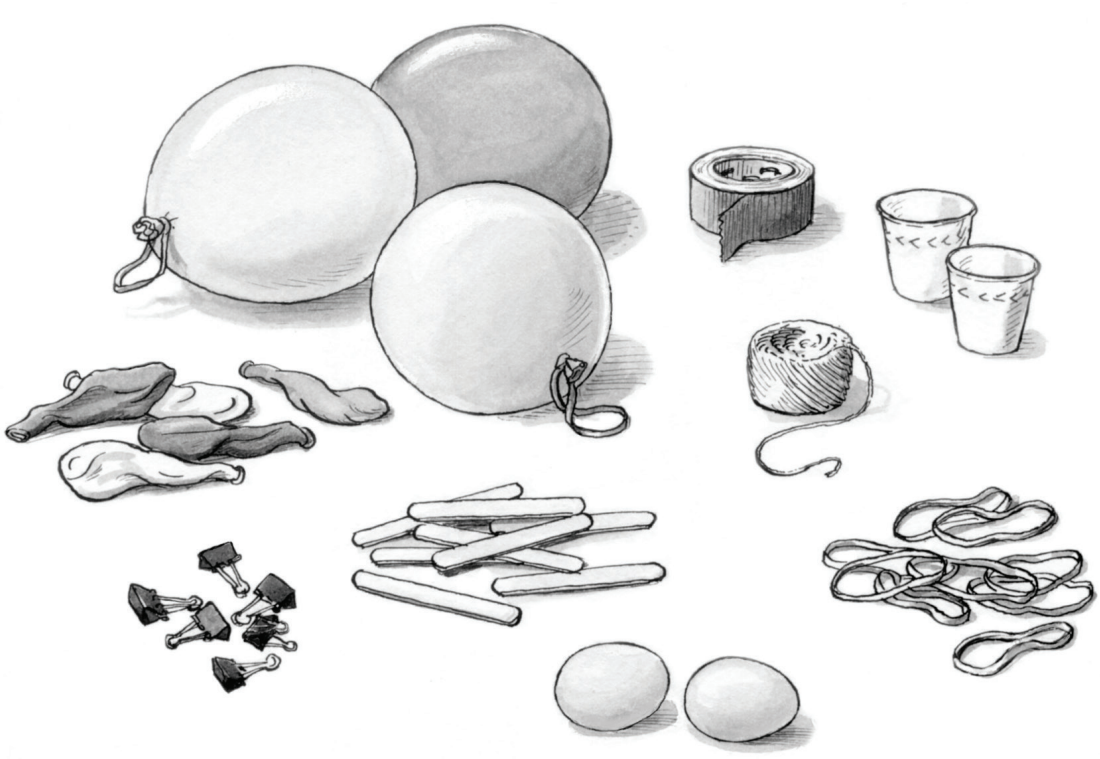
…design and build an airbag system that can safely land an egg dropped onto the floor.

1. IDENTIFY THE PROBLEM AND BRAINSTORM

- How will you make a frame that holds the egg?
- How will you attach balloons to your frame?
- How should you arrange the airbags to absorb shock?

2. DESIGN AND BUILD

Use the materials to invent your own design.



3. TEST

- Drop your lander from a height of 1 meter (39 inches).
- Watch how it bounces and rolls. Did the egg break?

MATERIALS (per lander)

- 2 hardboiled eggs
- 10 nine-inch balloons
- 10 craft sticks
- 8 small (i.e., ¾ inch) binder clips
- 20 assorted rubber bands
- 2 small paper cups (3-ounce)
- Tape (any kind)
- 1 meter (39 inches) string

WORDS TO USE

- **force:** *A push or a pull*
- **shock absorber:** *Absorbs the energy of an impact*

4. EVALUATE AND REDESIGN

- How well did the egg stay in the frame?
- How well do the balloons stay together to protect the egg on all sides?

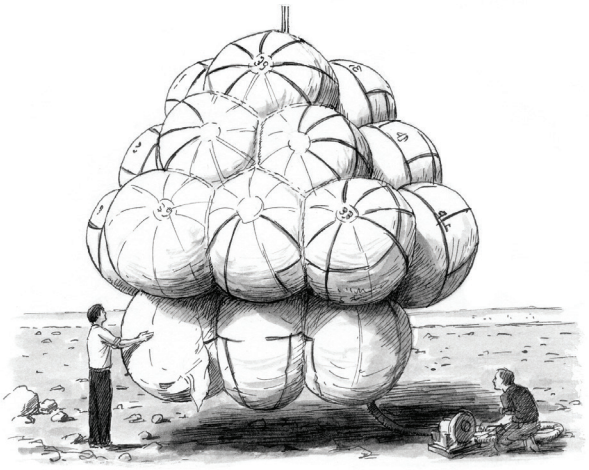
5. TRY THIS NEXT!

