# GIVE HERCULES A HELPING CLAW | EDUCATOR

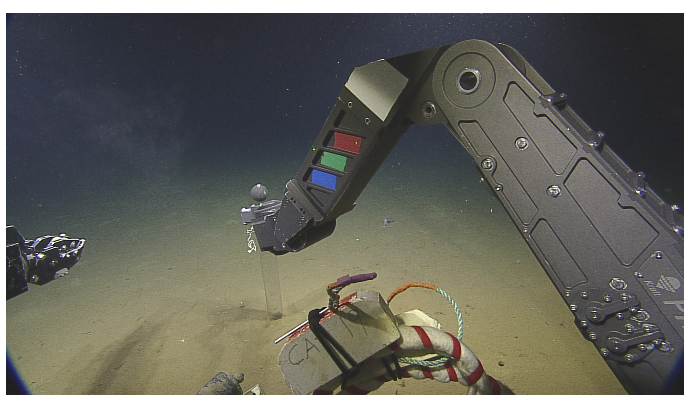
**Links to Next Generations Science Standards |**
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions 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.

**Links to Common Core Standards |**
CCSS.ELA-LITERACY.WHST.6-8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

S T E M

**Contributing Author |** Cassi Weathersbee, Science Communication Fellow
**Pacing |** 1-2 class periods
**Background Needed |** Basic tools, safety and properties of motion
**Assessment |** Rubric provided
**Materials/Resources |**

- Objects to pick up with student device (i.e tennis balls, cotton balls, paper cups, wood blocks, beanbags)
- Here are some of the materials students can use to build their ROV's hand:
    - brass fasteners
    - binder clips (different sizes)
    - paperclips
    - clothespins
    - corrugated cardboard
    - hole punch
    - 2–6 paint stirrers
    - cups (plastic or paper, different sizes optional)
    - rubber bands
    - hangers
    - ruler
    - sandpaper
    - scissors
    - string
    - tape (duct or masking)
    - wooden skewers or dowels
    - fishing line
    - pencils
    - other common household or classroom supplies, such as pipe cleaners, craft sticks, twine, etc.





### Extensions & Adaptations

**Introductory |**

Students work in groups to build and use this hydraulic demonstration robotic arm kit: http://www.pathfindersdesignandtechnology.com/portfolio-item/robotic-arm/

Ask students to think about ways they can modify the grippers for picking up various objects.

**Advanced |**

Students conduct research projects to examine the latest engineering and technology involved with developing ROV arms. Here are some helpful links: http://www.nautiluslive.org/people/brennan-phillips

https://www.nbcnews.com/storyline/the-big-questions/robots-take-our-jobs-they-need-get-grip-n741336

https://news.nationalgeographic.com/2016/01/160120-squishy-fingers-robotic-hands-corals-rovs/

## Overview

Exploration Vessel (E/V) *Nautilus* and the Corps of Exploration use two Remotely Operated Vehicles (ROVs) to explore the world's ocean. One of the ROVs, *Hercules*, is equipped with two manipulator arms designed to collect samples and recover artifacts. These arms have claws that grab tools to take samples and place recovered samples into sample drawers or onto elevators dropped to the seafloor from the ship above. The ability of claws to grab and release objects in a highly controlled way is criteria to the success of E/V *Nautilus's* mission of ocean exploration and scientific study. In this challenge, students will build an arm with grasping claws their crew (their group) can use to pick up and release a variety of different objects. The arm must be able to extend out at least 2 feet (0.6 meters). Within an expedition dives with different goals require ROV *Hercules* to be able to pick, use, and release many tools. This multifunctional ability is essential to collect the samples scientists need study the ocean and its unique geology, chemistry, and biology. Once students have built a working arm and claw they will use the design process to see how many objects of different shapes and weights their arm and claw can lift and release.

## Objectives & Learning Outcomes

- Students will learn about and discuss the importance of using ROVs in ocean exploration.
- Students will utilize the engineering design process to build an arm with a claw capable of grasping and releasing different objects.

