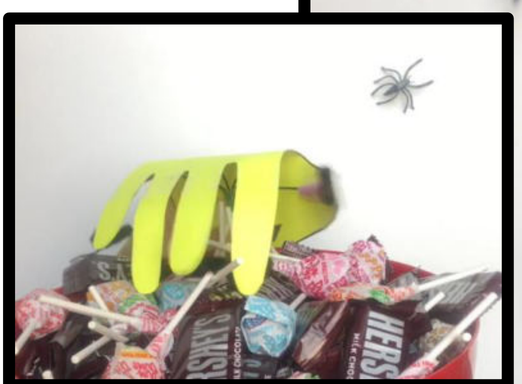
Robot Hand
Candy Grabber
Challenge



Using the Engineering Design Process

VIVIFYSTEM.COM vivify STEM EDUCATION

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THANK YOU!

Thank you for downloading a Vivify product! If you have any questions, please email us at info@vivifystem.com.

ABOUT VIVIFY

Vivify is a team comprised of two Aerospace Engineer friends, Natasha and Claire, who live in Texas. We met as college classmates and roommates at Texas A&M University and later left engineering careers in the Department of Defense and Air Tractor to pursue our passion for STEM education. Learn more of our story here.

Our goal is to bring engineering to life—to vivify learning—for kids of all ages. Please connect with us so we can learn how to better serve your students!

- Natasha & Claire, The Vivify Team

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Subscribe to our newsletter and receive access to a library of free STEM resources through www.vivifystem.com. Follow us on social media or listen to "The STEM Space" podcast for more resources and ideas. We also welcome you to join "The STEM Space" Facebook group to connect with other educators across the world.

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NEXT GENERATION SCIENCE STANDARDS

The Robot Hand Design Challenge follows the NGSS Engineering Design Standards for Elementary and Middle School.

3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2.	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3-5-ETS1-3.	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2.	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3.	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4.	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
4-ESS3-1.	Obtain and combine information from books and other reliable media to describe that energy and fuels are derived from natural resources and their uses affect the environment.

COMMON CORE STANDARDS

Understand ratio concepts and use ratio reasoning to solve problems.
CCSS.MATH.CONTENT.6.RPA.1-3

ABOUT THIS ACTIVITY

The following STEM activity is a great way to incorporate the engineering design process into your classroom or afterschool program! This hands-on activity is an engaging design challenge where students create their own movable hands out of straws, string, and paper.

Robot Hand Challenge

Using materials provided, students create a movable hand to mimic a real-life hand. Students test their hand by picking up various objects. Make it Halloween themed by picking up candy!

Prior to ACTIVITY

1. **READ** over the "Note to Teachers" overview on the following pages and the activity handouts to become familiar with the design challenge. Determine what will work best for your students, space, and time constraints.

2. **COLLECT MATERIALS** listed below.

3. **PREPARE TESTING STATION** Refer to pictures on following pages for further detail.

Show students this **instructional video** on building the robot hand:
https://www.vivifystem.com/blog/2020/4/superheroarm

Student Materials

- ❑ 1 sheet cardstock
- ❑ Scissors
- ❑ Clear tape
- ❑ 3 Plastic straws
- ❑ 1 Pipecleaner (+ one more to help during construction)
- ❑ 5, 12 inch pieces of string or twine

Testing Materials

- ❑ Various objects to pick-up such as crumpled paper or small baseball-sized balls
- ❑ Basket or bowl for dropping objects
- ❑ Halloween candy!

Note to Teachers

TEACHER INSTRUCTIONS

1. **Engage:** Show one of the real-world videos on Taking It Further.

2. **Introduce engineering design process** using the handout provided. Explain to students that real-world engineers use this process to create designs such as rockets, airplanes, skyscrapers, and computers. More great resources: http://pbskids.org/designsquad/parentseducators/workshop/process.html and http://thekidshouldseethis.com/post/whats-an-engineer-the-engineering-process-crash-course-kids

3. **Explain the science:** Pass out handout on "Basics of a Hand" and discuss as a class. What are the basics parts of a hand? What happens if someone loses a hand? You may wish to visit the website http://enablingthefuture.org/ to learn about 3D printed prosthetic hands.

4. **Robot Hand Activity:** Pass out the *Robot Hand Activity* handouts. This activity is completed best individually. This activity can be completed in two ways:

    - **Step-by-step:** You can guide students to complete the challenge as a class. This includes using the provided template to create the hand.

    - **Engineering Design Challenge:** You can allow students to independently complete this activity as a design challenge. Students can use the blank template, but they are not provided guidance on where to place straws, how to keep string in place, etc. For this option, show a video or photo example as a starting point.