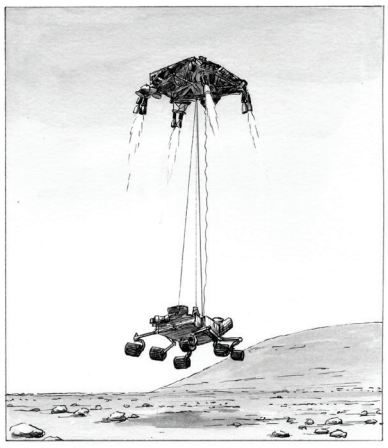
- Drop the lander from 2 meters (78 inches). How high can you go?
- Add a parachute or other system to slow the lander before it hits the ground.

Check out NASA's missions at nasa.gov

NASA EXPLORES SPACE

This picture shows NASA engineers testing an airbag-landing system on Earth. Three rovers have used this system to land safely on Mars. As they approach Mars, they're going about 20,000 kilometers (12,000 miles) per hour. Thanks to a parachute, heat shield, and rockets, the airbag-wrapped rovers hit the surface going about 80 kilometers (50 miles) per hour. One bounced as high as a five-story building. Then after 15 bounces, it stopped rolling, the airbags deflated, and the mission began.





The *Curiosity* rover is on Mars, studying the Martian climate and geology and looking for substances associated with life. *Curiosity* is the size of a small car. It is so big and heavy—about five times larger than earlier rovers—that it couldn't use an airbag-landing system. Instead, it used a rocket-propelled sky-crane that lowered it gently to the surface.

Visit the *Design Squad Nation* website at pbskids.org/designsquad.

MAJOR FUNDING PROJECT FUNDING ADDITIONAL FUNDING

Design Squad Nation is produced by WGBH Boston. Major funding is provided by the National Science Foundation. Project funding is provided by Northrop Grumman Foundation and S.D. Bechtel, Jr. Foundation. Additional funding is provided by United Engineering Foundation (ASCE, ASME, AIChE, IEEE, AIME). This *Design Squad Nation* material is based upon work supported by the National Science Foundation under Grant No. EEC-1129342. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. This NASA/Design Squad Nation challenge was produced through the support of the National Aeronautics and Space Administration under Grant No. <NNX12AB47G> issued through the Science Mission Directorate.

Kinetic Sculpture

48

Activity Description:
Make a sculpture that is at least six inches tall and has at least two parts that move in the wind. That's what makes it kinetic—it moves. But watch out, wind can also knock it over. So, make sure the tower is sturdy enough to stand up in the wind.

48

Cutting

Cu

Scissors

Measuring

Ms

Cups

Arts & Crafts

Ar

Craft Sticks
Colored Craft Paper
Craft Sticks

Sewing

Sw

Yarn

Joining

Jo

Tape

Brainstorm

Br

Markers
Colored Pencils

Other Materials

Electric Fan, cardbaord, ruler, ping pong balls, poster putty, metal washers

KINETIC SCULPTURE

YOUR CHALLENGE

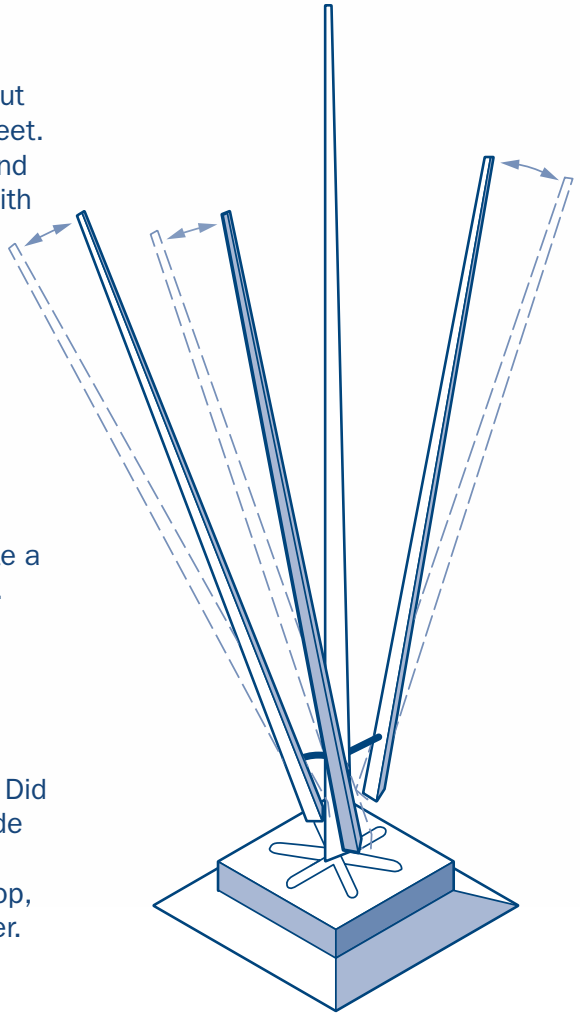
Make a sculpture that is at least six inches tall and has at least two parts that move in the wind. That's what makes it kinetic—it moves. But watch out, wind can also knock it over. So, make sure the tower is sturdy enough to stand up in the wind.

