ST[EMpower]

GADGETS AND GIZMOS!

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Crazy Inventions

THIS MONTH

POWER WORDS

- **gadget**: a small mechanical or electronic device or tool, especially an ingenious or novel one
- **gizmo:** gadget, especially one whose name is not known
- **zany**: whimsically comical; clownish

Happy January! Let's explore the **zany** world of **gadgets** and **gizmos**.

Alexander Graham Bell famously said, "Watson, come here. I need you." Bell had spilled acid on his clothes, and uttered those words. They were transmitted over his telegraph to his assistant, Thomas Watson. That began telephones.

Velcro was modeled after burdock seeds caught on George de Mestral's socks.

Silly putty was an accidental discovery. James Gilbert E. Wright was looking for a rubber replacement.

Can you imagine a world before Post-It-Notes? This was another accidental discover. Spencer Silver wanted to find a strong adhesive when he discovered one that lightly stuck to a surface, not bond tightly. That discovery was shelved for decades until Art Fry thought about a bookmark that would lightly adhere to a page, and

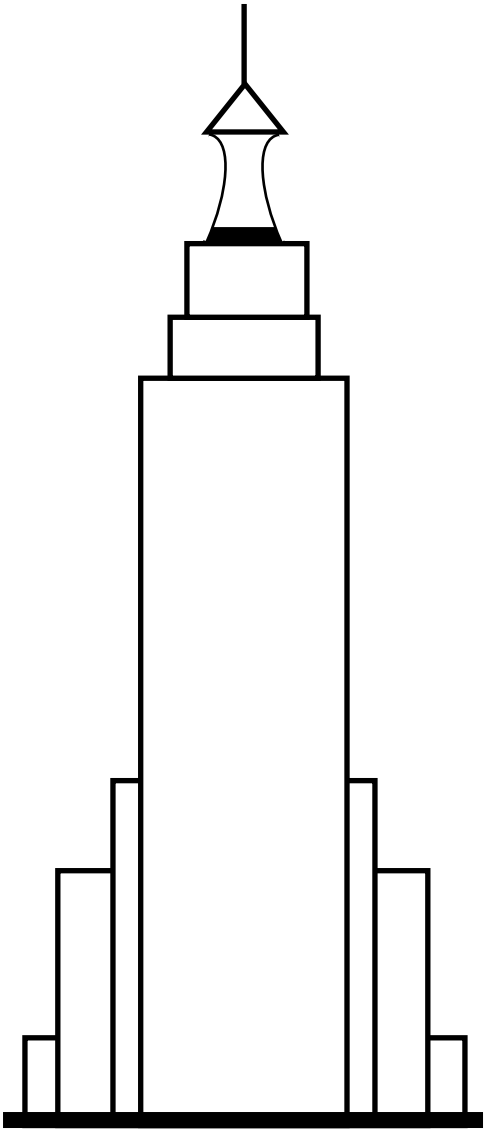
then be removed without damaging the book. Viola!

My favorite accidental invention: the chocolate chip cookie, 1930. Ruth Graves Wakefield was preparing chocolate cookies for her guests at Toll House Inn. She was out of baker's chocolate. She thought Nestle semi-sweet chocolate chopped into bits would melt into and spread throughout the dough as the cookie baked. Life is just better with chocolate chip cookies!

This issue is chockful whacky gizmos and fun gadgets. Who knows? Maybe it will inspire you to find your own accidental invention!

The first modern skyscraper, Home Insurance Building, was built in 1885 in Chicago, IL. It stood 180 feet with 12 stories, but was **demolished** in 1931.

The 1,454 foot Empire State Building (sketch below) broke ground that same year, and it remained the tallest building in the world until 1970 with 102 stories.



These buildings are dwarfed by the current tallest building. Burj Khalifa in Dubai soars 2,716 into the sky!

The tallest building in Denver is Republic Plaza, 717 feet (219 m) and 56 stories. It was completed in 1984. It stands as the 137th-tallest building in the United States.

How can skyscrapers stand in high winds? What is the tallest tower you can build that will resist a strong wind (a fan on high). There is a secret - can you discover the shape that increases the strength of a building?

Directions:

GENERAL RULES:

- You may only use the same size and shape cups, regular and/or jumbo craft sticks, and same size blocks in your tower. You may use as many or as few of these items as you choose.
- These materials may not be altered (e.g. cutting the cup).
- You will be given four challenges. After you have built your tower, before it tumbles, measure from the base to the tip of your tower, and record.
- You can build your tower as many times to improve on your **design**.

POWER WORDS

- **demolish**: pull or knock down (a building)
- **diameter**: a straight line passing from side to side through the center of a circle or sphere

CHALLENGE ONE:

- Build the tallest tower. How can you increase the height? You could spend time looking at tall buildings around the world to see what is common about these buildings. Can you add them to your **design**?
- When you are satisfied with your tower, measure from the base to tip of your tower.
- Record the height, the

MATERIALS

- cups (all the same shape, for example a 9 ounce Solo cup 3” tall, 3.5” **diameter**)
- craft sticks (can use regular or jumbo craft sticks, or a combination of the two)
- blocks (e.g. cube shaped building blocks all the same size)
- tape measure
- print page 4
- pencil
- fan
- Optional: camera

number of blocks, number of cups, and number of craft sticks in your **design**.
- Optional: take a picture of your tower.

CHALLENGE TWO:
- Place your fan 12” from your tower.
- Turn the fan on low. Record on your datasheet if your tower remains standing.
- Turn the fan on medium. Record on your datasheet if your tower remains standing.
- Turn the fan on high. Record on your datasheet if your

tower remains standing.
- If your tower tumbled, **redesign** and rebuild your tower for wind.
- Again, record the height, the number of blocks, number of cups, and number of craft sticks in your **design**.
- Optional: take a picture of your tower.
- Place your fan 12” from your tower.
- Turn the fan on low. Does your tower remain standing?
- Turn the fan on medium. Does your tower remain standing?
- Turn the fan on high. Does your tower remain standing?
- If your tower tumbled, **redesign** and rebuild your tower for wind.
- Do you need to **redesign** your tower? Repeat this step until your tower remains standing with the fan on high.

CHALLENGE THREE:
- How tall can you build your tower if you only use a single block as the base?
- It may take many tries to build your tower.
- Record the height, the number of blocks, number of cups, and number of craft sticks in your **design**.
- Optional: take a picture of your tower.

CHALLENGE FOUR:
- **Wacky** tower! Can you build a **unique** design? For example, can you add a floor that is not directly over the floor below?

CAN YOU IMPROVE YOUR DESIGN?

POWER WORDS
- **design**: plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is built or made
- **redesign**: **design** (something) again or in a different way
- **unique**: being the only one of its kind; unlike anything else
- **wacky**: funny or amusing in a slightly odd or peculiar way

Challenge (1, 2, 3, or 4)	Tower Height	Number Cups	Number Craft Sticks	Number Blocks	Fan Low Still Stands?	Fan Medium Still Stands?	Fan High Still Stands?

A rain stick is a **percussion** musical instrument. The origin is not known. There are several **hypotheses** to its invention.

It was made from different plants, including cactus. When the cactus was dried in the sun, the center (filled mostly with water) would become hollow. The cactus spines were removed. The spines were **helically** nailed into the cactus. Pebbles and seeds were poured into the cactus tube. The ends were sealed.

Rain sticks are found around the world. They are made from bamboo or plaited reed strips.

Inverting the rain stick, the pebbles and seeds bounce off the spines into the tube, making a soft sound like rain falling. It was used to call rainstorms.

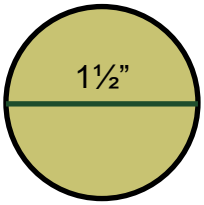
Similar instruments were made in Southeast Asia, Australia, and Africa. Instead of using cactus, these instruments were made with bamboo.

Directions:

- If you cannot locate a long tube, you can save up two or three paper towel tubes and tape them together end to end. Paper tubes have a spiral seam. Be sure to line the spiral seams.

- With your marker, make dots on the seam half an inch (½")

apart.
- To determine how long and how many nails you need depends on the tube you use.
- Measure the **diameter** of your tube. Many paper towel and gift wrap tubes are 1½". Most mailing tubes have bigger **diameters**.
Your nails need to be slightly shorter than the **diameter** of your tube. You want the nail to reach most of the way through your tube without piercing the far side. The example (above) the 1½" tube can use nails that are 1" to 1¼" long.



- To determine how many nails count the number of dots you made along the spiral seam of your tube.
- Poke the nail at each marker dot, and push the nail all the way into the tube. You may need to use gloves. Your finger can get sore, and the

POWER WORDS

- **diameter**: a straight line passing from side to side through the center of a circle or sphere
- **helix**: spiral; a three-dimensional object like that of a wire wound uniformly in a single layer around a cylinder, as in a corkscrew or spiral staircase
- **hypothesis**: position or proposed explanation made on the basis of limited evidence as a starting point for further investigation
- **invert**: put upside down or in the opposite position or order
- **percussion**: musical instruments played by striking or shaking with the hand e.g. drums

continued on page 6
POWER WORDS

MATERIALS

- sturdy long tube (mailing tube or paper towel tube)
- permanent marker
- ruler
- flat-head nails (directions for size and how many)
- masking tape
- brown paper bag
- scissors
- dried rice, beans, popcorn, or tiny pebbles
- wax paper
- paint (acrylic or tempera)
- paint brushes
- yarn or twine
- rubber bands
- masking tape
- beads, feathers, etc.

gloves will help.

- Secure the nails in place with the masking tape.
- If you are using a mailing tube, cover one end with the cap. If you do not have caps, you need to seal the top of your tube. Cut a piece of wax paper about 4" square (larger that the tube diameter) and cover one end of your tube. Secure with a rubber band.
- Pour about 1/4 cup of beans, peas, popcorn, rice, or small pebbles into the tube. Smaller objects will sound like a gentle

rain. Larger objects will sound like a downpour.

- Seal the other end of your tube.
- Paint your tube. Do you want

your rain stick to look natural or colorful. This is up to you.

- Allow your tube to dry completely.
- Cut two circles from the brown paper bag larger than the diameter of the tube.
- Crumple the paper bag circles.

This will make them look more natural (like a piece of leather).

- Place one of the paper bag circles over and around the edge of the tube opening until it cover the end. Secure with a rubber band. You may want to

continued from page 5

- **plait**: a single length of hair or other flexible material made up of three or more interlaced strands; a braid
- **region**: an area or division, especially part of a country or the world having definable characteristics but not always fixed boundaries

cut the edges of your paper bags to make it look like fringe.

- Cover the rubber bands on both ends of your rain tube with yarn or twine. Tie securely.
- Tie on feathers, beads, or charms on the yarn/twine.

FASCINATING FACTS

- South American Natives people from Southern Chili and Argentina may have been the first people to invent a rain stick. This area is the driest place on Earth.
- West Africa had tubular rattles pierced with nails. These people were kidnapped as slaves for the Americas. In 1619, the slaves in Lima Peru were 50% of the population. The indigenous South American people's invention of the rain stick may have been adapted from the West African slaves' rattles.

When you think about a **catapult,** a flashback to King Arthur and his knights defending Camelot's walls from weapons of war might cross your mind. But **catapults** have been around since long before wars were fought on the plains of England.

