National Inventors Hall of Fame®
EDUCATION PROGRAMS

# READY, SET, STEM HANDBOOK

## Get Set To Invent With These At-Home Family Activities

# LET'S GET CREATIVE!

We put this handbook together to inspire young innovators everywhere. Here, you'll find hands-on, open-ended activities designed to spark creativity as you and your family work together to design, prototype, explore STEM concepts and overcome real-world challenges.

Get ready to invent by identifying useful resources that will help as you make your way through this guide. Here are a few basic tips as you're setting up:

### 1. Gather supplies

Basic materials are often used to develop big ideas! You can get started with an assortment of supplies including pencils, paper, scissors, glue and recyclable materials. Simple items like these are all you'll need for constructing prototypes.

### 2. Start an Inventor Log

Keeping a log or journal is a fun way to track thoughts, designs and discoveries. Keep a notebook and pencil handy to record observations, create sketches and write out ideas while working through each of these activities.

### 3. Create a makerspace

What kind of space might inspire creativity? Maybe it's your kitchen or dining room table, or a quiet corner of the family room. Place your supplies here and consider giving your child the chance to make this space their own by hanging posters or decorating in their style.

Ready to use your imagination and put creative problem-solving skills into action? Let's go!

Happy hands-on creating,
Your National Inventors Hall of Fame® team

# MAKE MUSIC WITH INSTRUMENTAL INVENTIONS

**Experience the science of sound waves as you create your own instrument and invent new ways to produce music! Sketch your musical designs, then bring them to life with objects found around your home.**

## WHAT ARE WE LEARNING?

By strumming and plucking guitars, shaking maracas and banging drums, students experience the science of sound waves in action. By prototyping different instruments, children also have the opportunity to practice their creative problem-solving skills and invent new ways to produce music.

## MATERIALS NEEDED

- Beads, beans, jingle bells or other shakable objects
- Cardboard box (e.g., cereal box, shoebox)
- Cardboard tube
- Decorations (e.g., pipe cleaners, stickers, etc.)
- Markers
- Paper
- Rubber bands
- Scissors
- Tape


## INSTRUCTIONS

1. Brainstorm different types of instruments. Conduct a quick online search for inspiration!
2. Sketch a few different versions of your own original instrument that vibrates air to create sound.
3. Consider the following questions as you generate your ideas:
   - What material might be good to use as a base, container or body for the instrument?
   - What materials will vibrate the best?
   - Will the material be attached to or inside of the instrument?
   - How might you play your instrument?
   - Will you shake it, strum it, hit it, blow on it or something else?
4. Gather the materials and make your prototype.
5. Try to change the pitch of your instrument. To change the pitch of a guitar, for example, the guitarist presses on the strings to make them different lengths, which changes how fast or slow the strings vibrate.
6. Have an Invention Concert, celebrating the sweet sounds of creativity and innovation!

# BUILD YOUR OWN HIGGINS BOAT

**Construct an aquatic vessel using inspiration from the historically significant Higgins Boat! Create buoyancy to stay afloat and identify features that will enhance your boat for cargo and passengers.**

## WHAT ARE WE LEARNING?

The Higgins Boat, or Landing Craft, Vehicle, Personnel (LCVP), was critical to the Allied success in World War II. NIHF Inductee Andrew Higgins made modifications to the Eureka, a boat he invented to retrieve hard-to-reach trees in Louisiana swamps and used in his lumber business, to allow for efficient ship-to-shore deployment of troops and equipment. Due to the landing craft's innovative design, the Higgins Boat was able to land on a beach, lower its ramp, empty troops and cargo in seconds, and then extract from the beach to reload. Along with having a retractable bow ramp, the landing craft also had a patented ballast system that allowed it to travel in shallow water and a carrying capacity of 8,100 pounds, and it was made of mostly plywood, which allowed it to be lightweight. After the attack on Pearl Harbor on Dec. 7, 1941, Higgins Boats were used in the island-hopping campaign through Guadalcanal, Iwo Jima and Okinawa, in North Africa and Italy, and for the D-Day landing on the beaches of Normandy.

This activity also explores simple machines, or devices that make work easier by changing either the size or direction of force. Simple machines often play a role in technological innovations.
Two such devices, inclined planes and pulleys, are featured in this activity to help unload cargo.