## Guiding Questions

- 1. Why are ROVs important when studying deep ocean environments?
    - ✓ *ROVs allow teams to explore the extreme depths safely and effectively by being equipped with lights, cameras, instrumentation and sampling tools to enable scientists to collect visual, chemical, and physical data from these environments. ROVs are connected back to a support ship above meaning they don't rely on batteries or have mandatory surfacing times.*
- 2. How can these ROVs be used to collect physical samples, rather than just take video images?
    - ✓ *ROVs can be equipped with uniquely designed arms and apparatus to grab, clip, slurp (vacuum) and scoop up samples. Samples can be placed in a variety of holding containers on the ROV by the manipulator arm or into canisters by the slurp sampler system.*



## Activity/Tasks

Students will:

- read the introduction and complete guiding questions,
- build a prototype arm,
- test, evaluate, and redesign their model,
- complete the wrap-up questions.

## Student Procedure

1. Choose your materials and build the arms.

✓ *Tips: Connect paint stirrers with brass fasteners. Make a hole in the stirrer or cardboard by turning and twisting a blade of a scissors in one spot until it goes through to the other side. This can be tricky, so use caution as you make holes.*

✓ *If the arms are too long, they might bend and not open and close easily. Short arms don't bend as easily as long ones.*

2. Decide how you will connect the two arms. Think about how you will make the arms press together. Choose the materials and connect the arms.

3. Open and close the arms to be sure they move smoothly. Redesign your arms if they don't open and close easily.

✓ *Tips: If the arms have a weak grip, try increasing their force, or pressure, by adjusting the fulcrum's position and the arm length.*

✓ *If the arms bend or twist, reinforce them with something stiff.*

4. Decide how your jaws will grip an object and hold on to it. Think about how your jaws will be attached to the end of the arms. Choose the materials and build the jaws.

✓ *Tips: If your jaws don't hold an object, try changing the shape of the jaws so they have a firm grip when they grab hold of an object.*

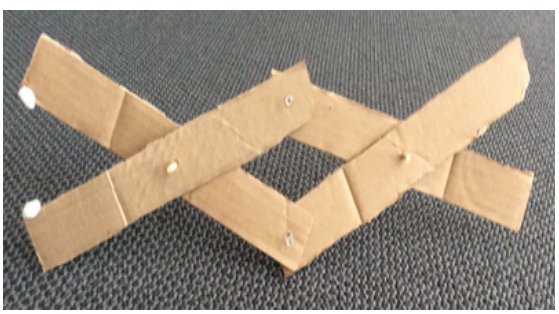
✓ *If the gripping surface of the jaws can't hold on to things, try adding materials that would increase the friction or allow the jaws to bite into an object.*

5. Place an object about 2 feet (0.6 m) away from you. Grab it with your grabber. Lift the object, lower it, and then release it.

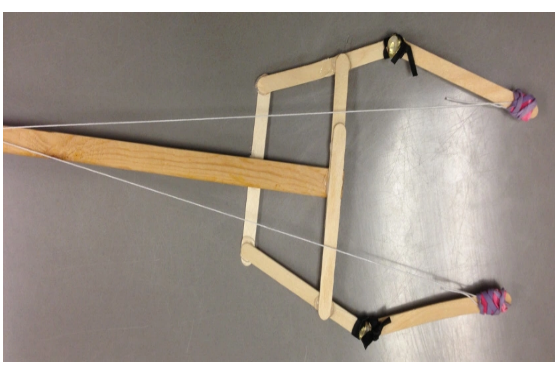
✓ *Tip: If your jaws don't open, check that nothing is blocking their movement. Or check that the two parts can slide easily past each other.*

Possible solutions:

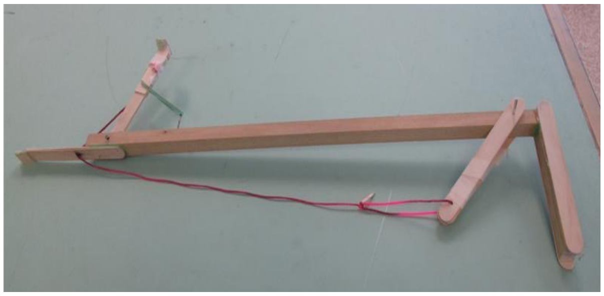
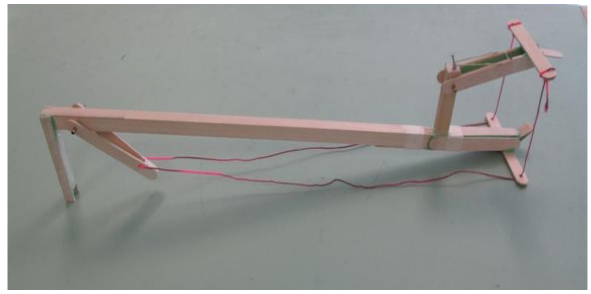
Figures (Clockwise from upper left): A possible solution using paint stir sticks and brass fasteners as fulcrums. A solution with half-cups as jaws for scooping a sample. Another variation on scoop sampler with sample bucket attached to grabbing jaws.



Another possible solution: This design uses cardboard levers, pin fulcrums, and sticky putty placed at the end of the jaw to stick to the sample a student is trying to pick up.



This solution uses craft sticks, string pulleys to close the jaw, and rubber bands at the fingertips to increase the friction of the jaws on a sample.

Possible solution using a design based on an EZ Reacher and Grabber.

✓ *Teaching tip: Discuss the design changes students employ throughout the building and testing period. Make sure to talk about different approaches each group took to complete the challenge. Everyone working on the E/V Nautilus needs to be able to solve problems together and individually while at sea. Discuss why teamwork, clear communication, and the ability to use the design process would be important skills to have on E/V Nautilus.*

Scientist Spotlight Question:

1. Why do you think Dr. Tamara wanted her sampler to be able to be fitted on more vehicles than just ROV *Hercules*?
    - ✓ She wanted the sampler to be able to be used on more just the ROV Hercules so that sampler could be able to used on ROVs aboard other research ships. Most ROVs have two rotating arms.

## Additional References:

http://pbskids.org/designsquad/build/helping-hand/
http://tryengineering.org/sites/default/files/lessons/robotarm_0.pdf
https://teachingphysics.wordpress.com/2013/03/17/helping-hand-challenge/
https://www.bcit.cc/Page/5202

# GIVE HERCULES A HELPING CLAW | STUDENT

### *Learning Goals*

- Learn about and discuss the importance of using ROVs in ocean exploration.
- Utilize the engineering design process to build an arm with a claw capable of grasping and releasing different objects.

### *THINK About It!*

- *Why do you think ROVs are important when studying deep ocean environments?*

**Introduction |** E/V *Nautilus* and the Corps of Exploration use two ROVs to explore the world's ocean. One of the ROVs, *Hercules* is equipped with two manipulator arms designed to collect samples and recover artifacts. The arms have claws or "hands" to handle tools, grab samples, and place recovered items into sample drawers or onto elevators dropped to the seafloor from the ship above. The claws' ability to grab and release objects in a highly controlled way is critical to the success of E/V *Nautilus's* mission to explore parts of the ocean never seen before.

While on expedition, ROV dives with different goals require *Hercules* to be able to pick, use, and release many tools. This multifunctional ability is essential to collect the variety of samples scientists need study the ocean and its unique geology, chemistry, and biology.

In this challenge you will build an arm with grasping claws your crew (your group) can use to pick up and release a variety of different objects. Your arm must be able to reach out at least 2 feet (0.6 meters).

ROV Pilot Mike Hannaford checks the right manipulator arm on *Hercules* before a dive.

SCIENTIST SPOTLIGHT

**Dr.Tamara Baumberger**
**Assistant Professor, NOAA/PMEL and Oregon State University**

Tamara led the team as Chief Scientist and studied the gas composition of cold seeps on the 2018 Cascadia Margin expedition. During this cruise the ROVs spent time capturing bubbles that rise from methane seeps on the seafloor. "Knowing the composition of the sampled gases helps us to understand a lot about its source and the interactions it had during rising and circulation," she explained to *Nautilus* staff. Tamara used a specially designed sampler to help her collect methane hydrates on the expedition. Methane hydrates expand from a solid state ice into a gas state as they are brought up from depth. Tamara's sampler drilled an ice core out of solid exposed hydrate. The sample was then dropped into a canister and sealed off. The canister was manufactured to withstand the immense pressure methane exerted on it as the sample expanded when brought to the surface.