5. **Hand Testing:** For testing, place various objects at the testing area. Students will determine success if their hand is able to grab an object and place into a bowl or basket. Objects for testing should be about baseball sized and lightweight. Examples include: crumpled paper, light plastic ball, or crumpled tissue paper.

Teacher instructions continued

6. **Design Process:** If completing as a design challenge, teachers are provided with two versions of the engineering design process student sheets: (1) Compact and (2) Expanded. Both versions take students through all phases of the design process. The expanded version has additional space for identifying the key concepts and more room for brainstorming and planning.

   - **Understand:** Make sure student teams understand challenge by completing the "Identify" section.
   - **Brainstorm:** For "Brainstorming", students will need to review the materials. You can either have then come to the materials station and look or you can pass out materials. Passing out materials allows them to see and touch the different items, but they may get distracted and start building.
   - **Design:** Students will then move to the "Design" phase. The brainstorming phase allowed them to get to know the materials, and now they will put it all together into a design.
   - **Build & Test:** For this challenge, building and testing happens together. Students will now need access to all materials and to the testing area. They are allowed to make changes to their design as they build. Ensure everyone is actively participating in the building and testing. Refer to previous section on testing guidelines. After every trial, teams should reflect on how to improve the design and record in the mission sheet.

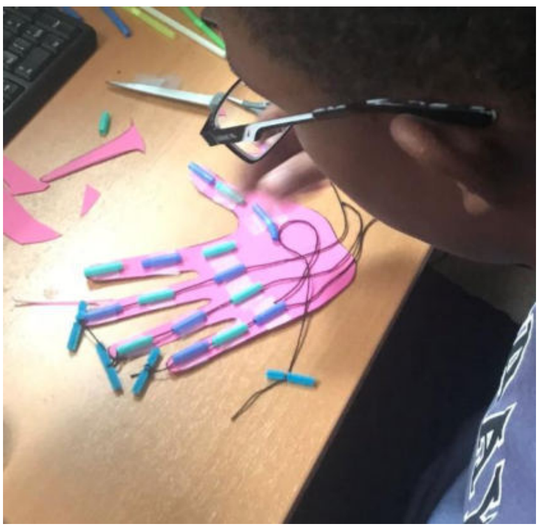
7. **Reflection:** Ask students to reflect on their experience and draw their final design.

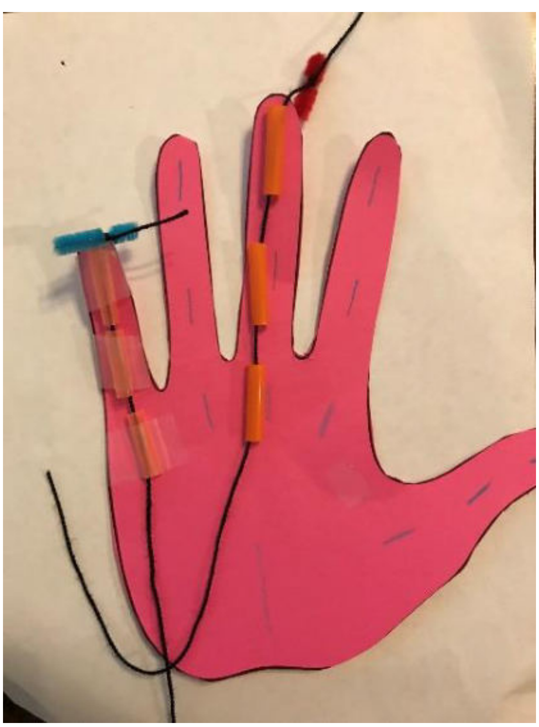
8. **Taking It Further:** Additional handouts are provided for a math extension.

Note to Teachers

Helpful Hints

- You may wish to pre-cut the string and pipecleaners.
- Allowing students to trace their hands is fun, but small hands are harder to create.
- Cutting the straws will take a while because they tend to fly away!
- If items are pre-cut, allow for 20 minutes to complete activity. If students are designing on their own, allow for 1 – 1.5 hours depending on student ability.





RESOURCES

Robot Hand in Action: https://www.instagram.com/p/BnhRoF9nXe-/?taken-by=vivifystem

Math Connections:

- Calculate ratio of straw to finger length

Video Resources including real-world examples

- Sci-Show Real-Life Robots: https://www.youtube.com/watch?v=8wHJjLMnikU
- Robonaut NASA: https://www.youtube.com/watch?v=JLU0c0mmvxg
- Robots Inspired by Animals: https://www.youtube.com/watch?v=tPAqrA9tkJU&t=6s
- 3D Printed Hands: https://www.youtube.com/watch?v=Cl8ijPGEKO8

TEACHER INSTRUCTIONS - RUBRIC

The following rubrics are recommended for use with our Engineering Design Challenges. This analytic assessment rubric can be used to assess each student or team in addition to grading their math extension questions. The editable rubric files are also provided to be customized for your specific needs.