Additionally, this activity involves discoveries in buoyancy. When an object is placed in water, two primary forces are acting on it. A gravitational force yields a downward force, while a buoyancy force yields an upward force. The gravitational force is determined by an object's weight, and the buoyancy force is determined by the weight of the water displaced by the object.

## MATERIALS NEEDED

- Balloons
- Balsa wood (if available)
- Boat from the Camp Invention® Deep Sea Mystery™ experience (if available)
- Bucket, large container or pool
- Drawing materials (e.g., crayons, markers, paper, pencils)
- Recyclables (e.g., cardboard, shoebox, water bottle)
- Scissors
- Straws
- String
- Tape
- Washers (or other small objects to act as weights)

## INSTRUCTIONS

1. Use invent.org and other websites and books to research the Higgins Boat and its unique design.
2. Gather drawing materials and sketch boat designs that will allow cargo to be unloaded and passengers to easily disembark. Might you try adding a ramp? How about a pulley system?
3. Build a prototype of the boat you designed. Use recyclables and other available craft supplies to do so.
4. Consider adding other elements to help your boat stay afloat (e.g., adding ballast), and accomplish other tasks like getting to shore safely (e.g., design a grappling hook).
5. Explore various materials for taking your boat features to the next level. Experiment with the buoyancy of different supplies to make a seaworthy vessel.
6. Test your boat and its elements in a container, bucket or wading pool. Play this video for extra immersion while testing!

# HARNESS THE SUPERPOWER OF EMPATHY

**Understand the value of empathy as you develop inventions that can help the people you love. You'll see how recognizing the specific needs of individuals can lead to universally helpful innovations.**

## WHAT ARE WE LEARNING?

Empathy is a key tenet of design thinking. Many National Inventors Hall of Fame® (NIHF) Inductees, as well as participants in NIHF's Collegiate Inventors Competition®, share stories of empathizing with specific needs of individuals in their life and designing solutions through their inventions. The more helpful and useful an invention is, the greater chance it will be successful and benefit people all over the world.

## MATERIALS NEEDED

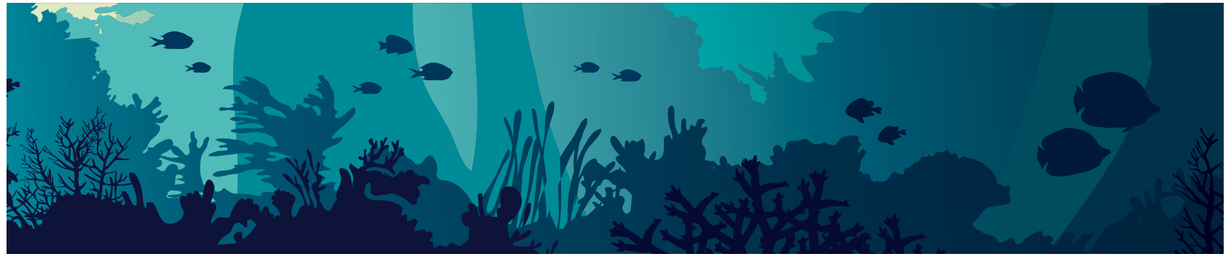
- Paper
- Pencil
- Recyclables
- Scissors
- Tape

## INSTRUCTIONS

1. Ask your child if they can think of an invention that helps people.
2. Explain that some inventions improve the health and wellness of others. Share a few examples (e.g., a pacemaker, X-ray machines, prosthetic limbs, special medicines, hearing aids, glucose testing strips, etc.).
3. Ask your child if there is a person (e.g., an infant, elderly person) who they wish they could help by making an invention to meet their needs.
4. Tell them that the feeling we have when we consider someone else's needs is called empathy. Empathy is like a superpower that allows us to put ourselves in someone else's shoes and take their needs into consideration.
5. Explain that many inventors use empathy to design inventions.
6. Once your child has a person in mind for whom they want to make an invention, have them sketch ideas for a solution to a challenge or need they have.
7. Next, have them use recyclables, craft materials or household items to build a prototype.
8. Encourage your child to continue using empathy and the power of invention to consider how they might be helpful change agents in the world.

# DIVE INTO DEEP SEA INVENTION

**Plunge into innovation as you use recyclables to make a model submarine — a vehicle designed to operate underwater. As you design, draw on concepts from Alvin, the first research submersible in the United States.**



## WHAT ARE WE LEARNING?

In this STEM activity, students are given the opportunity to practice their design-thinking skills and create solutions to problems a submarine might encounter while diving deep beneath the surface of the ocean. Because each submarine mission involves different objectives, children have the chance to customize their vessels in different ways depending on the goal at hand. This need to continuously learn, improve and change is essential to all STEM careers, and is a part of what makes the field so exciting!