## Vocabulary |

- The **fulcrum** is the point around which a lever turns, or pivots.
- A **lever** is a strong bar that is used to lift and move something heavy.
- **ROV** (Remotely Operated Vehicle) is a tethered underwater mobile vehicle.

## Guiding Questions |

1. Why are ROVs important when studying deep ocean environments?

2. How can these ROVs be used to collect physical samples, rather than just take video images?

## Materials |

Objects to pick up with your device (i.e. tennis balls, cotton balls, paper cups)

Here are some materials you can use to build an ROV hand:

brass fasteners
binder clips paperclips
clothespins
corrugated cardboard
hole punch
2–6 paint stirrers
2 paper cups
rubber bands
hangers
ruler
sandpaper
scissors
string
tape (duct or masking)
wooden skewers or dowels
fishing line
pencils
other common household or classroom supplies



## SCIENTIST SPOTLIGHT

**Continued from previous page**

While going through the engineering design process building her samplers, Tamara consulted with *Nautilus'* ROV engineering team to make sure her design goals -- to have one arm hold the sampler rigidly in place while another arm rotated the sampler into the methane hydrate on the seafloor -- matched the capabilities of the ROV. She also worked with other teams because it was important to Tamara, that the sampler be compatible with a variety of ROVs, not just the configuration of ROV *Hercules*. Dr. Baumberger is confident the methane hydrate sampler has met this goal.

### *THINK About It!*

- *Why do you think Dr. Tamara wanted her sampler to be able to be fitted on more vehicles than just ROV Hercules?*

## Think about the challenge |

Ocean exploration is a complicated endeavor requiring the latest tools and technology. Ocean Exploration Trust's vessel, E/V *Nautilus*, is one of only two dedicated ships of exploration in the world. The exploration team on *Nautilus* uses a multibeam sonar system to map unknown areas of the seafloor. Once the data is analyzed and targets are chosen, they use remotely operated vehicles (ROVs) to collect video footage and a variety of samples. *Nautilus* uses two ROVs in tandem, *Argus* and *Hercules*. Video from *Hercules*' high-definition main camera is streamed up a fiber-optic cable to *Argus,* up the cable to the control van on *Nautilus*, then out to the world. *Hercules* is equipped with six thrusters that allow the pilots to "fly" it in any direction. Its two manipulator arms are designed for collecting samples and recovering artifacts. These arms have claws to grab tools, to take samples ,and place recovered samples into sample drawers or place them in elevators dropped to the bottom from the surface ship above. The ability of claws to grab and release objects in a highly controlled way is criteria to the success of E/V *Nautilus*'s mission of ocean exploration and scientific study.

Think about the differences between grabbing, scooping, and the kind of motion you use to squeeze something. When you grab something, you collect a smaller number of objects than you would if you scooped objects as a group. But the grabbing motion allows you to handle objects with more control than scooping. To grab objects with your hand you use your thumb and fingers to hold the object in place on two sides. The muscles in your fingers can apply pressure towards the objects to hold them. More pressure equals a tighter hold.

## Write down your ideas |

1. Having a longer reach might be handy. Think about how to make the arms long enough to reach at least 2 feet (0.6 m). What materials do you have to make long, sturdy arms?

2. Your arms, legs, and jaw make squeezing motions. Think about what all grabbing devices have in common. To grab something a device needs two parts that go on either side of the item being grabbed. A grabber also needs a way to press the two parts together to make a pinching motion. Some devices, like pliers, act as levers. A lever is a rigid bar that turns around a fulcrum. A fulcrum is the point around which the two parts swivel. How will you make the parts press together? What materials will you use to make the jaws grip items tightly?



## Build |

1. Choose your materials and build the arms.

    *Tips:*

    - ✓ *You can connect paint stirrers with brass fasteners. Make a hole in the stirrer or cardboard by turning and twisting a blade of a scissors in one spot until it goes through to the other side. This can be tricky, so use caution as you make holes.*
    - ✓ *If the arms are too long, they might bend and not open and close easily. Short arms don't bend as easily as long ones.*

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    *Tips:*

    - ✓ *If the arms have a weak grip, try increasing their force, or pressure, by adjusting the fulcrum’s position and the arm length.*
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4. Decide how your jaws will grip an object and hold on to it. Think about how your jaws will be attached to the end of the arms. Choose the materials and build the jaws.