MATERIALS

- Electric fan (you only need one)
- Strips of colored paper or fabric
- Ruler
- Pens or markers
- Cardboard
- Metal washers (various sizes)
- Markers
- Ping-Pong balls
- Poster putty
- Paper cups (various sizes)
- Scissors
- Wooden skewers
- String
- Tape (duct or masking)

BRAINSTORM AND DESIGN

Looking for inspiration? Get your creative juices flowing by checking out the illustrations of kinetic sculptures on the front and back of this sheet. Don't worry, it's not cheating! Being inspired by other people's work and combining the parts you like in new ways is a great way to come up with a unique creation of your own. Now, look at the materials and think about how you can meet the challenge.



Tall Grasses

BUILD

1. **Assemble your sculpture.**
2. **Name your sculpture.**
   Artists typically name their sculptures because it can add meaning. Look at the picture. Why do you think it is named Tall Grasses? Create a name for your sculpture that is accurate, funny, poetic, or mysterious.

TEST

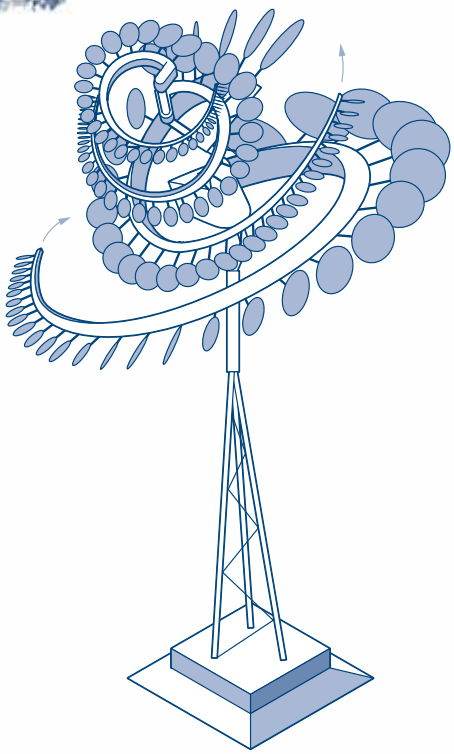
Set your sculpture in front of the fan. Do the parts move as you expected? We had to tweak ours to get it to work the way we wanted. Did the wind knock your sculpture over? It knocked ours over! So, we made ours more stable by giving it a wide, heavy base. Where the weight is located also effects how it stands. If too much weight is toward the top, it may tip over. If most of the weight is at the bottom, it stays up better.

KINETIC SCULPTURE Continued

REDESIGN

What adjustments will help your sculpture's parts move in the wind? Does it need additional support to keep it from falling over? How can you make it more stable? Once everything's working the way you want, how about:

- adding another moving part?
- making your sculpture taller?
- changing it to work in either more or less wind?



The Cyclone

INSIDE THE ENGINEERING

What would you have to do to make your sculpture stand up in typhoon-strength winds (74 miles per hour or greater)? That's something the engineers who built one of the tallest buildings in the world—the Taipei 101 Tower of Taiwan (1,670 feet tall)—were worried about. Very worried! Typhoons regularly slam into Taiwan. So to keep the tower from being blown over, engineers made the skyscraper much wider at the bottom than at the top. They also used special materials, including strong, flexible steel to make the building sturdy enough to withstand those typhoons. So the next time you're visiting the top of the Taipei 101 Tower during a typhoon, you don't have anything to worry about. Right?