The first **catapults** were built approximately 400 B.C. in Greece. These first **catapults** more closely resembled a crossbow, called a ballista. Over the years, catapult designs were improved upon. Their capacity and range were greatly increased. From the ballista (giant crossbows image below), to mangonel (designed to throw

heavy projectiles from a bowl-shaped bucket at the end of its arm), to the most recognized form, the trebuchet. The trebuchet was the most powerful **catapult** employed in the Middle Ages using many different forms of projectiles to cause massive destruction on its target.

Designs were changed and improved upon for several reasons. Designers were concerned about being able to increase the **range** a projectile could cover in order to cause damage to its intended target, the consistency of hitting the target, and the amount of time it took to reload the war machine before the next **payload.** The popularity behind the **catapult** is the ability to take **potential energy** and, through use of a **lever** and **fulcrum**, transform the potential or **elastic energy** of the machine into **kinetic energy** - movement!

Catapults are still widely used today in many forms, from a handheld toy such as a sling

US Navy image of the catapult structure on a aircraft carrier.

shot, to launching aircraft from giant battleships.

<u>Activity:</u> Let's **catapult** right in for STEM fun! Check out the basic material list below and gather the necessary supplies to

build your own spoon **catapult**.

We will go over the basic steps of how to make a simple **catapult** (**lever**) with a **fulcrum** and **payload**. With a little effort, you will be flinging **payload**s at your target for hours! Then, can

POWER WORDS

- **accurate**: capable of or successful in reaching the intended target.
- **catapult**: a mechanical device worked by a **lever** and ropes for hurling large objects, like stones
- **elastic energy**: potential energy that is stored when a body is deformed (as in a coiled spring, or rubber band)
- **fulcrum**: the pivot or supporting point of a **lever**.
- **kinetic energy**: energy in a moving object
- **lever**: simple machine consisting of a rigid bar and a **fulcrum** providing mechanical advantage; lift, load, and **fulcrum**

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POWER WORDS

continued from page 7

MATERIALS

- popsicle sticks
- rubber bands
- plastic spoon
- **payload** (cotton balls, marshmallows, pennies, etc.)
- markers
- paper
- tape
- ruler or measuring tape

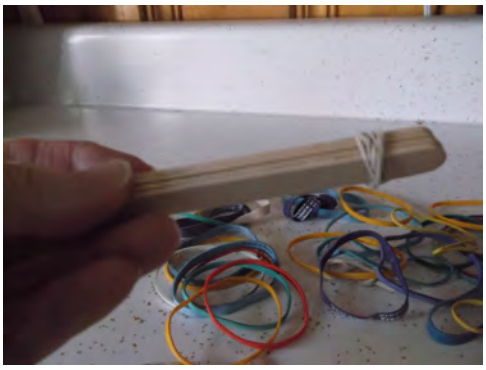
you modify your design to develop the ultimate gizmo that could launch your garbage can into space?

Directions:

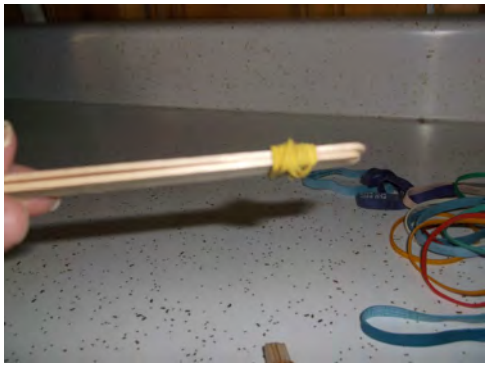
- Pick out 6 popsicle sticks. For fun, use the markers to

color your sticks and make your **catapult unique** to you! *Be sure to decorate both sides of your sticks.*

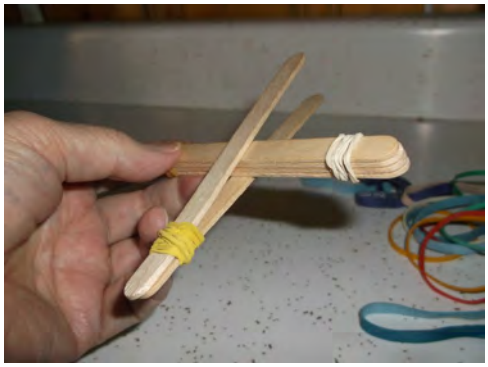
- Base: Take 4 of your



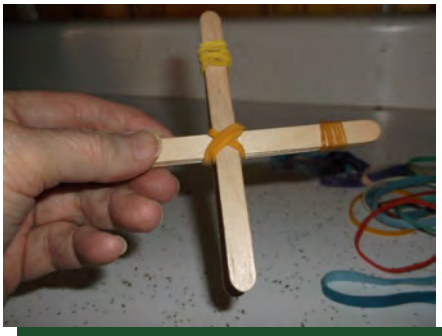
decorated popsicle sticks and stack them on top of each other.



- Rubber band the 4 stacked popsicle sticks at both ends. Use only 1 rubber band at each end and wrap until tight at both ends.
- Flinger: Take two remaining popsicle sticks, and rubber



band them at one end.



- **payload**: the projectile that is shot from a **catapult** (i.e. arrows, stones, wooden spears, hot oil, etc.)
- **potential energy**: stored energy that depends upon the relative position of various parts of a system
- **range**: the horizontal distance to which a projectile can be propelled
- **splay**: thrust or spread (things, especially limbs or fingers) out and apart

- Wedge the base in the middle so they **splay** apart. *You can change the **lever** length of your **catapult** by moving your base to different positions.*

CATAPULT CHALLENGE!

- You don't have to be the only one having fun! Challenge your whole family to build their own **catapults**, make different sized targets, and have a war!
- Place your targets all over the house or yard at different angles and distances and see who will be crowned the catapult King or Queen of the family! Will you share with your family the secrets of harnessing **potential energy** into **kinetic** force?

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

- Use one rubber band to attach the spoon at the top of the craft stick. Attach the bottom of the spoon using the X already made to connect the base and flinger.
- Take the paper and markers and create yourself at least one large target. Create as many targets as you want. *Later on, you may wish to test your **catapult designs** and **re-designs** at different distances or at more precise **ranges**.*
- Tape your target/s to a location where you can practice with your **catapult**. Make sure there is floor space to run distance tests.

Test your Machine:
Now it's time to test your **catapult** creation.

- Take your ruler or measuring tape and measure out 2 ft, 4ft, and 6 ft distances away from your taped target.
- You can mark each distance with your tape and write on the tape with the markers the distance.
- Now you are ready to fling!

Take your **catapult** and load it with your desired projectile.

- Stand at the closest distance (2 ft), put pressure on the top part of the spoon (the V shaped open part of your **catapult**), aim, and release!
- Repeat the process at each distance.

Outcome:
So what have you discovered. Does your **catapult** hit your target every time from every distance? What about the **payload**? If you change the type of weight of the **payload**, does it make your **catapult** more **accurate** or less?

Re–Design and Re-Test:
Now it's your turn to engineer! Try redesigning your **catapult** into a more effective flinging machine. Think about these improvements:

- How can I increase the **range** my projectile travels?
- How can I make my **catapult** more consistent at hitting the target on bullseye?
- What if I use a heavier **payload**? Will my **catapult** still be **accurate**?
- What other materials could I use to increase the size and abilities of my **catapult**?

Think like an engineer. How can you modify, alter, or change your design to make your **catapult** design even better!

FASCINATING FACTS

- There were 3 variations of catapults:
  1. Ballista, also called a bolt thrower, was similar to a crossbow but much larger. Two wooden arms were attached to a rope. It was very accurate. It first appeared in Ancient Greece, around 400 B.C. invented by Dionysius of Syracues.
  2. Trebuchet was a powerful catapult with maximum force. It first appeared in China 300 B.C. The catapult incorporated a counterbalance (heavy weight) to swing the arm.

continued below
FASCINATING FACTS

continued

The long arm would fling projectiles extremely long distances.

3. Mangonel is Latin meaning engine of war. The Romans invented this device around 400 B.C. It consisted of a long wooden arm with a bucket and rope attached to it.

National Audubon Society is an amazing organization. The Audubon's bird guide website is: https://www.audubon.org/bird-guide

Birders use their ears. Good birders can identify birds calls, songs, and whistles (example, check out all the calls of the Red-Winged Blackbird on Audubon's website https://www.audubon.org/field-guide/bird/red-winged-blackbird). They can identify what species of birds and how many birds are present. Spring and summer are prime times for birding by ear.

This is a two-part activity. The first part is attracting birds to your backyard. The second part is identify what birds visit your feeder.

Directions:
Make a hanging feeder

- Gather your materials. You can use either a 1-quart mason jar or plastic jar with a mouth opening the same size as the mason jar.

- Screw on the chick feeder base.

- Wrap the wire around the mouth of the jar. Make sure that the wire catches the lip of the jar, so it will easily remain suspended when hanging. Hold the jar by the wire to check.
- Continue to wrap the wire around the jar, moving toward the bottom of the jar (which is the top of the bird feeder). Leave about 12" of the wire at the top.
- Unscrew the jar and fill your jar with the bird seed. During the winter, birds need high calorie food with a high fat content. Black sunflower

POWER WORDS
- **birder**: a bird-watcher
- **metabolism**: the chemical processes that occur within a living organism in order to maintain life
- **overwinter**: spend the winter; (of an insect, plant, etc.) live through the winter

continued on page 11

MATERIALS for Hanging and Ground Feeders
- 2 chick feeder bases (for 1-quart mason jar; farm supply store)
- 2 one-quart mason jar or plastic jar with same regular mouth opening
- 3 feet 8-gauge copper or galvanized steel wire (home improvement store—copper is easier to use)
- pliers to help bend the wire for the hanging feeder
- bird seed—black sunflower seeds are primo!

seeds are great! Screw it back on.

- Finish the feeder by twisting a hook to the top of the wire.

Check it several times to make sure it is correctly balanced. continue to make adjustments. The copper wire is easier to use, but the steel wire will work with some effort.

Make a ground feeder

- Gather your materials. You can use either a regular mouth 1-quart mason jar or plastic jar with a opening the same size as the mason jar.

- Fill your jar with the bird seed. During the winter, birds need high calorie food with a high fat content. Black sunflower seeds are great!
- Keep the jar upside down and screw on the chick feeder base. It is easier to keep it **inverted** until you place it outside for the birds.

Make a suet feeder

- Suet is high quality food, especially for little birds like chickadees or woodpeckers.

You can use suet, but the recipe from Audubon uses shortening. Easier to find and not as stinky!

- Be sure to get your adult's permission to use old coffee mugs.

POWER WORDS
continued from page 10

- **plumage**: the feathers of a bird
- **resident**: a bird, butterfly, or other animal of a species that does not migrate
- **seasonal**: relating to or characteristic of a particular season of the year for migrating birds
- **solidify**: make or become hard or solid
- **survive**: continue to live or exist, especially in spite of danger or hardship

- Gather sticks to act as perches for your suet feeder. They should be about 4" more than the length of your mug. If the mug is 4", find sticks longer than 8" and trim them with scissors. Sturdier sticks work better. I accidently broke my perch, and had to replace it with a skewer.
- Mix:
  - ½ cup corn meal.
  - 1 cup quick oats

MATERIALS for suet feeder

- old coffee cups about 4
- sticks (find outside)
- carabiners or twine
- 2 large microwavable mixing bowls
- spoon
- shortening (no palm oils)
- nut butter (no palm oils)
- wild bird seed
- rolled oats (quick best)
- corn meal

Suet recipe from National Audubon Society

- 3½ cups bird seed
- In the other mixing bowl,

add:

- 1½ cups shortening (be

sure that the shortening does not have any palm oil)

- NOTE: you can use beef suet instead of shortening
- ¾ cup nut butter (any kind, like peanut butter or almond butter)

- Heat the shortening / nut butter in the microwave 30 seconds at a time. Stir each

30 seconds, until melted.