During the engineering design process, use the rubric to assess the individual and/or team progress as you initial the bottom of each packet page. Grading can be provided as a whole team or individual score.

STEM Activity Rubric

Activity: ______________________________ Grade: _______/ 15

Student/Team: ____

	POINTS	3 EXCEPTIONAL	2 ACCEPTABLE	1 MARGINAL	0 UNACCEPTABLE
Identify the Problem		Complete understanding of design problem and constraints. Clear understanding of key scientific principals.	Overall sound understanding of design problem and constraints. Clear understanding of key scientific topics.	Limited understanding of design problem and constraints. Some understanding of key scientific topics.	Little or no grasp of problem and constraints. Lack of understanding of key scientific topics.
Brainstorming & Design		Final design achieved after review of multiple ideas for use of materials. Design meets all design constraints.	Alternate approaches identified to some degree. Design meets all design constraints.	Serious deficiencies in exploring use of materials. Design does not consider all design constraints.	Lack of understanding on how materials will affect design and selection is infeasible.
Test & Evaluation		Detailed design notes. Design meets or exceeds desired objectives through systematic testing.	Clear notes for design modifications. Design meets desired objectives.	Limited notes for design modifications. Design barely capable of meeting objective.	Unclear or no notes for design modifications. Design not capable of achieving objective.
Reflection Questions & Team Presentation		Clear understanding of the challenge and in-depth analysis of engineering process and teamwork.	Clear understanding of the challenge and clear analysis of engineering process and teamwork.	Limited understanding of the challenge and clear analysis of engineering process and teamwork.	Incorrect understanding of the challenge and incorrect analysis of engineering process and teamwork.
Teamwork		Active collaboration, effective communication, and impressive effort.	Some collaboration, mostly effective communication, and average effort.	Limited collaboration, some negative communication, and limited effort.	Lack of collaboration, negative communication, and limited effort.