## MATERIALS NEEDED

- Cardboard
- Markers
- Ruler or tape measure
- Tape
- Coin battery and LED lights (optional)
- Flashlight (optional)

## INSTRUCTIONS

1. Find a large cardboard box to turn into a model of a submarine or submersible.
2. Research the many different types of submarines and submersibles, and use your findings as inspiration for your own original design.
3. Design a model using a scale where 1 inch equals 1 foot. For example, since Alvin is approximately 23 feet long, create a model that is 23 inches long.
4. Discuss what types of special features a submarine or submersible might have. This can include features that already exist and ones you may invent.
5. Add an optional control panel with prototype circuitry, working lights (e.g., LEDs powered by coin batteries) or other fun features.
6. Design grabbers or other tools for the front of the submarine model that can collect samples from the ocean floor.

# HOP TO IT WITH FROG ORIGAMI

**Discover how folding a simple piece of paper in specific ways can transform it into something awesome! Once you have your paper frog, set up an obstacle course to practice your jumps and agility.**

## WHAT ARE WE LEARNING?

Origami is the art of folding paper, and while the end result can be a fun, interactive toy such as a jumping frog, this art has many more benefits. Making small, deliberate folds requires precision, which helps children develop their fine motor skills as well as their ability to focus. Origami also involves many mathematical principles, such as creating a 3D object from a flat piece of paper and exploring fractions and angles.

Leroy Grumman, a National Inventors Hall of Fame® (NIHF) Inductee, developed retractable landing gear and a foldable wing for naval aircraft. Both inventions utilize the math behind folding to advance the design and usability of aircraft. Another NIHF Inductee and engineer, Richard Hoe, developed the mechanisms to mass print and fold newspapers, which led to the modern-day printing press. While origami is a fun exercise, it can also serve as inspiration in the invention process and could be the catalyst for a world-changing invention idea!

## MATERIALS NEEDED

- Craft supplies (optional)
- Index cards
- Markers, crayons or colored pencils
- Paper
- Recyclables (optional)
- Ruler

## INSTRUCTIONS

1. Follow along with this interactive video to create an origami jumping frog using index cards. Click the “next” button at the bottom right of the video to move through each step.
2. Once you’ve created your frog, press down on the bottom edge to make it jump!
3. Make additional frogs and experiment with different sizes and types of paper.
4. Measure how far your different frogs jump. What is the farthest distance you were able to achieve?
5. For even more fun, consider creating an obstacle course with small objects for your frog to jump over, around and through.

Want to take this activity even further? You can challenge participants to use their origami frogs in a carnival-style game. Encourage them to think about racing games, games of skill where the frogs need to reach a target and more. Then, ask them to write out the rules of the game, determine the cost to play and even create unique prizes.

# INVENT SOMETHING FROM NOTHING

**Learn how the creative process often involves making something out of nothing as you dream up an amazing invention! Then, bring your idea to life by making a model with common household items.**

## WHAT ARE WE LEARNING?

Any product on store shelves started with an idea. Ideas can range from wild and impractical to realistic and useful. An example of this is National Inventors Hall of Fame® (NIHF) Inductee Steve Sasson's "Do Nothing" box. When he was a child, Sasson built a box with lights that flashed. He showed it to his father who asked what it did, and Sasson responded, "nothing." It became known as the "Do Nothing" box, but the process of turning the idea into a prototype and then sharing it was significant. Taking his ideas to the next level helped make Sasson a patented inventor best known for inventing the digital camera. To hear more about the "Do Nothing" box, check out this video. At NIHF, we believe people of all ages can be inventors. Explore our education programs available in school, at home, in college and beyond.

## MATERIALS NEEDED

- Clay or play dough
- Craft items (e.g., patterned paper, fabric scraps, stickers)
- Drawing materials (crayons, markers, pencils)
- Paper
- Recyclables (e.g., cardboard, plastic containers) or other unused objects around the house
- Tape and/or glue

## INSTRUCTIONS

1. Take turns filling in the blanks to complete the sentence: I wish I had a _____ that could _____.
   If you need help getting started, fill in the first blank with an object, such as a toy.
   Some examples:
   I wish I had a scooter that could _____.
   I wish I had a ball that could _____.
   I wish I had a watch that could _____.