- Pour melted ingredients into the dry ingredients and mix until combined.
- Spoon into your coffee mugs. This recipe will fill 4 average size mugs.

- Insert the stick into the cup on the opposite side of the handle. Be sure that the stick touches the bottom of the cup.
- Place your suet bird

RESOURCES

- Learning bird basics, The Cornell Lab All About Birds has great steps. Check out their website: https://www.birds.cornell.edu/k12/teaching-bird-id/
- National Audubon Society also has a great website to learn: https://www.audubon.org/birding/how-to-start-birding
- There are bird apps to help you identify birds. The Cornell Lab All About Birds lists five birding apps: https://www.birds.cornell.edu/k12/best-apps-for-birding-with-kids/

MATERIALS to meet your feathered friends

- print 14-16
- 3 page protectors
- pencil
- computer with internet access
- optional: camera

feeder in the refrigerator overnight, or until the suet

has **solidified**.

- To hang the suet feeder, you can use a carabiner, wire, or twine for hanging.

Attracting Winter Birds

Winter is a very tough time for

the birds who **overwinter** in Colorado. What do these animals need to **survive**? You know the answer!

- Food: high energy foods like black sunflower seeds and suet supply birds with plenty of calories for keeping warm.
- Water: birds can get their water from snow, but that is **metabolically** expensive. You can bring out water each day (or even better, several times a day). You can also provide a heated bird bath. Do it yourself (find directions online) or buy a heated dog water bowl. Add a couple of rocks to make islands for small birds to perch.
- Shelter: Birds seek out shelter especially during winter storms. Conifer trees are great places for birds to roost. Build a brush pile. Locate your brush pile in a sheltered area.

Identifying the Birds

- Now comes the fun part—meeting feathered friends!
- Place your feeders where you can see them from a window. It may take several days to several weeks for the birds to find your feeders.
- Read through your bird information, pages 14-16, and check out the National Audubon Society website.
- Take a picture of the birds at your feeders. Match them to your pictures (pages 14-16) and record the date, time, and how many you see on the back of the sheet .
- Keep the images of birds you can't identify right now.
- The green box above will get you started on how to identify those unknown feathered friends.
- Colorado has 511 species of birds. Your backyard will not get all 511 (phew!), and there are fewer birds her during the winter.
- Don't be surprised if you find birding fascinating! Birding is a life-long passion for many!

GETTING STARTED

- There are four basic keys identifying birds:
  - size and shape—compare to known birds, like the American Robin) and silhouette (duck or song bird)
  - color pattern—overall light or dark, markings bold or faint, bold colors
  - behavior—posture, movement, flight pattern, feeding style, and flocking
  - habitat—can they be in your backyard? Use the Audubon's range maps to narrow down the species that could be in your backyard, if they are **seasonal** or **resident.**

Black-Capped Chickadee © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 1/ 4/20

GREAT BIRDING WEBSITES (control click to load site)

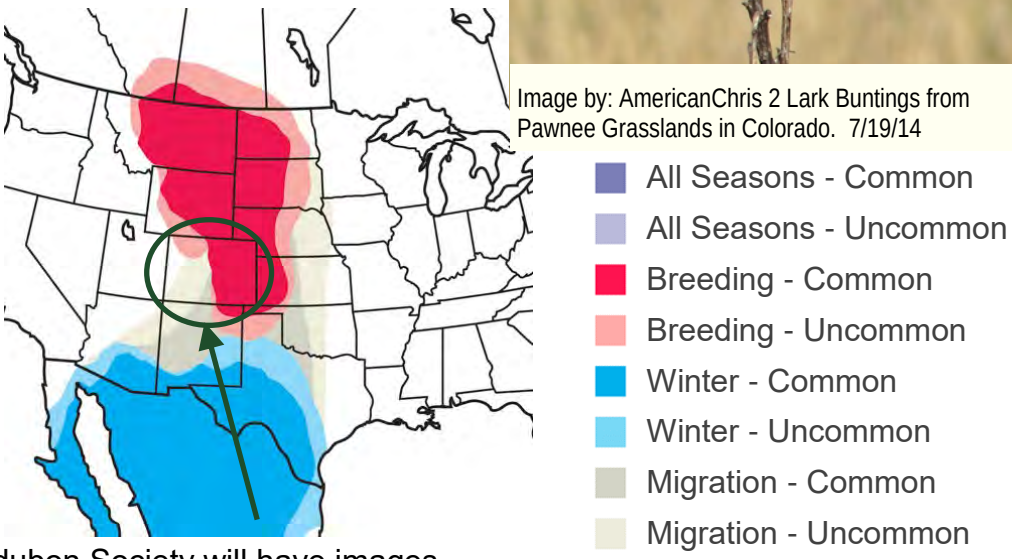
- National Audubon Society: https://www.audubon.org/
  Audubon Bird Guide: https://www.audubon.org/bird-guide
- Audubon Rockies Regional Office of National Audubon Society, serving Colorado, Wyoming, and Utah: https://rockies.audubon.org/
- The Cornell Lab, All About Birds: https://www.birds.cornell.edu/home
  Learning Birds: https://www.birds.cornell.edu/k12/teaching-bird-id/

Ten Common Birds of Colorado
Information from National Audubon Society
Images from Flickr (Permission given by photographers)

Example: Lark Bunting—Colorado State Bird

Designated as the Colorado state bird in 1931, it is only found on the Eastern Slope of Colorado. It has a wonderful courtship dance and melodious song. Lark buntings are members of the sparrow family (5-7 inches). They feeds on insects on the ground, or chase them in short flight. They also feeds on seeds. Only a summer resident, you can spot the males fluttering above the grasses in flight song.
https://www.audubon.org/field-guide/bird/lark-bunting

Image by: AmericanChris 2 Lark Buntings from Pawnee Grasslands in Colorado. 7/19/14



Explore the Lark Bunting webpage on Audubon.org. Verify that the bird is found in your location during the specific season (e.g. the Lark Bunting does not winter in Colorado).

NOTE: images of these birds are in winter **plumage**. The National Audubon Society will have images of these birds in both winter and breeding (summer) **plumage**.

1. American Goldfinch

These active birds (4.3—5.1 inches) forage in flocks, except during breeding season, in weeds, shrubs, and trees. They dine on mostly seeds (and some insects). The males are striking yellow and black during the summer, and muted colors like the females during the winter.

If there is a good food supply, these birds will winter in Colorado.

https://www.audubon.org/field-guide/bird/american-goldfinch#

Image by: Nicole Archambault, Quebec, Canada 1/12/20

2. Black-Billed Magpie

Black and white with blue in their wings and long tails (18—24 inches), these social birds can often be found in groups feeding on carrion or, more pleasantly, eating fruit, grain, insects or other things in your yard. You can find them throughout most of the West in groups atop fences and utility poles, often squawking in what sounds like anger.

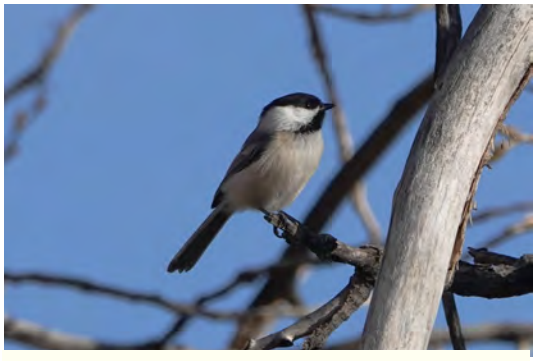
https://www.audubon.org/field-guide/bird/black-billed-magpie

Black-Billed Magpie © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 1/18/20

3. Black-Capped Chickadee

Found in the northern half of the continent, this small (4—6 inches) round bird has the shape of an egg with wings. As the name suggests, they have black heads, and a call that sounds like "chick-a-dee." They're extremely curious and are not shy about visiting feeders. They have an affinity for suet, sunflower and peanuts.

https://www.audubon.org/field-guide/bird/black-capped-chickadee



Black-Capped Chickadee © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 1/ 4/20

4. Cedar Waxwing

One of the few birds in North America with a crest, this mid-sized songbird (6.1 inches) has a distinctive mask; small red markings on wings and yellow on tip of tail, and lemon yellow belly. Waxwings are not as active as other songbirds.

The flocks move through trees searching for fruits and berries. You can hear them before your see them with their peeping while foraging.

https://www.audubon.org/field-guide/bird/cedar-waxwing

Cedar Waxwing © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 1/26/2019

5. Downy Woodpecker

Black, white and found nearly all over the country, this small woodpecker (5.7—6.7 inches) is as comfortable pecking away at a tree as eating from a backyard feeder, which is rare for a woodpecker. You'll have the most luck with suet, sunflower seeds, millet, peanuts and peanut butter.

You'll most likely find woodpeckers in areas with large, established trees. It's smaller than its look-alike cousin, the hairy woodpecker, which has a much longer bill.

https://www.audubon.org/field-guide/bird/downy-woodpecker

Downy Woodpecker © Steve Frye. 11/ 21/120

6. House Finch

Small (5.5 inches) and musical, house finches are found throughout the city, often in noisy groups. They are slow and have a bouncy flight, and are known for their cheerful, twittering song. Natives of the West that do as well in grasslands as in city parks and neighborhoods, they're now found throughout the country.

They have large beaks and long, flat heads. Males have red breasts while females are gray. Finches take well to bird feeders.

https://www.audubon.org/field-guide/bird/house-finch

House Finch © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 1/18/20

Ten Common Birds of Colorado

7. Mourning Dove

If you hear a solemn, almost lamenting song from

overhead power lines, it's probably a mourning dove.

Gray and rotund bird (8.9—14 inches), they are common throughout the country and will often nest on power lines or in scrub oak. They do most of their feeding on the ground, so scattering millet seeds may attract them. Just don't let any house cats out, as ground-feeders are particularly vulnerable.

https://www.audubon.org/field-guide/bird/mourning-dove

8. Northern Flicker

This type of woodpecker (12-14 inches) is found across the country, pecking not on trees but the ground, in search of ants and other insects.

Spotted and striped with a spot of red on the head, they're handsome birds, most commonly found in lawns near trees and parks and in mountain forests as high as timberline. They probably won't come to a feeder but may stop by for a bath.

https://www.audubon.org/field-guide/bird/northern-flicker

9. White-Breasted Nuthatch

These active little birds (5—6 inches) are known for jamming nuts and acorns into the bark of a tree and then hitting it with their bill to hatch the seed. They'll also be happy to enjoy nuts, sunflower seeds or peanuts from a bird feeder.

Like woodpeckers, the more trees around your neighborhood, the more nuthatches. Look for the smaller and more animated pygmy nuthatch in the higher elevation ponderosa pine forests of Colorado.

https://www.audubon.org/field-guide/bird/white-breasted-nuthatch

10. Woodhouse's Scrub Jay

These bright blue birds (11—12 inches), often inhabiting dry shrub lands and lower-elevation pinyon-juniper forests, are no strangers to backyards. They may come to sunflower seeds or peanuts at a feeder.