Engineering Design Process

1. Identify the Problem

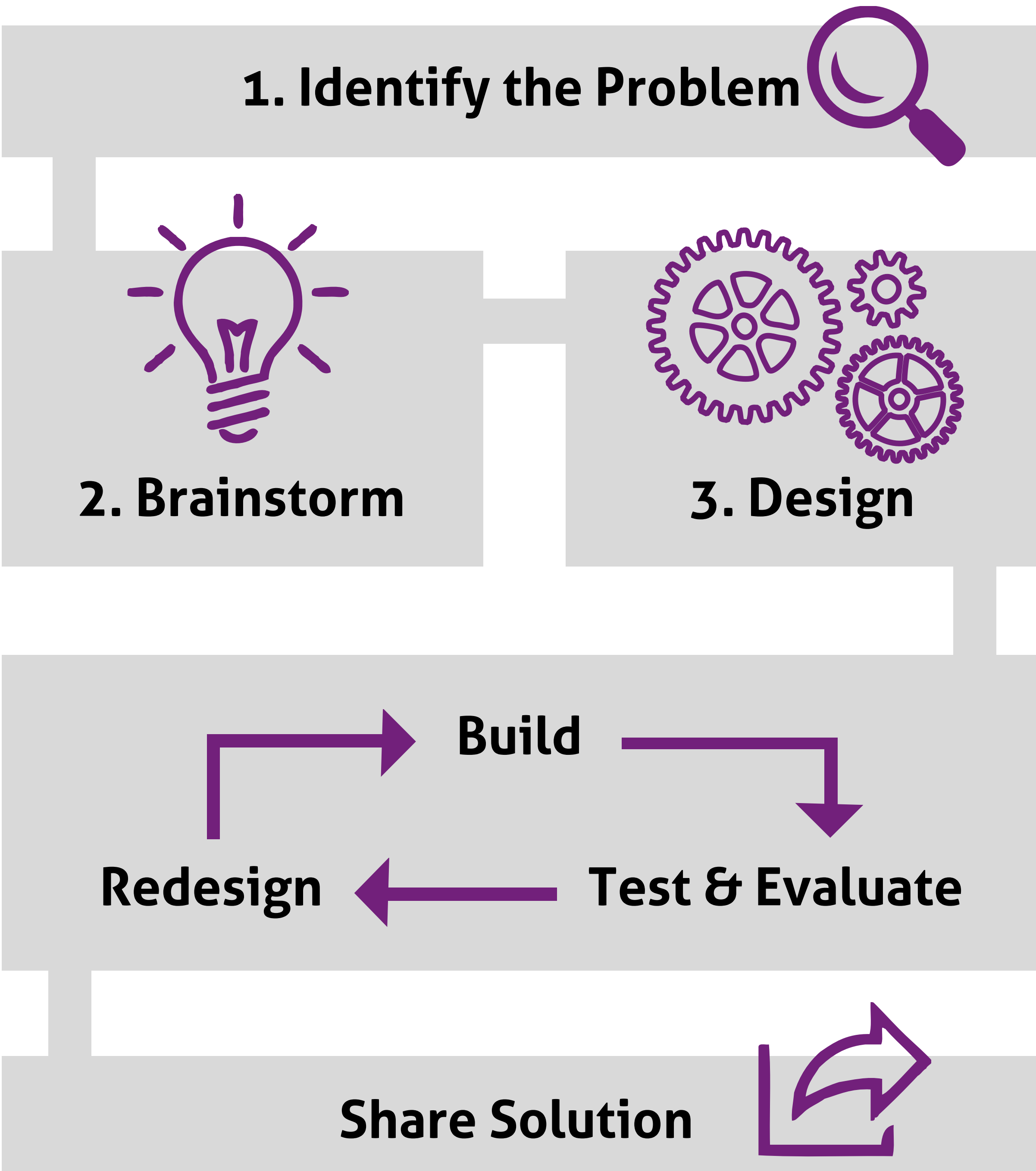
2. Brainstorm

3. Design

4. Build → Test & Evaluate → Redesign → Build

5. Share Solution

Engineering Design Process



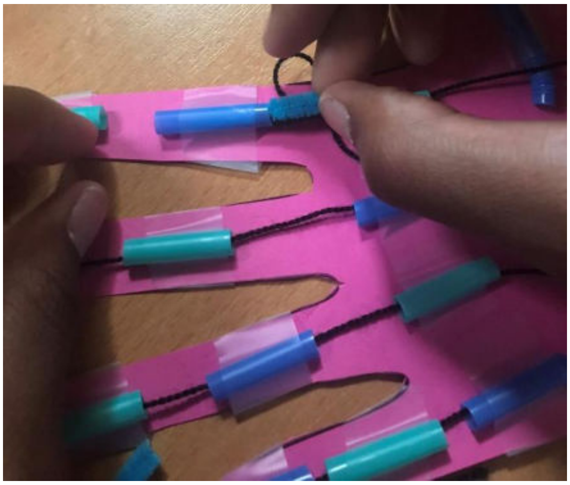
Robot
Hand Challenge

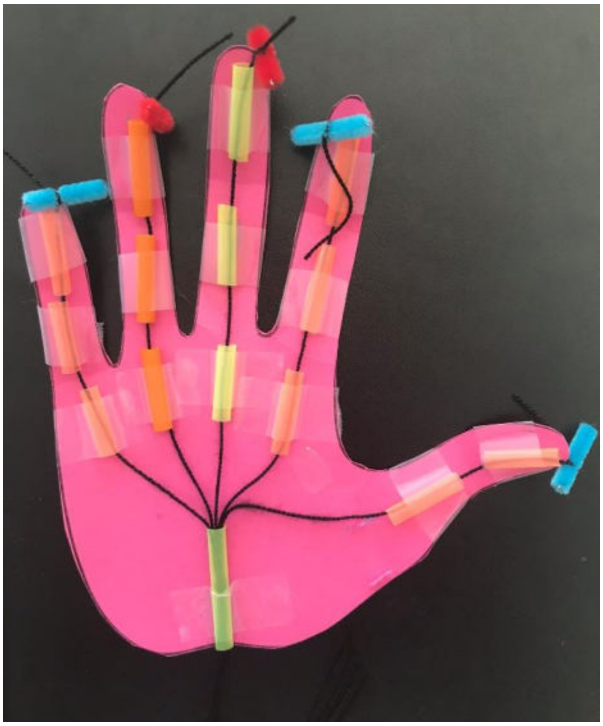
Students design and build a movable hand to pick-up objects