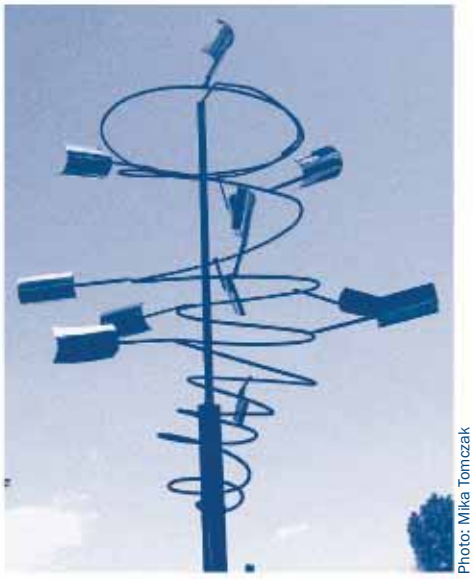


Photo: Mika Tomczak

The *Design Squad* cast welded their kinetic sculpture, called the Urban Tornado, out of heavy scrap metal.

If you liked this challenge, go to **pbskidsgo.org/designsquad** to download more challenges to try at home.

Major funding for *Design Squad* is provided by the National Science Foundation and the Intel Foundation. Additional funding is provided by Tyco Electronics, National Council of Examiners for Engineering and Surveying, The Harold and Esther Edgerton Family Foundation, Noyce Foundation, Intel Corporation, American Society of Civil Engineers, and the IEEE.

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Global Cardboard Challenge

49

Activity Description:
Creativity is the most important skill of the future, and the Cardboard Challenge is a powerful tool to foster it through playful learning. The Carboard Challenge brings the world together around the value of creativity. It's a worldwide celebration of the genius of every child and the simple things adults can do to foster it.

49

Cutting

Cu

Scissors

Cardboard Tools

Cr

All Items From Bin

Joining

Jo

Tape

Joining

Jo

Hot Glue
Hot Glue Guns

Other Materials
Cardboard

DESIGN CHALLENGE: CARDBOARD CHALLENGE

Caine's Arcade

Caine's Arcade is a short film about a 9 year old boy's cardboard arcade, and his dream of having customers. The 11 minute short film became a global phenomenon in 2012, with over 10 million views online. It received international media attention and was added to MoMA's permanent collection. Tens-of-thousands of customers visited Caine's Arcade to play, and kids around the world began making their own cardboard arcades. Shortly after posting the film, Nirvan founded a non-profit called Imagination.org which launched a Global Cardboard Challenge to foster kid creativity worldwide.

View the website www.cainesarcade.com

GLOBAL CARDBOARD CHALLENGE

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https://cardboardchallenge.com

Tech Take Apart Robot

50

Activity Description:
Working in pairs, take apart old technology and use the pieces you salvage to build a robot. Write a story and/or make a video about your robot to share with the class!

Cutting

Cu

Scissors

Joining

Jo

Hot Glue
Hot Glue Guns

50

Joining

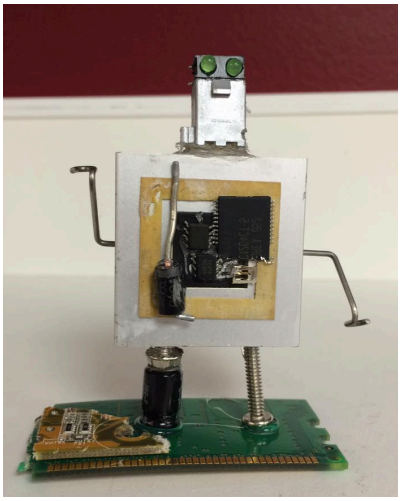
Jo

Tape

Other Materials
Several different types of technology that are relatively easy to take apart. Think broken computers, keyboards, alarm clocks, etc...
Saftey goggles, screwdrivers, pliers

DESIGN CHALLENGE—

Tech Take-apart Robot Challenge



Tech take-apart is a classic makerspace activity. This design challenge takes it a step further by recycling the technology into a robot made by students. This project doesn't have to be super complex — picture a shoebox painted with black paint that has keyboard keys and circuit boards glued to it.

Design Prompt: Working in pairs, take apart old technology and use the pieces you salvage to build a robot. Write a story and/or make a video about your robot to share with the class.

For this challenge, you'll need the following supplies:

Several different types of technology that are relatively easy to take apart. Think broken computers, keyboards, alarm clocks, etc.
Safety goggles for students to wear to protect their eyes.
An assortment of tools, such as screwdrivers, pliers, etc.

For safety, cut off the power cords before allowing students to tackle the tech. Make sure to discuss how to safely take apart technology before letting students loose and set consequences for abusing the tools.

The first session will be mostly taking apart the tech and salvaging pieces for the students' designs. The second session will focus on brainstorming and creating their robots. The final session will be where students can create the stories or videos about their robots.