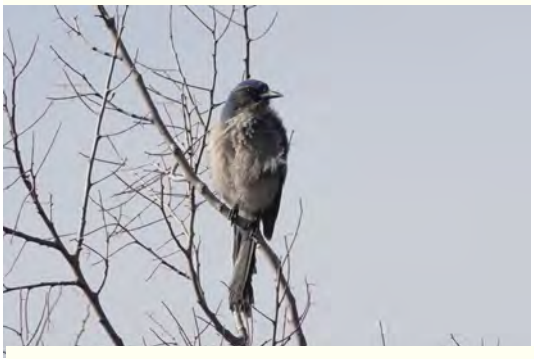
They nest in shrubs or small trees and can be recognized with a sharp series of screeches.

https://www.audubon.org/field-guide/bird/woodhouses-scrub-jay

House Finch © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 3/26/16

Northern Flicker – Boulder, Colorado ©Steve Frye. Photo taken on the Wild Bird Company Saturday Bird Walk on 11/28/15

White-Breasted Nuthatch © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 3/16/19



Woodhouse's Scrub-Jay © Steve Frye. Photo taken on the Boulder Flying Circus Birders Walk on 4/6/19

Can you answer this riddle:

What is everywhere but never seen?

Have you figured out what it is?

Think again! You can do it!

What is everywhere but never seen? The answer is air.

Air can move as a gentle breeze, or bring devastation, destruction and death in **tornados**, **typhoons**, **cyclones**, and **hurricanes**.

Air is something, but what is it? **Atoms** are the building blocks of all **matter**. **Atoms** bond in different combinations to **compounds** and **molecules**.

The air is made from primarily two different **molecules**, nitrogen (78%) and oxygen (21%). There are many other **molecules**, but combined, they only make up 1% of the atmosphere. Carbon dioxide, the primary component needed by plants for photosynthesis, is only 0.04% of the total volume. If you had $100.00 (10,000 cents), 0.04% is only 4¢!

Matter exists in different **phases**. The most common **phases** on Earth are **solid**, **liquid**, and **gas**. Air is in the **gas phase**.

Air also has weight. The closer to sea level, the more air pushes down. At sea level, air pressure is 14.7 pounds per inch. That means every square inch of your skin has almost 15 pounds pushing on it! Well, in Colorado, we are much higher in altitude, so there isn't as much air pressing down. Here, we only have about 12.5 pounds pushing down. You don't feel that because you have air in your lungs and stomach pressing out at the same pressure. Cool!

We feel the air **molecules** move as the wind. Air moves because there are differences in air pressure. It always moves from areas of high to low air pressure. Differences in air pressure can, for example, be caused by temperature differences.

You can also physically move air and create areas of high and low air pressure by "pushing" or manipulating the air around you. Investigation of how and why air flows is called **aerodynamics**.

One fascinating airflow phenomenon is a toroidal **vortex**, which looks like a doughnut-shaped ring of air. You rarely notice these unless there are some particles in the air such as steam or smoke, which make the **vortex** ring visible.

POWER WORDS

- **aerodynamics**: study of properties of moving air and interaction between air and solid bodies moving through it
- **atom**: the basic building block of all matter
- **compound**: a substance formed from two or more elements chemically united in fixed proportions
- **cyclone**: circular storm
- **gas**: matter in a state in which it will expand freely to fill the whole of a container, having no fixed shape (unlike a solid) and no fixed volume (unlike a liquid)
- **hurricane**: a storm with circular violent winds in the Atlantic Ocean

continued on page 18

POWER WORDS

continued from page 17

- **molecule**: group of atoms bonded together,

MATERIALS

- plastic cup
- large balloon
- rubber band
- scissors
- 15 cotton balls
- cloth or steel measuring tape
- tissue or toilet paper
- tape
- data sheet
- box cutter (and adult)

Tornado image from National Oceanic and Atmospheric Administration, National Severe Storm Laboratory: https://www.nssl.noaa.gov/education/svrwx101/tornadoes/types/

Directions:

- Ask a parent to put a slit in the bottom of your cup with a box cutter. Once they have cut a slit into the bottom of the cup, insert a scissors blade into the slit. Cut a hole that is smaller than the bottom of the cup with your scissors.

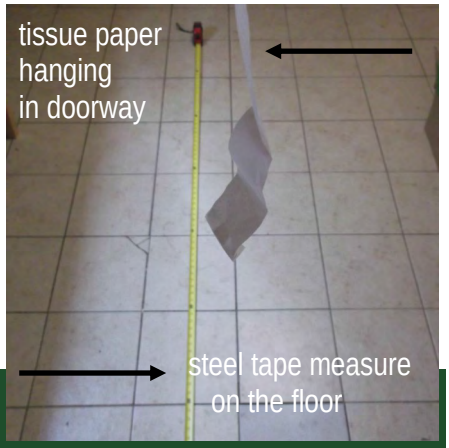
- Use scissors to cut off neck of the balloon. You want to make your cut so that you have a large section of the balloon remaining.

- Stretch the balloon carefully over the lip of the cup to cover the opening

completely, with excess balloon overlapping all sides of the lip of the cup.

- Wrap the rubber band around the mouth of the cup to secure the balloon beneath the lip of the cup.

- To work your **vortex** cannon, hold the cup in one hand with the hole facing away from you and pinch the center of the stretched balloon with the other hand. Pull the balloon back gently and release. Practice pointing your air **vortex** cannon at some cotton balls. What happens?
- Hang up a strip of tissue with tape in a doorframe.
- Lay the measuring tape on the floor with the 0” under the hanging tissue paper (image page 18).
- Stand directly in front of the tissue paper and fire



representing the smallest fundamental unit of a chemical compound

- **phase**: physical form of matter (i.e. a particular solid, liquid, or gas) separated by its surface from other forms
- **shape**: the external form, contours, or outline of someone or something
- **solid**: firm and stable in shape; not liquid or fluid
- **tornado**: a storm with circular violent winds over land

continued on page 19

POWER WORDS

continued from page 18

- **typhoon**: a storm with circular violent winds in the Pacific Ocean
- **volume** : the amount of

FASCINATING FACTS

- The **air** that shoots out of the cannon is a **vortex** of **air** similar to smoke rings.
- **Air** does not hold a shape of its own so it gets difficult to apply a consistent force on **air** molecules at a time to push.

your cannon at the tissue paper (the tissue paper should move). Record at 0" and check "yes" column.

- Stand at 6" from of the tissue paper and fire your cannon several times at the tissue paper. If the tissue paper moves, check "yes" column at 6" row. Check "no" if the tissue does not move.
- Repeat at 12", 18", 24", until the tissue paper stops moving. That is the maximum distance the air from your air cannon can travel while still exerting enough force to move the tissue paper.

Going farther:

- Experiment with your **vortex** cannon design. You can make an air **vortex** cannon out of any container and stretchy plastic material. What changes can you make to this air cannon design so that it shoots air farther? As you plan changes to your design, think about how force is applied to the air molecules inside of the chamber to form a jet.
- Change a single feature at a time, testing each change to see how it affects the maximum distance that your cannon can shoot air. Record your data to determine the maximum firing distance. Try changing your **vortex** cannon's:
  - **volume**
  - **shape**
  - shape or size of the opening
  - chamber cover
  - position of the opening
- Sketch and build a prototype of your new air cannon design. Test your improved air cannon to see how far your new design is able to shoot, and record on your datasheet.
- Which changes improved how far your air **vortex** cannon shoots air
- Design your final improved **vortex** cannon.
- How far does air travel?


Air Cannon Datasheet:

How far can your air cannon shoot air?
Sketch air cannon design; label improvements, then test your new design, recording the results in the table on the right. The last row is for over 30" – include how far

Original Air Cannon		
Distance	Yes	No
0"		
6"		
12"		
18"		
24"		
30"		

Redesign #1 Air Cannon		
Distance	Yes	No
0"		
6"		
12"		
18"		
24"		
30"		

Redesign #2 Air Cannon		
Distance	Yes	No
0"		
6"		
12"		
18"		
24"		
30"		

4-H FUN! — Vortex Cannon Datasheet

space that a substance or object occupies, or that is enclosed within a container, especially when great

- **vortex**: a mass of whirling fluid or air, especially a whirlpool or whirlwind

NOAA (National Oceanic and Atmospheric Administration) states:

- A tornado is a narrow, violently rotating column (a **vortex**) of air that extends from a thunderstorm to the ground. Because wind is invisible, it is hard to see a tornado unless it forms a condensation funnel made up of water droplets, dust and debris. Tornadoes can be among the most violent phenomena of all atmospheric storms we experience.

Air Cannon Datasheet:

How far can your air cannon shoot air?
Sketch air cannon design: label improvements, then test your new design, recording the results in the table on the right. The last row is for over 30” – include how far .

Original Air Cannon		
Distance	**Yes**	**No**
0”		
6”		
12”		
18”		
24”		
30”		

Redesign #1 Air Cannon		
Distance	**Yes**	**No**
0”		
6”		
12”		
18”		
24”		
30”		

Redesign #2 Air Cannon		
Distance	**Yes**	**No**
0”		
6”		
12”		
18”		
24”		
30”		

Air Cannon Datasheet (continued):

How far can your air cannon shoot air?
Sketch air cannon design: label improvements, then test your new design, recording the results in the table on the right. The last row is for over 30” – include how far .

Redesign #3 Air Cannon		
Distance	**Yes**	**No**
0”		
6”		
12”		
18”		
24”		
30”		

Redesign #4 Air Cannon		
Distance	**Yes**	**No**
0”		
6”		
12”		
18”		
24”		
30”		

Redesign #5 Air Cannon		
Distance	**Yes**	**No**
0”		
6”		
12”		
18”		
24”		
30”		

4-H FUN! — Mini-Kite Designs

Japan has many kite festivals. The Ikazaki Kite Festival, for example, is 400 years old. It is held on children's day (May 5th). A child born the previous year has his/her name printed on a kite wishing prosperity and happiness.

One of the biggest is the Wanwan kite. It has a 10m diameter (32 feet). It's origin is ancient, and thought to have first been built in 1692. The largest Wanwan kite to fly had a 20m diameter (65 feet). Because of the size and weight of the kite, many people and a strong wind are needed to fly it successfully.

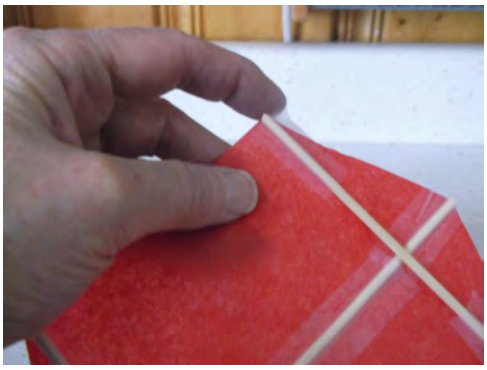
The smallest kites can be a few **millimeters** (about the length of a grain of rice)! These tiny kites fly above the rising heat of woks.

Regardless of whether they are gigantic or dinky, each particular kite is beautifully decorated.

Some kites even take the shape of flowers or animals.