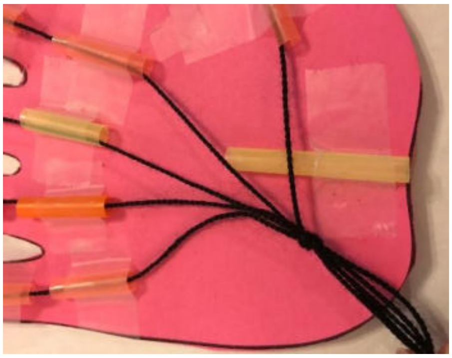
Building a Robot Hand

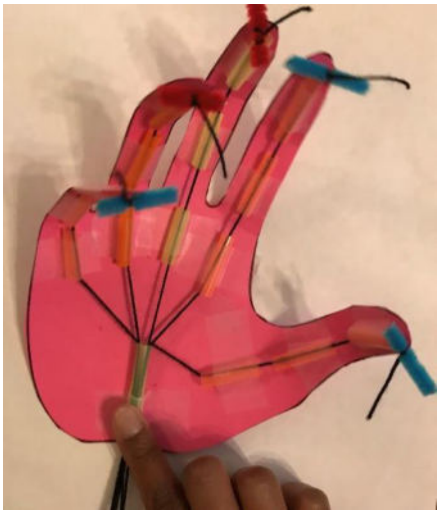
1. Cut five, 12 inch long pieces of string or twine.
2. Cut out an outline of a hand from cardstock. Use template provided or trace hand. A larger hand will be easier.
3. Cut pipe cleaner into 5 pieces.
4. Tie string to each pipe cleaner piece.
5. Cut straw into 1 inch pieces. Make sure it doesn't fly away when cutting! You will need 3 pieces per finger and 2 pieces for the thumb.
6. Cut a 2 inch piece of straw. This will be used at the bottom of the hand.
7. Tape the pieces of straw onto the hand.
8. Thread the string through the straws using the pipecleaner end to help push through each straw.
9. Knot together the 5 pieces of threaded string. Push through the bottom straw, using a pipecleaner for help.
10. Test out your hand!
11. Fingers not curling properly? Try adjusting the location, length, and spacing of the straws.