2. Pick your favorite idea and imagine some of the details. Then, take it one step further and sketch how it might look.

3. Make a model in your mind or gather some handy materials from around your home (e.g., cardboard box, juice containers) — nothing fancy necessary. In fact, check out what these collegiate inventors used to make their prototype (model).

4. That's it! This is all it takes to invent something from nothing! Keep brainstorming and using common objects in new ways to turn nothing into something special. Need more inspiration? Check out this video from Mighty Minds winner Mya Sewell!

# CONSTRUCT THE STRONGEST TOWER

**Build a sturdy structure with marshmallows and toothpicks as you experiment with tension and compression in a fun way. Use design thinking to strategize and assemble your tower!**

## WHAT ARE WE LEARNING?

Any structure – from spiderwebs to bridges to tall buildings – must be strong in both tension and compression. Tension refers to the pulling or stretching of materials. As more and more materials are added to elongate a structure, these materials must stretch without breaking – much like a rubber band. Compression refers to the pushing force that occurs when weight is added to a structure. For example, if you sit on a marshmallow, it will compress. Materials used for building must have the ability to hold weight as they are added to the structure.

## MATERIALS NEEDED

- Medium washers
- Miniature marshmallows
- Paper plates
- Round toothpicks

## INSTRUCTIONS

### PREPARATION

**(AN ADULT SHOULD HANDLE EACH OF THE FOLLOWING STEPS)**

1. Prepare marshmallows ahead of time. Open the marshmallow bag, put marshmallows in an open container and allow them to sit uncovered for two days.
2. Create one or two structures to use as examples for those participating in the activity. Place a marshmallow at each end of a toothpick. Add a second toothpick by sticking it into one marshmallow. Add a marshmallow at the end of this toothpick. Continue adding toothpicks and marshmallows, experimenting with different shapes to create various structure components (squares, triangles and rectangles).

### INSTRUCTIONS

1. Provide containers of marshmallows and toothpicks for your child to use.
2. Give a set amount of time for your child to use the marshmallows and toothpicks to create different towers with various shapes and sizes.
3. Have your child test their structure. Place a paper plate at the very top of each one, then slowly add metal washers on the plate until the structure begins to buckle.
4. Keep a running count of the number of washers each structure can hold.
5. Point out the different shapes your child used in their structures. Ask them why they used the shapes they did and if they think one is stronger than another.
6. Explain that the triangle is the strongest building shape because it evenly distributes weight. It is used in the construction of bridges, roofs and buildings.

# PLAY WITH PARACHUTES

**Have fun with physics as you develop a water balloon-saving parachute! Think about air resistance and gravity as you design your chute and see if you can get your balloon to land without bursting.**


## MATERIALS NEEDED

- Plastic bag or disposable tablecloth
- Scissors
- String or yarn
- Tape
- Water balloons

## WHAT ARE WE LEARNING?

Trapeze artist turned inventor, Floyd Smith, designed the modern parachute. Previous parachute designs were attached by a static line directly to the plane. Smith's parachute, however, allowed the jumper to manually open the chute using a ripcord. Smith's parachute design both set the standard for decades to come and jump-started the entire parachute industry.

Air resistance pushes a parachute upward while gravity pushes a parachute downward. With greater air resistance, such as a strong wind, the parachute stays up longer. The heavier the object that is attached to the parachute, the stronger the downward pull of gravity. Using these physics principles, you can experiment with your parachute shape, materials and size, and the weight of the object attached to it.

## INSTRUCTIONS

1. Fill up those water balloons as much as possible. The bigger they are, the greater the challenge!
2. Tie off each balloon and then tie a piece of string to the knot of the balloon.
3. Build a parachute using a sturdy, lightweight material such as a plastic bag or a piece of a disposable tablecloth, or whatever else you can find around your home.
4. Attach your parachute to the water balloon using string and tape. Tip: Tie the string or yarn of your parachute to the knot at the end of the water balloon.
5. Find a high place where it is safe for you to stand, such as a slide, treehouse or balcony. Make sure no one walks under your experiment area, unless they would like to get splashed.

   *If you don't have a safe place to stand, simply hold your water balloon and parachute together, and throw them in the air as high as you can.
6. Launch your water balloon parachute and observe what happens.
   - Did the water balloon break?
   - Did the parachute stay attached?
   - Did the parachute open?
   - Were you successful on your first try?
   - How quickly did the water balloon fall?
7. Continue experimenting with different materials, shapes and sizes for your parachute, as well as different-sized water balloons.