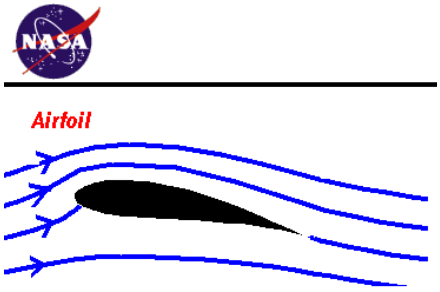
Directions:
Design

- On page 25, there is a NASA drawing of five different kit styles. Examine the designs. Look for the **airfoil** on each of the kites.
- To start this activity, use the diamond or Rokkaku kite (these are easier to build). Page 25 has websites with directions for making several designs, including the Rokkaku kite. The images in the directions are a simple Rokkaku kite that are included in the websites on page 25.
- Read the side green box on page 24 for anatomy of a kite terms. The directions below use those terms.
- The spine and spar are bamboo skewers. Measure the length you need and snip with sharp scissors.
- The sail material is tissue



POWER WORDS

- **airfoil**: streamlined surface designed in such a way that air flowing around it produces useful motion; The cross section of an airplane wing is an **airfoil**
- **asymmetry**: opposite of symmetry; not balanced



patterns of self-similarity
- center of gravity: the single point in any object (symmetrical or asymmetrical) which everything can be balanced
- **millimeter**: a unit of length equal to one thousandth of a meter and equivalent to 0.03937 inch or inch has 25.4 **millimeters**
- **plumb**: test an upright surface to determine the vertical

continued on page 23
POWER WORDS
continued from page 23

MATERIALS

- tissue paper (in the wrapping paper section)
- plastic shopping bag
- bamboo skewers
- straws
- thread
- tape
- scissors
- optional—iron and ironing board

As you explore the world of mini-kites, you may need other materials for really tiny kits, like paint brush bristles for the spine and spar.

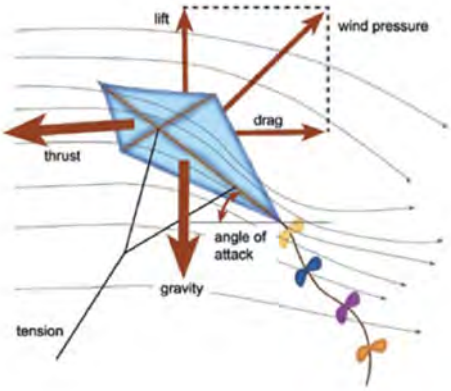
paper or a plastic shopping bag. HINT: iron the tissue paper before making the kite.

- Use the thread to string your kite and make the bridle. your kite line is either heavy duty or regular thread.

- Test your kite with a fan. Try using different speeds of the fan.

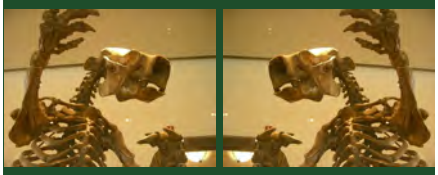
Redesign

- Reexamine the different styles of kites on page 25.
- The following concepts will improve your design, and help you make all six of the kite designs:
  - Symmetry in cover (sail) shape: The shape of the sail on the right side exactly mirrors the shape of the sail on the left. To get a symmetrical sail, fold the paper in half and cut your sail design. When you open the paper, you will have a symmetric sail.

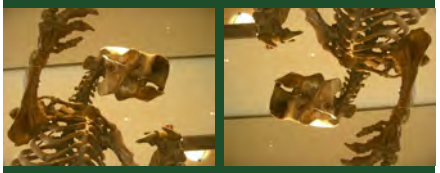


  - Symmetry in cover (sail) billow: This means how taut or baggy the sail is on the frame. If one side is baggy and the other taut, the force applied by the wind will not be uniform. Hint, taut is better than baggy.
  - Center of gravity: The point at which the entire weight of an object (for example, our kite) is concentrated so that if supported at this point the entire object remains in

- **symmetry:** precise and well-defined concept of patterned self-similarity
  - Reflection symmetry - the mirror image
  - Rotational symmetry - the image turned on its axis



  - Translational symmetry - the images are offset

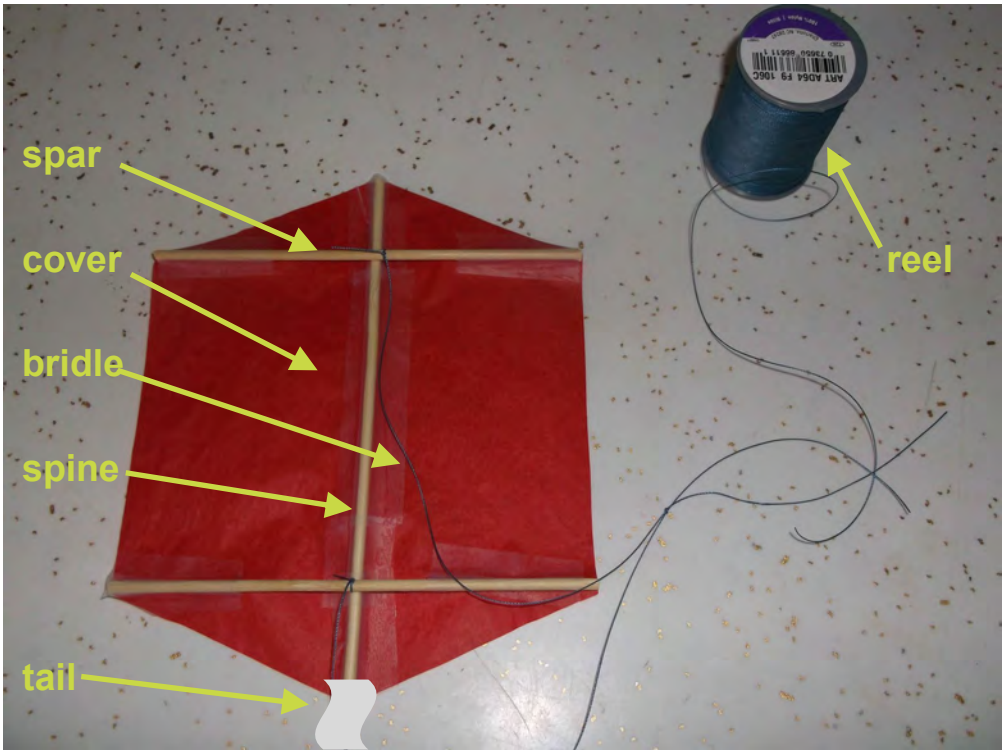


FASCINATING FACTS

The forces for flight:

- lift - the force that holds an airplane in the air
- gravity - the force that pulls on a object
- thrust - a force that moves an aircraft in the direction of the motion
- drag - the force that acts opposite to the direction of motion

Smithsonian National Air and Space Museum



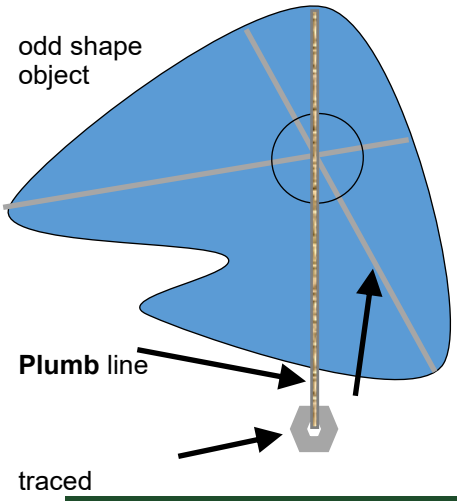
ANATOMY OF A KITE

- **bridle**: string attached to the frame
- **cover** (sail): plastic, paper, or fabric to catch the wind
- **kite line**: string from bridle to the person flying kite
- **reel**: the spool you wind the kite line around.
- **sail**: another term for cover
- **spar**: cross-piece, often curved or bowed
- **spine**: vertical stick, usually wood or plastic
- **tail**: long ribbon or string with knotted bits of material that helps to balance the kite

balance. It is at this point that you want to place your bridle.
  - Symmetry and center of gravity are the keys! Both sides need to be equally weighted.
  - Weight: Make your kite as light as possible.
- Build several different kites. Compare and contrast the designs. Were are the **airfoils**?

Test It
- Measure 25 feet. Walk your course holding the kite line at least 30cm (10 inches) from the bridle.
- Turn your fan on low. Hold your kite line at least 30cm (10 inches) from the bridle to test for 10 seconds.
- Repeat with the fan at medium, and again with high.

Challenges!
- Try building an asymmetrical mini-kite. See below for how to find center of gravity to help you design and build your kite!

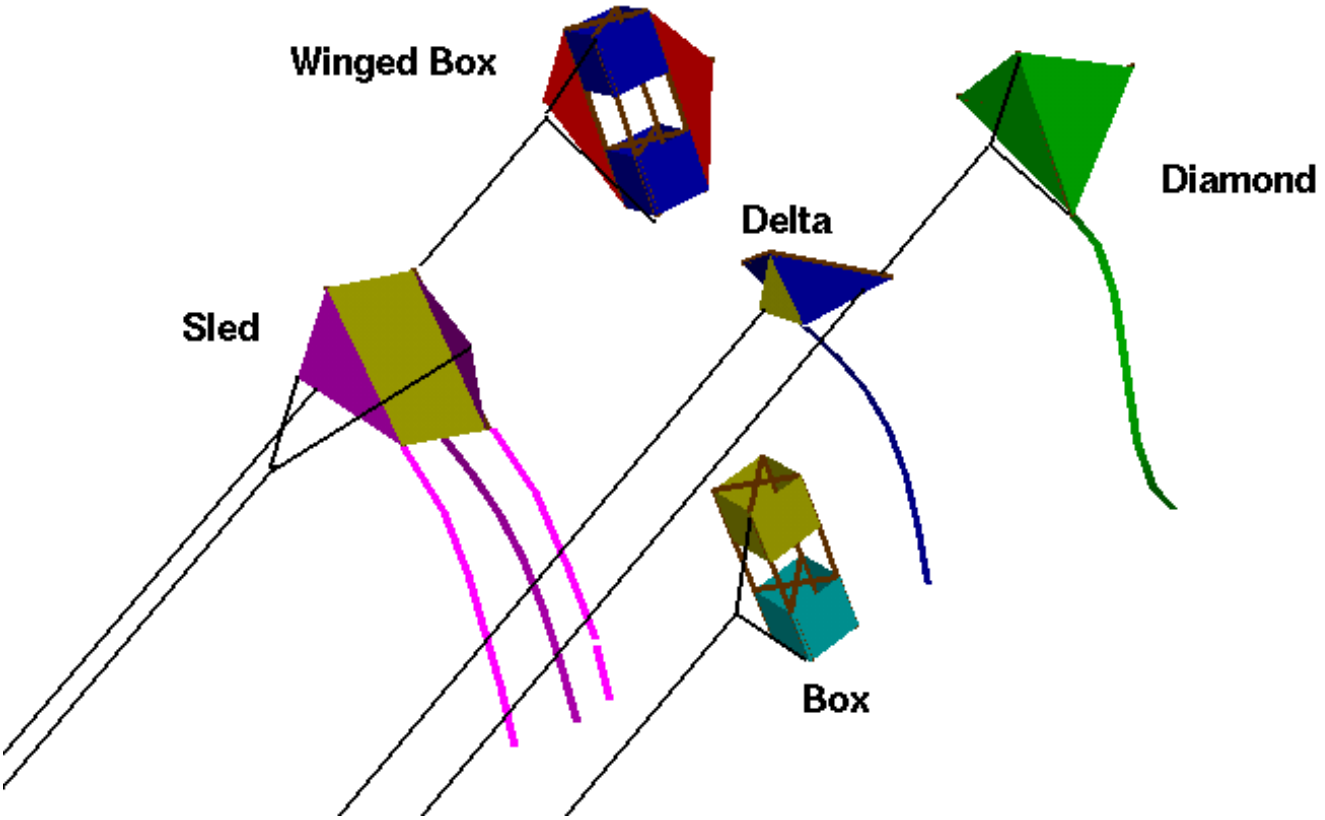


FINDING CENTER OF GRAVITY for odd shapes

- Center of gravity is the balancing point for any object.
- Dangle a **plumb** (string with a heavy weight called the plumb bob). The sting will hang vertically. Trace on the object along the string line (grey lines above).
- Rotate the object, and dangle to plumb at a different point on the object. Trace the string line.
- Repeat one more time at a different location.
- Where the three string tracing lines cross, that is the center of gravity. The kite brindle is located here.