Building a Robot Hand

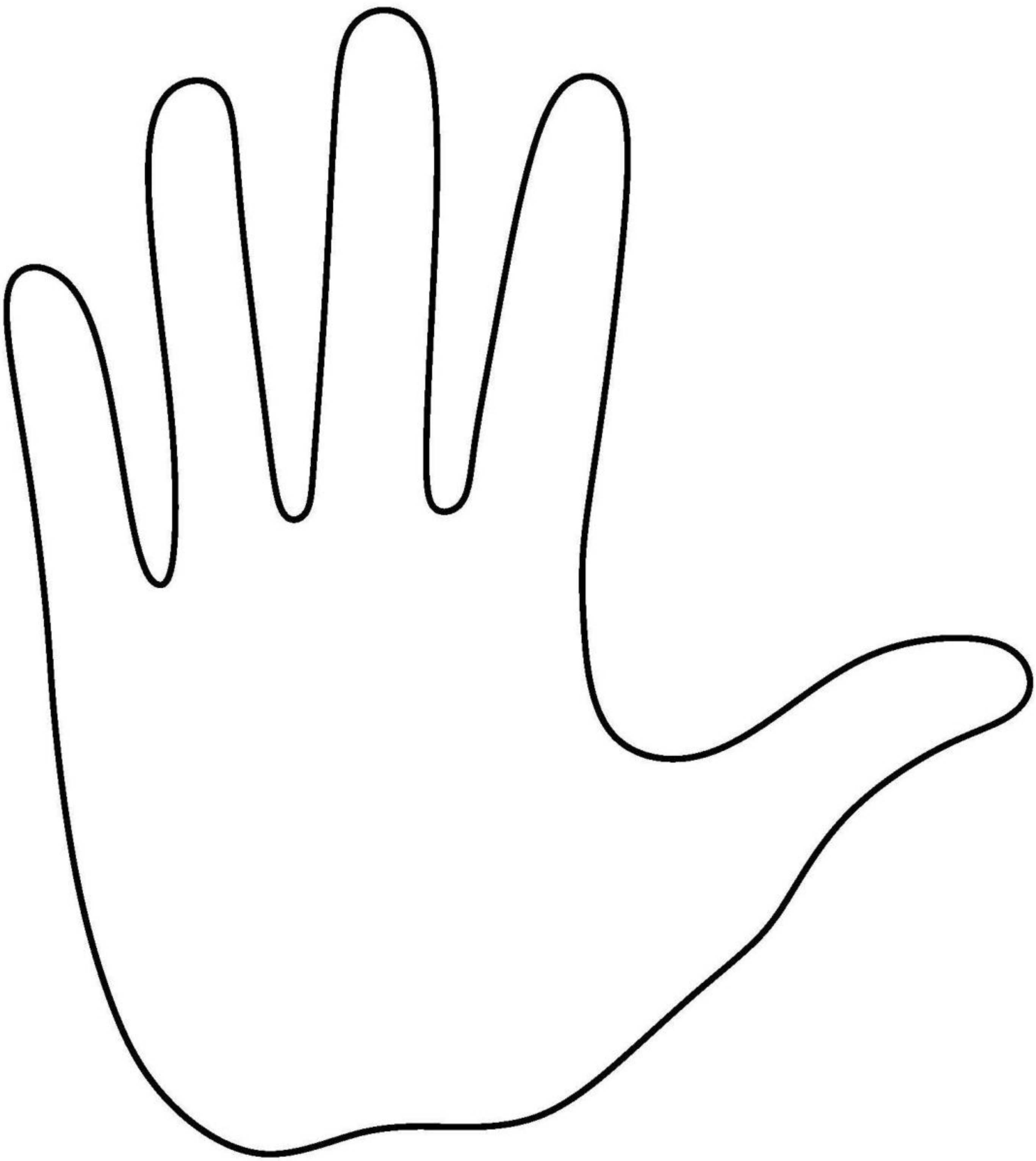




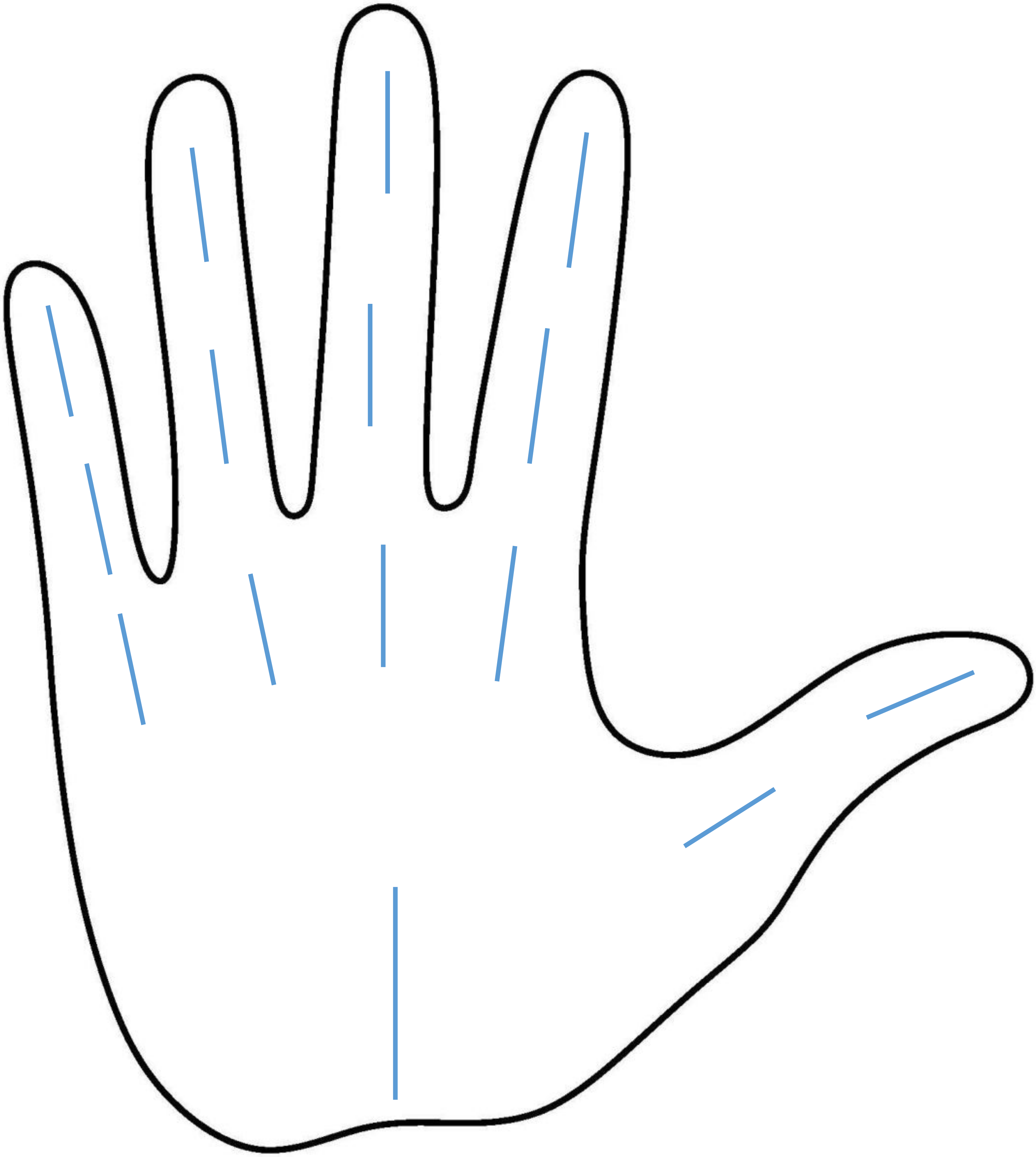




Use the template below to create your robot hand or trace your own hand!



Use the template below to create your robot hand or trace your own hand! The blue lines are where straws should be taped down.



Robot Hand Challenge

Design and build a movable hand to pick-up objects.