# DESIGN A WILDLIFE PARK

**Be the designer of your own natural environment! Determine how to attract wildlife, provide what animals will need to thrive in your park and make the environment enjoyable for people too.**

## WHAT ARE WE LEARNING?

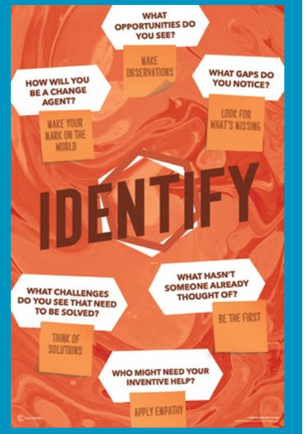
When engineers create a new design, they have to think through problems from various perspectives and identify the best solutions. They also need to employ empathy, or the ability to put yourself in someone else's shoes, as they are creating solutions. Children often feel strong empathy toward animals and nature. National Inventors Hall of Fame® Inductee Chieko Asakawa, inventor of the Home Page Reader (which gives people who are blind or visually impaired access to the internet), highlights the importance of empathy in designing products that best fit the end user. To learn more about Asakawa, we invite you to visit our website.

## MATERIALS NEEDED

- Aluminum foil
- Craft items (clay, construction paper, craft sticks)
- Markers or pencil
- Paper
- Recyclable materials (boxes, cardboard tubes, packaging materials)
- Small plastic or stuffed toy animals
- Toothpicks

## INSTRUCTIONS

1. Imagine that you need to design and build a park where wild animals can safely live and people can also enjoy the environment.
2. Make a list of the types of animals you hope to attract.
3. Begin by identifying potential challenges and thinking through what you can do to help.
4. Consider the following:
   - What types of habitats will suit the animals you hope to attract?
   - What types of pathways might be useful for people?
   - Might there be other features, like bridges or gates?
   - What inventions might be needed to ensure there is enough water or energy available?
5. Design a prototype (model) of your park and test your design using stuffed or plastic toy animals.
6. Ask for feedback and improve upon your design to make it even better!



# EXPLORE X-RAY TECHNOLOGY

**Uncover the skeletal structures inside living creatures by examining X-ray technology! Learn how bones function together to provide shape and support for the body while protecting organs and tissues.**

## WHAT ARE WE LEARNING?

This activity can kick-start a discussion about bones and X-ray technology. X-rays are an important way to see the structure of skeletons inside living creatures. Learning about structure helps us understand how bones function together to protect soft tissues and why different creatures move in different ways (walking on two legs or four legs, hopping, etc.).

Take this opportunity to introduce children to National Inventors Hall of Fame® Inductee William Coolidge, who invented the X-ray tube in 1913. This invention, which was then popularly called the "Coolidge tube," completely revolutionized X-rays and remains to this day the model upon which all X-ray tubes for medical applications are patterned. Today, X-rays are used in medical diagnosis for fractures, in radiation to fight cancer, in airport security and even to reveal counterfeit art. What new ideas might your STEM activity participants have for the use of X-ray technology?

## MATERIALS NEEDED

- Animal and X-ray printouts
- Pretzel sticks and/or pretzel loops

## INSTRUCTIONS

### ACTIVITY ONE

1. Go online and locate various images of animals (tiger, lion, snake, etc.) and their corresponding skeletons.
2. Print out these images and have your participants match the animal images with the correct skeleton images.
3. Ask the children what helped them match the animals to their skeletons.
4. Have everyone work together to create a list of the similarities and differences between the various skeleton images.
5. Facilitate a discussion where children think about the bones in their own bodies. Have them sketch out what they think a human skeleton looks like.

### ACTIVITY TWO

1. Gather the X-ray images used in the first activity.
2. Cut out various body parts from these printouts (legs, ribs, skull) to create a jigsaw puzzle.
3. Mix two or three different animal X-rays together to create new hybrid animals.

### ACTIVITY THREE

1. Extend the fun by building a skeleton of your own out of pretzel shapes.
2. Have your participants create new skeletons from their imaginations.
3. Pretzel sticks are great for making long bones. Use other pretzel shapes to form hips, skulls or shoulders.
4. Ask your participants to explain how their animal would move, and how the skeletal structure they've created enables this.

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