Kites

Glenn Research Center



The NASA image above captured from: https://www.grc.nasa.gov/www/k-12/airplane/kite1.html
The following websites are places to help you build different designs of kites. If you are struggling with the how to, they may help you past those problems.

- My Best Kite is a website with directions for making mini-kits. https://www.my-best-kite.com/how-to-make-a-kite.html. The patterns and directions are located under the sub-heading 1-Skewer Series. It includes Sled, Diamond, Barn Door, Rokkaku, Sode, Delta, Roller, and Dopero. Scroll down to find the box mini-kite design (labeled The 1-Skewer Box Kit).
- Instructable is only for the diamond design kite, but has clear directions. https://www.instructables.com/Mini-Kite/
- Public Lab has great tips and the mini-Rokkaku kite design. https://publiclab.org/wiki/mini-kites. The demonstration kite build for this lesson was a mini-Rokkaku kite.
- For really miniature kite designs (as small as 1”), check out this site. http://www.miniaturekiteguild.org/main/techniques/87-how-to-make-really-small-kites-that-really-fly. It will help you with ideas for materials (like nylon paintbrush bristles for the spars). Very cool!
- Beautiful mini Kites! Check these out! http://www.kiteman.co.uk/MiniKites.html

Hot air rises and cold air sinks. Why?

Air is comprised of primarily nitrogen, oxygen, and xenon in the gas **state of matter** (**phase**).

As the gas warms, the molecules move faster. They strike each other, moving further apart. Fewer molecules are lighter, and they begin to rise. As they rise, they cool down. As they cool, they slow down, and can move closer together. More molecules together are heavier, and they begin to sink. That warm air can lift hot air balloons, glider planes, and vultures.

Directions:
Experiment on Hot Fluids

- This is a quick experiment on rising hot and sinking cold **fluids**. Liquid and gases act in a similar manner. In this experiment, we will use water to help us see this concept in action.
- This can be a messy experiment. If you conduct this experiment on the cookie sheet in your kitchen, it can help contain any spills.
- The two playing cards need to be larger than the mouth of your jars. If you can't find a card large enough, you can use wax coated piece of paper.
- Your jars need to be the same size. You can use baby food jars, pint mason jars, or other jars that can be heated and cooled without breaking.
- Add 10 drops of blue food color into two jars. You will add cold tap water into these two jars. Blue = cold.
- Fill the two jars to the very top with cold tap water. Place in the cookie sheet.
- Add 10 drops of red food color into the other two jars. Add hot tap water into these two jars. Red = hot.
- Turn on the hot water tap, and heat the water. Use pot holders. If you are using cloth pot holders, put each inside a plastic bag. If they get wet, they will still protect your hands.
- Fill the two red food color jars with water to the very top with hot water, and place in the cookie sheet.
- Grab a parent to help you with this next step.

- Place the playing card on top of a red jar.
- Hold the card against the red jar mouth and **invert** the jar. Be sure to do this over the sink or cookie sheet.
- Carefully remove your hand from the card. The card will remain in place.
- Place the **inverted** red jar on top of a blue jar. With the help from your parent, **align** the two jar mouths,

POWER WORDS

- **align**: place or arrange (things) in a straight line
- **aloft**: up in or into the air; overhead
- **dense**: closely compacted in substance
- **fluid**: substance with no fixed shape and yields to external pressure; a gas or a liquid
- **interface**: point where two systems (e.g. card/ water and mason jar/ water), meet and interact
- **invert**: put upside down or in the opposite position or order

continued on page 27

MATERIALS

- 4 wide mouth mason jars
- red food color
- blue food color
- two playing cards
- cookie sheet
- tissue paper (wrapping paper aisle)
- construction paper
- glue stick
- yard stick or ruler
- pencil
- scissors
- hot air popcorn popper
- optional: tin can with both ends removed
- large space (to make the hot air balloon)

with the card in between the two jars.

- The red jar is on top, and the blue jar is on the bottom.

Predict what will happen to the warm red water and the cold blue water can mix.

- With your parent still holding the top jar, carefully remove the card between the two jar mouths. What happens?
- Hold the card against the blue jar mouth and **invert** the jar. Be sure to do this over the sink or cookie sheet.
- Carefully remove your hand from the card. The card will remain in place.
- Place the **inverted** blue jar on top of a red jar. With the help from your parent, **align** the two jar mouths, with the card in between the two jars.
- The blue jar is on top, and the red jar is on the bottom. Predict what will happen to the warm red water and the cold blue water can mix.
- With your parent still holding the top jar, carefully remove the card between the two jar mouths. What happens?
- See the bottom green box on page 29 for an explanation of how this works.

Explanation:

- Hot fluids rise, and cold fluids sink. With the red hot water on top and the blue cold water on the bottom, there is very little mixing. The blue water is more **dense** than the red water.
- With the blue cold water on top and red hot water on the bottom, the hot water will rise, and the blue water will sink. The water in these two jars mix.
- This is what will happen when we fill our hot air balloon with hot air. It will rise in the cooler air atmosphere.

Build the Balloon:

You will need a large space to do this activity.

- Your tissue paper will come in sheets 20” x 26”. If the measurement is different, you will need to make some adjustments. The 20” in these directions are to match the width of the tissue paper.
- Cut four **trapezoids** (top) 20” x (bottom) 6” x (sides) 15”.
- **NOTE**: Use plenty of glue stick to glue together. You don’t want any gaps in the seams between the

POWER WORDS

continued from page 26

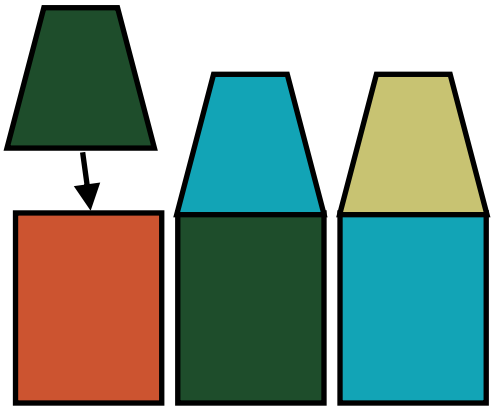
- **state of matter**: One of the four principal conditions in which matter exists-solid, liquid, gas, and plasma (see page 29 right green box for plasma information)
- **trapezoid**: flat shape with two opposite lines parallel, the other two lines do not have to be parallel
- **troubleshoot**: trace and correct faults in a mechanical or electronic system

FASCINATING FACTS

- The Chinese were the first to invent the hot air balloon in the 3rd century BC. They used the balloons to send messages.
- The first hot air balloon passengers were a duck, rooster, and sheep in 1754!
- Jean-Francois Pilâtre De Rozier and Francois Laurent d’Arlandes were the first humans to experience sustained flight (20 minutes) in a hot air balloon.

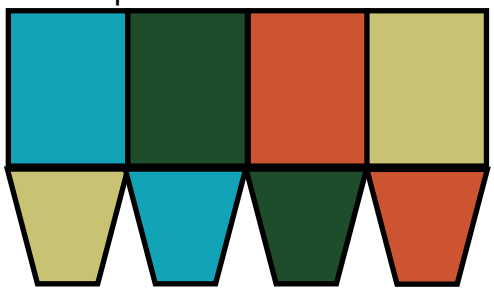
two sheets.

- Glue the 20” top of the **trapezoid** to the 20” bottom of the sheet of tissue paper.
- Glue one trapezoid to one sheet of tissue paper.
- Glue the four panels together on the length side of the full tissue paper sheet.
- Cut one square 20” x 20” (the width of your tissue

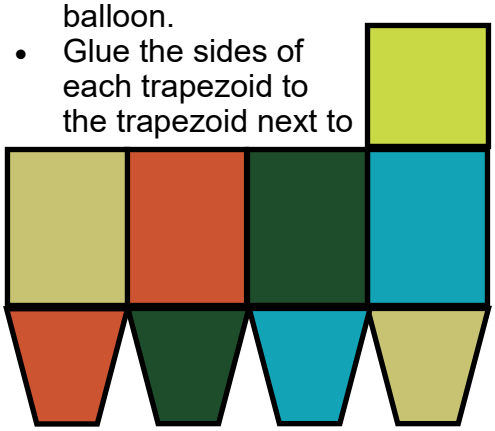


paper). This will be the top of your hot air balloon.

- Glue the square top to one of the panels.



- Glue the left and right sides of your panels together to form your body of the hot air balloon.
- Glue the sides of each trapezoid to the trapezoid next to



it. This will taper the mouth of your hot air balloon.

- Glue the square to the panels to form the top of your hot air balloon.
- Cut a strip of construction paper 26” x 1”. You may need to glue several strips together until it is 26” long.
- Glue the construction paper to the bottom of the

trapezoids to reinforce the tapered end of your hot air

balloon.

How to launch

- You can launch on a day with no breeze or wind. Alternatively, if you are in school, you can use the gym.
- Remove the hot air popcorn popper lid to expose the bottom of the popper.
- Depending on the style of the popcorn popper, you

TROUBLESHOOT popper

- The most common problem with the popper is the element is recessed, and it is difficult to get the mouth of your hot air balloon over it. The tin can usually works. Only rest the can on the popper.
- The other common issue with the hot air popcorn popper is the wattage is lower than 1400 watts.
- A hair dryer will not work. It blows hot hair, and you can’t keep your balloon stable while you try to heat the air.

TROUBLESHOOT balloon

- Usually the balloon that doesn’t float **aloft** has a gap in one of the seams. Check all the seams, and seal them with your glue stick.
- The second most common reason is a tear in the tissue. Simple use your glue stick on one side of the tear, and overlap the other side on top of the tear. You can also use a tissue paper patch, and glue on top over the tear.

can use a clean tin can (both ends removed) to be a nozzle to connect the popper to your hot air balloon.

- Place the opening of your balloon over the popper nozzle. Turn the popper on and hold your balloon on the popper.
- Your balloon will fill with hot air and start to lift off the popper. You can let go, or continue to hold and add more hot air into your balloon.

Challenges:

- How long can you keep your hot air balloon **aloft**?
- What is the largest hot air balloon you can make? Will it stay **aloft** longer or shorter than the one you made first?
- What is the smallest hot air balloon you can make? Will it stay **aloft** longer or shorter than the one you made first?
- Can you design the shape to look more like the traditional hot air balloon?

- How high can you send your hot air balloon **aloft**?
- What happens if you change the size of the opening to the balloon?