Design Constraints

1. Use only materials provided
2. Use template hand or trace your own hand on cardstock
3. Each finger must have 3 “bones” (straw pieces)
4. Thumb must have 2 “bones”
5. Straw “bones” are no longer than 1 inch
6. Each finger must curl inward when string is pulled

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Student Name

Basics of a Hand

Engineers can now 3D print a hand!

All ABOUT BONES

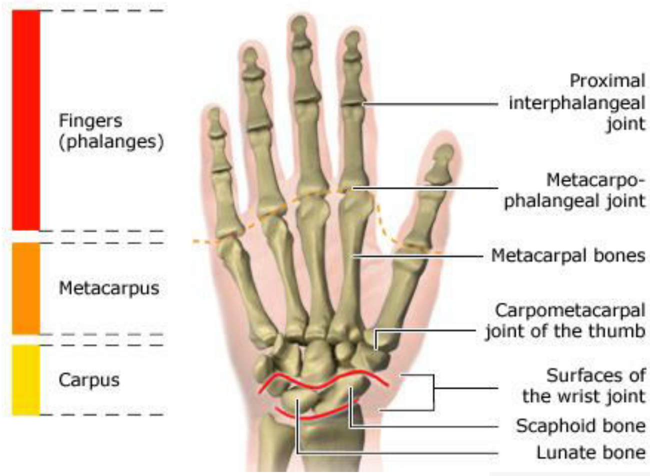
Bones are what give your body structure, let you move, and protect your internal organs. Do you know how many bones you have? An adult has 206 bones!

As a baby, everything is tiny, and your body had about 300 bones at birth. Some of these bones are made of cartilage, a soft and flexible material. That's why babies are so flexible! As you grow up, the cartilage grows and is replaced by hard bone, with the help of calcium. Bones also start to fuse or grow together, and this process continues until you are 25 years old and end up with 206 bones. That's why kids need to drink a lot of milk to keep their bones growing healthy and strong.

YOUR HANDS

Whenever you throw a ball, write a letter, eat a bowl of cereal, or clean-up your room, you are using the bones in your hand.

Your wrist has 8 bones that make up the carpus region. The center of your hand is made of five separate bones, which are part of the metacarpus region. Each finger on your hand has three bones, except for your thumb, which has two. The bones of your four finger are attached with joints that can only curl inward. The thumb can rotate because of a joint called the carpometacarpal joint. Can you feel these bones in your hand?

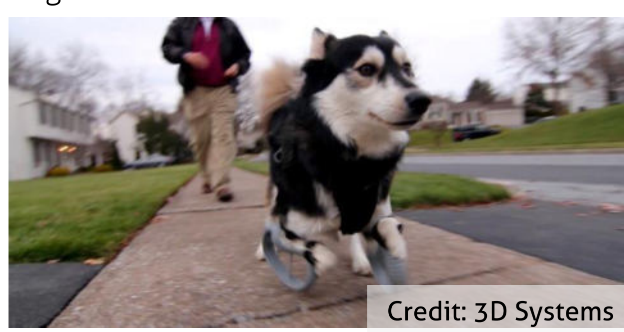


Credit: NCBI

3D Printed Hand

A biomedical engineer applies their knowledge of the human body to create devices to make us healthier. There are many exciting new technologies in the field of bioengineering! One is bioprinting, where scientists may soon be able to print artificial organs to replace sick ones such as a heart or ear.

Another exciting technology is 3D printed prosthetics or artificial body parts. With the affordability of 3D printers, people around the world are able to print custom prosthetics such as hands or feet for people. You can even print a prosthetic leg for a dog!



Credit: 3D Systems

Robot Hand Challenge: *Student Sheets*

Compact Version

Identify the problem

What is the goal of the challenge?

How many bones does each finger have?

Brainstorm

Review the materials. Think about how you will use these materials to make a movable hand. How will you make the fingers curl?

Design

How will you solve the challenge? Sketch a design for your movable robot hand.

Build

Time to build your solution! Keep in mind that materials may not work as you predicted. Engineers often have to make several modifications to their original design before they are successful. List any challenges you experience during the building phase.

Test & Evaluate

Test your design and record results below. Circle if the challenge was a success. Remember that failure is an important part of the engineering process! After each trial, review the results and make changes to improve your design.

Trial	Test Results	Ideas for Improvement
1		
2		
3		
4		
Final Testing Results:		

Robot Hand Challenge: *Student Sheets*

Expanded Version

Identify the Problem

Mission
In your own words, describe the overall mission of this challenge.

Constraints
What are the constraints for your design? I.e. What are the rules for this challenge?

Key Topics
Answer the following in your own words.