National Balloon Museum in Iowa has information about the history of hot air balloons: https://www.nationalballoonmuseum.com/about/history-of-ballooning/

PLASMA

- Plasma is the most common known state of matter in our universe. All the stars are in the plasma state.
- States of matter depend on how much energy is in the system. Increasing in energy:
  - Solid (low energy)
  - Liquid
  - Gas
  - Plasma (high energy)
- There is so much energy, the electrons are freed from atoms.
- Solids keep their shape.
- Liquids keep the bottom shape of a container.
- Gases fill a container.
- Plasma has no fixed shape or volume. They are charged electrons and protons.

WHY THE CARD "STICKS"

- Why? Cohesion, adhesion, and air pressure!
- Water is cohesive (sticks to itself). It also is adhesive (sticks to other objects). Water form a seal around **interface** of the card and the cup.
- Air pressure pushes in all directions. Remember that the air presser at sea lever pushes 14.7 pounds per square inch. (In Montrose, CO, it pushes 11.9 pounds per square inch. The air pressure keeps the card in place.

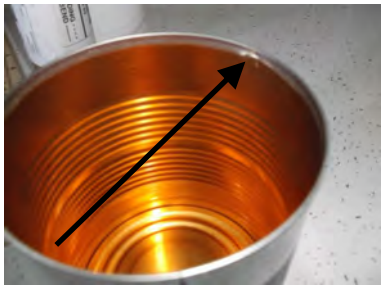
Visible light is part of the **electromagnetic spectrum**. This form of energy travels in wavelengths of ROY G BIV (Red, Orange, Yellow, Green Blue, Indigo, Violet). When **incoherent**, it appears as white light. When sunlight shines though raindrops, it separates the wavelengths of ROY G BIV, and we see a rainbow.

The word LASER is an **acronym**:
L—Light
A—Amplification by
S—Stimulated
E—Emitted
R—Radiation

Dr. Albert Einstein deduced that light could exist as stimulated emission in 1916. This is a way for light to emit more waves of light. This laid the foundation for LASERs!

can. Plastic is very difficult to remove the bottom to make an open tube.

- *You need to add one extra step if you are using a can.*
- Remove the bottom lid of your empty, clean can with the can opener, so both ends are open.



- There will be a sharp tab on the can (see black arrow).
- Place the can on a cutting board. With a hammer, tap the tab flush with the can rim.

POWER WORDS

- **acronym**: an abbreviation formed from the initial letters of other words and pronounced as a word e.g. NASA (National Aeronautics and Space Administration)
- **electromagnetic spectrum**: the entire range of wavelengths or frequencies of **radiation** extending from the most intense gamma rays to the lowest energy radio **waves** (including visible light)
- **incoherent**: wavelength of light travelling in different directions
- **radiation**: energy

Here's an activity for an at-home version of LASER show that you can build yourself.

Directions:

- Gather your materials. Your LASER Light Show Gizmo works best if you use a cardboard mailing tube or

MATERIALS

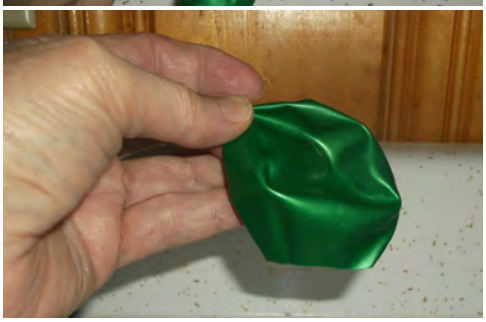
- metal can or cardboard tube mailer
- can opener
- ruler
- hammer
- cutting board
- duct or electric tape
- large balloon
- clothes pin
- double sided tape
- scissors
- 1cm^2 (0.75"^{2}) mirror
- LASER (dollar store)
- paper plate
- optional: art supplies to decorate LASER Light Show gizmo

Cover that spot with a piece of duct or electrical tape.

- Remove both of the caps if

using a mailing tube.

- Cut the neck off a balloon at the point the neck ends and the body - neck transition.
- Stretch the bottom portion of the balloon over one end of the can or mailing tube cylinder.

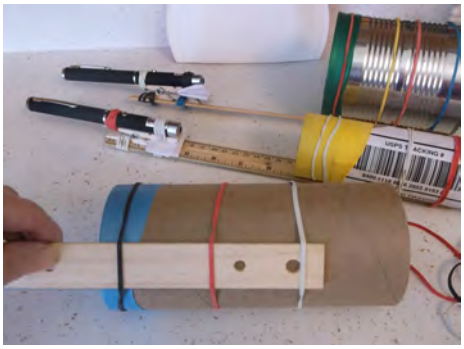


- Notice the drip point on the

balloon (white arrow on image left bottom). Stretch the balloon as tightly as possible, and shift the balloon dimple to the edge of your cylinder.

- Secure the balloon to the cylinder with a rubber band. Your cylinder should look like a drum.

- Secure a wood ruler or paint stick to the cylinder with three rubber bands. The cylinder should attach to 3-4" of the end of the ruler. The open end of the cylinder points away from the ruler. The balloon points towards the ruler as imaged below.
- With two rubber bands, attach the LASER to the



clothes pin, with the LASER light toward the opening side of the clothes pin, and the back

FASCINATING FACTS

- Depending on the material being lased, you can get different colored LASERs.
- A MASER, (Microwave by Stimulated Emission of Radiation) was the first LASER. It works like a LASER but light given off is microwave radiation. Townes, Basov, and Prochorov won the Nobel Prize for this discovery in 1964.
- HeNe LASERs are red. The HeNe stands for helium and neon, the two materials lased.
- Green LASERs are infrared (just beyond visible light range), but pass through a frequency doubler, turning it into green light.

FASCINATING FACTS

- Sound vibrates air molecules in our atmosphere. These vibrations are compression waves.
- There is no sound in space. Since there are no air molecules to vibrate, the sound cannot be transmitted.
- The loudest sound on Earth is caused by erupting volcanos. Krakatoa (in Indonesia) erupted in 1883. It is classified as one of the most destructive and deadliest volcanic events in recorded history. It's explosions were heard over 1900 miles away!

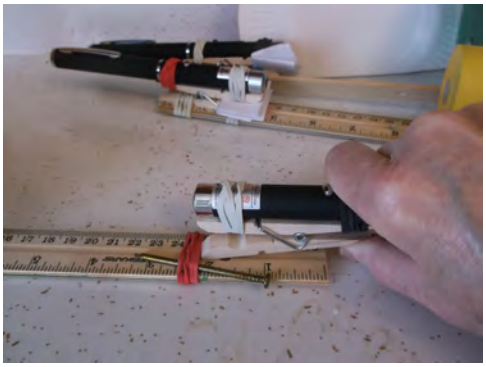
side of the LASER light on the pinching end of the clothes pin.

- Wrap a rubber band on the ruler about 2.5 inches in from the end (between 9.5 and 10” in the image below).
- Slip the opening of the

clothes pin under the rubber band. If you use something to slide under the bands (like a nail) and lift, it is easier to

slip the opening end of the clothes pin under the bands.

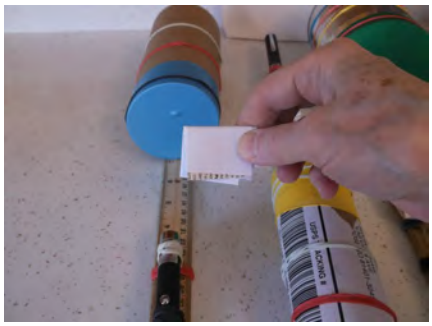
- Wrap a second rubber band attaching the pinching end of the clothes pin to the ruler.



- Turn on the LASER. It will point towards or on the bottom of your balloon.

- Fold a scrap piece of paper in half several times.
- Pinch open the clothes pin

and insert the paper to lift the light closer to the center of



your balloon. Modify the piece of paper until the

FASCINATING FACTS

- The sun shines in a broad range of colors combined to produce white light. LASERs lase by producing concentrated beam of a single wavelength color.
- A lidar (light detection and ranging) system shoots out a LASER pulse, calculates how long it takes the pulse to bounce back, and determines how far away an object is, like bats using echolocation to find dinner.
- The Apollo astronauts left mirrors on the moon. LASER beams fire at the mirrors measure the precise distance. It shows the moon is slowly moving away from us.

FASCINATING FACTS

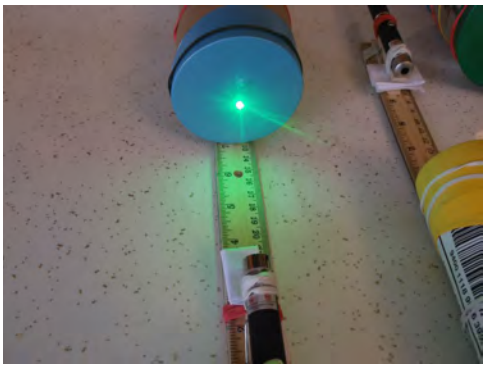
- Dogs hear sounds at a much higher frequency than humans can. That means they can hear sounds or noises humans cannot.
- Flies are not able to hear any sounds at all.
- Most blue-eyed white cats are usually deaf.
- Dolphins hear sounds underwater as far as 15 miles.
- Whale voices are able to travel a whopping 479 miles through the waters of the ocean.

LASER light points about halfway up the balloon.

- Turn on your LASER light. The point where the light hits

the balloon is where you need to place your mirror.

- Where is the balloon drip point? You may need to shift



the cylinder so the light doesn't point near the dimple.

- Your mirror may be self-adhesive. If it is not sticky, add a small piece of double sided tape to the back of the mirror. If it is self-adhesive, peel off the cover.
- Secure the small mirror exactly over the point where the LASER hits the balloon.
- This will **reflect** the LASER pointer towards the wall and

away from you.

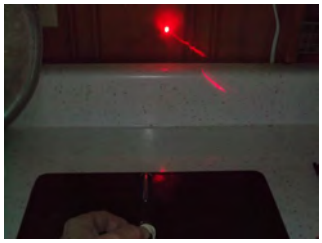
- You can fold the bottom third of a paper plate to form a

screen.

FASCINATING FACTS

- Light is made up of energy.
- Light travels in a straight line. Objects in its path cause light to bend or refract.
- The speed of light in a vacuum (like space) is exactly 299 792 km per second (186,282 *miles per second*).
- Travelling at the speed of light, you could go around Earth 7.5 times in a second.
- Visible light makes up very little of the electromagnetic spectrum. On the spectrum, you will find everything from infrared to gamma rays.
- Photography" in Greek means "writing with light".

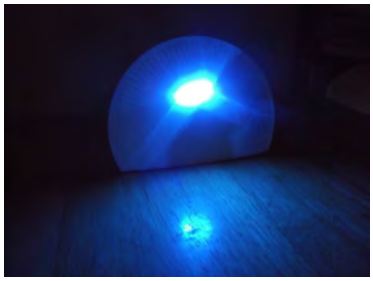
NEVER point LASERs at anyone's eyes.



FASCINATING FACTS

- Sound travels at a speed of 767 miles per hour.
- The majority of cows which listen to music end up producing more milk than those that do not.
- In order for a whip to crackle or make the noise it creates, it must travel faster than the speed of sound.
- The rapid heated air that surrounds lighting is what causes the sound of thunder. The lightning ends up expanding at a faster speed rate than sound itself.

- Turn out the lights, point the can at a blank wall, turn the LASER on, hold the open end of the can up to your mouth and sing! You will see fun light patterns form and change on the wall. The camera wasn't able to



capture the designs in the dark. However, the first image on the left and the image below, you can see how the sound vibrations form different designs.

I am going to turn over the rest of this activity to my colleague, Andrew Reed, the amazing

Admin Assistant in the CSU Extension Montrose Office. He has been helping us produce video activities you can find on STEMming with Steph: https://www.youtube.com/channel/UCSFQv8o-IAYHMQ_GWCLWOug/videos. He is also a disc jockey in his "other life."

LASER Light Show Gizmos with three types of LASERs, blue, green and red.

Mr. Drew will give you some ideas for making your own LASER light show!

FASCINATING FACTS

- There are different types of light and each one has its own wavelength.
- Some animals can see wavelengths that humans cannot. Ultraviolet light (UV light), for example.
- Sunlight can be seen 80 meters underwater.
- Plants are green because they reflect green light while absorbing other colors. The other colors that they absorb are used in photosynthesis to create food.
- A double rainbow occurs when light is reflected twice within each water droplet.

FASCINATING FACTS

- LED lights are made up entirely of visible (to humans) light. This is why they appear much brighter.
- Light from the sun takes over 8 minutes to reach earth.
- The speed of light is relevant to the atmosphere that it is travelling through.
- Plato (a famous Greek philosopher) thought that we see by shooting light rays out of our eyes.

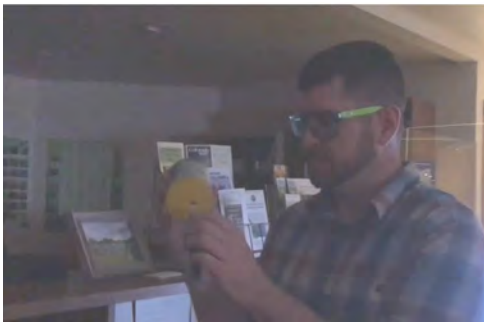
Facts from FACTS.NET (https://facts.net/science/physics/light-facts)

So, ready to make your own LASER show! Here we GO!

Directions:

- Never point the LASER at anyone's eyes. It is coherent light, and very powerful. It can damage your eyes, and even cause blindness. If you see the LASER light, just close your eyes.
- What to do:
  - Turn out the lights
  - Point the can at a blank wall
  - Turn on the LASER
  - Hold the open end of the can to your mouth
  - and sing

- You will see fun light patterns form and change on the wall.
- What happens when you make a really low sound. What happens when you make a really high sound?



- What happens if hold your LASER show gizmo up to a speaker playing music?

LASER LIGHT SHOW

- Try these different ideas for your LASER light show
  - Make a LASER show gizmo for each member of your family
  - Try different instruments—which work best?
  - Try different music
  - Sing songs together
  - Change the volume
  - Can your barking dog make a LASER light show?
- What other ideas do you have?

Have fun!

- What happens if you hold your LASER show gizmo up to a musical instrument, and play different single notes or chords?
- Do different kinds of music produce different LASER shows? Compare classical music to electronic music and your favorite music.
- What about bird calls. Use the National Audubon Society website, and try different Colorado

Never point LASERs at eyes!

MATERIALS

- blank wall
- LASER show gizmo
- musical instruments
- radio (or other electrical component)

birds.

- What happens when you increase the volume?
- Make a different LASER show gizmo with red, green, and purple LASER lights. These are easy to find online at reasonable prices.
- Each LASER needs to be operated by a different person. Try singing a song in different harmony, or a round (like Row, Row, Row Your Boat).
- Set each LASER show gizmo pointing in the same general direction and play the music.
- Try different experiment with different sounds. Can you develop your very own LASER Light Show with your LASER show gizmo?

What's happening?

- Sound is mechanical energy. It vibrates the molecules in the air. Those molecules vibrate the balloon and mirror. The light **reflecting** on the mirror forms the vibration patterns on the wall.
- The LASER is a very intense light dot. Notice that there are no shadows. LASERs are **coherent** light. That means it is a single wavelength of light with all the wavelengths moving in the same direction.
- Light is the fastest thing in science. As the dot of LASER light moves from the vibrations on the mirror, it appears as a line or circle. Our brain cannot separate the dot as it moves. It is so fast that your brain puts each tiny dot of LASER light together as one consistent image. This concept is called persistence of vision. Flipbooks, movies, and cartoons all use this concept.
- Professional LASER shows use the same concepts as in our LASER light show gizmo. The also use computer controlled mirror movements for precise and elaborate shapes.

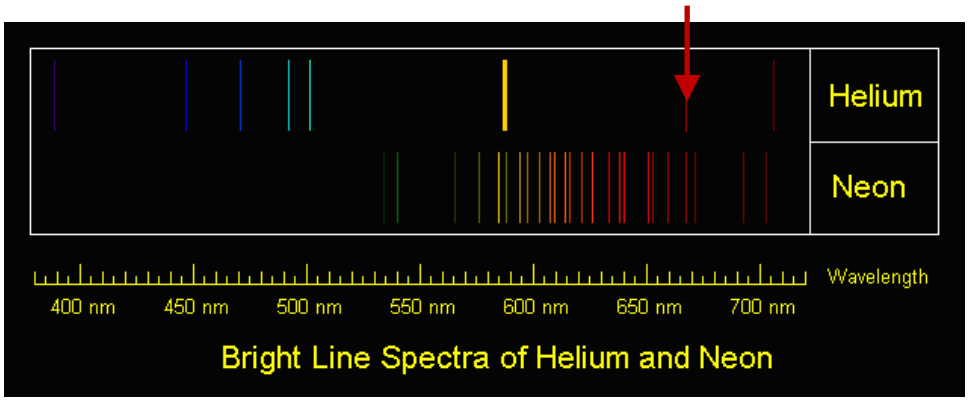
Dr. Albert Einstein was the first person to propose the concepts of LASER light. In 1917, Dr. Einstein wrote a paper on the **quantum** theory of **radiation**. In that paper, he predicated stimulated emission. This is the way scientists can take a wavelength of light (for example red), and point them all in the same direction. That is stimulated emission.

The red LASER uses helium and neon gas. Notice that both of them share a red wavelength.

POWER WORDS

- **absorb**: soak up or take in
- **coherent**: wavelengths of light moving in the same direction with identical wavelengths
- **quantum**: a specific amount of energy at the atomic level
- **reflect**: throw back, like your image in a mirror
- **refract**: bending light when it passes through a raindrop or prism

Spectral signatures of Helium and Neon image are used with permission by "the Engineer" at https://www.experimental-engineering.co.uk/helium-neon-lasers/viewing-spectral-lines-in-discharge-other-colours-in-output/



FASCINATING FACTS

- **Incoherent** light—from light bulbs or the sun—travels in all directions
- **Coherent** light—from LASERs—travels in a single direction

The matchstick was an accidental invention. John Walker was testing different chemicals known to **ignite**, but he discovered a stable, slow-burning friction match.

His match was made from a wooden **splint** coated with Sulphur and tipped with a mixture of sulphide of antimony, chlorate of potash, and gum.

Before this invention in 1827, people would light their fires with a fire striker. A piece of **flint** or **chert** (rocks) are stuck on a piece of carbon steel, which cause sparking.

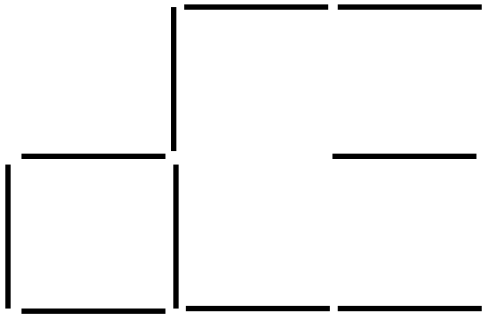
Not only were matchsticks used for easily starting fires, they were also used as brainteasers: matchstick puzzles! In this activity, you can use either matchsticks or toothpicks. Lay out your toothpicks as diagramed. By rearranging a specific number of toothpicks, you form a new pattern.

Answers will be in the Next 2021 ST[EMpower] issue.

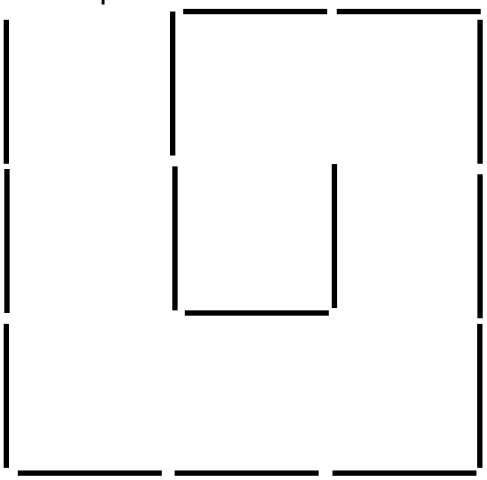
Have fun!

Directions:

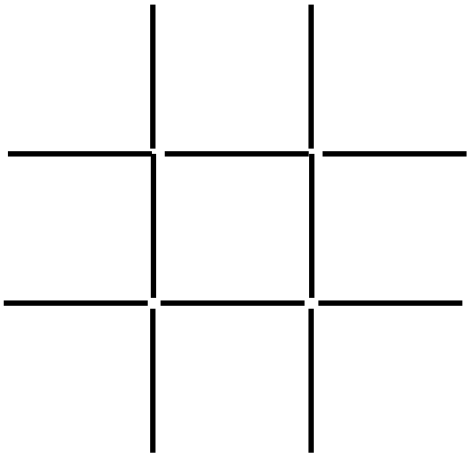
- Move three toothpicks to make two squares.



Move three matchsticks to make two squares.



- Move three matchsticks to make three squares.



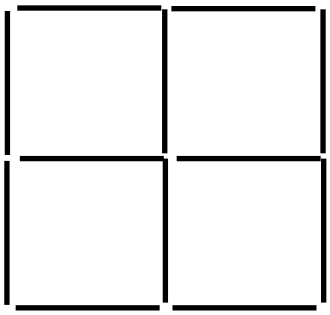
- Take away six matchsticks from the fifteen to leave ten.

POWER WORDS

- **chert**: a hard, dark, opaque rock composed of silica (chalcedony) with an amorphous or microscopically fine-grained texture
- **flint**: a hard gray rock consisting of nearly pure chert, occurring chiefly as nodules in chalk
- **ignite**: catch fire or cause to catch fire
- **splint**: a long, thin strip of wood used to light a fire

Matchstick puzzles modified from: https://www.puzzles-to-print.com/printable-brain-teasers/matchstick-puzzles.shtml

- Move two matchsticks to make six squares.



- How did you do?

MATERIALS

- toothpicks or matchsticks

AUTHORS

- Dr. Barbara J. Shaw, Colorado State University Extension Western Region Youth Development 4-H STEM K/12 Specialist
- Stephanie Lamm, Colorado State University, Montrose County Extension Youth Development 4-H STEM K-12 Associate
- Andrew Reed, Colorado State University, Montrose County Extension Administrative Assistant
- Tom Lindsay, retired Portland State University instructor (geology and paleontology); HS science teacher (AP and IB Chemistry, Physics, Biology, and Calculus)

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CITATIONS

- Tall Tower: Empire State Building captured from the History Channel 11/6/2020 https://www.history.com/this-day-in-history/empire-state-building-dedicated;
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