1. How many bones are in each finger?

2. How does a hand pick-up objects?

Teacher Check! Show this page to your teacher for approval before moving to the next part of the engineering design process. *Teacher Initials*: _______

Brainstorm

Carefully review the materials provided. How will you use these materials to build your movable robot hand? Remember you need to build a hand that can pick-up an object.

Variable	Curl Fingers to Pick-up Object
Straws	*Straws act as the bones of a finger that keep the string in place when pulling it.*
String	
Tape	
Pipecleaners	
Cardstock	

Teacher Check! Show this page to your teacher for approval before moving to the next part of the engineering design process. *Teacher Initials*: _______

Design

Review your brainstorming and determine a possible starting design for your straw rocket. Think about how each variable may affect the outcome. Sketch your design and label all parts. Think about how you will keep the string in place to curl the fingers.

Teacher Check! Show this page to your teacher for approval before moving to the next part of the engineering design process. *Teacher Initials*: _______

Build

Time to build your solution! Keep in mind that materials may not work as you predicted. Engineers often have to make several modifications to their original design before they are successful. List any challenges you experience during the building phase.

Test & Evaluate

Test your design and record results below. Where you able to pick-up an object? Remember that failure is an important part of the engineering process! After each trial, review the results and make changes to improve your design.

Trial	Test Results	Ideas for Improvement
1		
2		
3		
4		
Final Testing Results:		

Robot Hand Challenge: *Student Sheets*

Reflection Pages & Taking It Further

Reflection

Sketch your final design solution and label.

1. Compare your final design to your initial ideas. What changes did you make? Why?

2. How would you improve your design if given another opportunity?

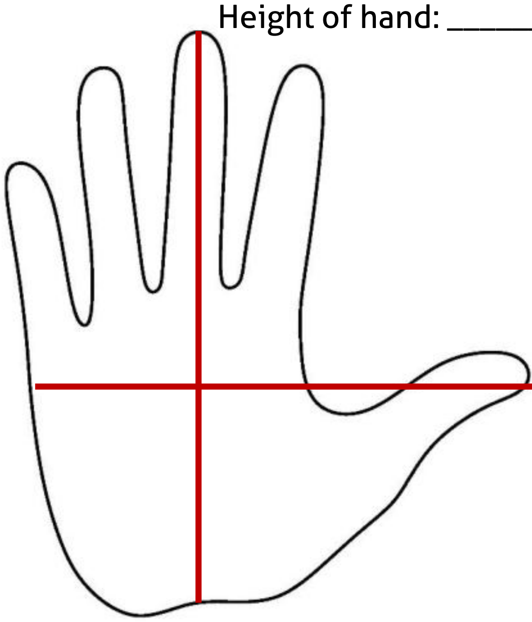
3. What was the greatest challenge you faced in robot hand challenge?

4. Why do you think failure is important in engineering design?

Taking it Further

1. Let's take some measurements of your robot hand. Use a ruler to complete the following dimensions:

Height of hand: _______________



Width of hand: _______________

2. What is the length of the index finger?

3. What is the length of one of the straw pieces used in the index finger?

4. What percentage is the straw piece compared to the overall length of the index finger?

5. What percentage is the straw piece compared to the overall height of the whole hand?

WANT MORE STEM?

For a complete list of all of Vivify STEM resources broken down by standards, topics, and grade levels, go here: http://bit.ly/VivifyResourceGuide

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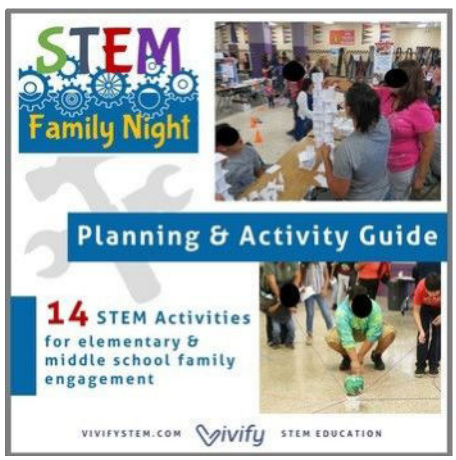

bit.ly/STEMfamilynight

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Vivify's Overview of STEM Education

Successful STEM education is an empowering interdisciplinary approach that brings math and science concepts to life through problems that mimic the complexities and excitement of the real world. STEM revolves around the Engineering Design Process that embraces failure, relies on teamwork, and requires critical thinking and creativity. While exciting, educators often become intimidated as a search for curriculum leads to an overwhelming range of activities from index towers to robotics competitions. At Vivify, we believe that not all STEM is created equal. Educators should adopt a 3 Stages of STEM approach by progressively building towards more complex projects.

To learn more about the 3 Stages of STEM, go here: http://bit.ly/stemstages