    *Tips:*

    - ✓ *If your jaws don’t hold an object, try changing the shape of the jaws so they have a firm grip when they grab hold of an object.*
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5. Place an object about 2 feet (0.6 m) away from you. Grab it with your grabber. Lift the object, lower it, and then release it.

    *Tip:*

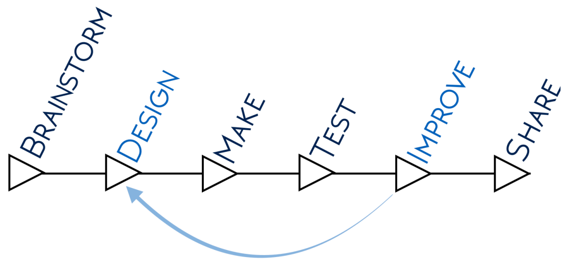
    - ✓ *If your jaws don’t open, check that nothing is blocking their movement. Or check that the two parts can slide easily past each other.*

6. Document your design either by photo, video (insert links) or illustration below:



## Test, evaluate, and redesign |

Ensure your ROV *Hercules* arm can successfully grab and release objects. If it does not, remember that engineers improve their designs by testing them, researching, making changes, and retesting. The steps they follow are called the design process.




Once you have a successful design, try grabbing and releasing objects with different shapes and weights. This will help you find ways to make your design even better. Use the design process to increase the variety of objects your *Hercules* arm can grab. For an extra challenge try picking up two objects at the same time.

## Reflection question |

Describe the changes you made to your design as you tried to either get the ROV *Hercules* arm to grab and release objects or to increase the variety of objects the arm could grab and release.



Scientific Modeling & Communication Rubric

| OBJECTIVE | CRITERIA | | | |
|---|---|---|---|---|
| | 4<br>Exemplary | 3<br>Commended | 2<br>Emerging | 1<br>Developing |
| **Evidence of Planning and Research \|** | Student submits thoroughly completed and accurate worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic. | Student submits completed and mostly accurate worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic. | Student submits partially completed worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic. Some information may be inaccurate. | Student submits minimally completed worksheets, documents, outlines, drafts, etc. of preliminary planning and research on topic. Information may be inaccurate. |
| **Student Model or Product \|** | Adheres to all guidelines and expectations set forth. Model or product exhibits neatness, creativity and thoughtfulness in design. | Adheres to most guidelines and expectations set forth. Model or product exhibits neatness, some creativity and thoughtfulness in design. | Adheres to some guidelines and expectations set forth. Model or product exhibits some neatness, creativity and thoughtfulness in design, or these may be inconsistent. | Adheres to few guidelines and expectations set forth. Model or product does not exhibit neatness, creativity or thoughtfulness in design. |
| **Communication of Content \|** | Student is able to thoroughly discuss content through use of their model/ product. Student thoroughly completes all associated follow-up worksheets, questions, reports, etc. with no content errors. Student can answer questions about their ideas using examples from what they learned. | Student is able to discuss content through use of their model/product. Student completes follow-up worksheets, questions, reports, etc. with few content errors. Student can answer questions about their ideas using examples from what they learned. | Student is able to weakly discuss content through use of their model/ product. Student completes some associated follow-up worksheets, questions, reports, etc. There may be some content errors. Student can answer rudimentary questions about their ideas. | Student is able to minimally discuss content through use of their model/ product. Student minimally completes associated follow-up worksheets, questions, reports, etc. Student has difficulty answering questions about their ideas. |
| **Total Score:**<br><br>______________ | **Comments:** | | | |

# HOW LARGE IS NAUTILUS NATION?

*Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.*

**Name:** **My Community (City, State):**

**Email Address:**

**School's Name:**

**Instruction date:** **Grade level instructed:**

**Subject area:**

**My education space is a...**

- ❏ Classroom
- ❏ After school program / Club meeting
- ❏ Fair / Festival / Event
- ❏ Museum / Science Center
- ❏ Other. Tell us more:

**Who did you engage in your teaching?**

# Students

# Community Members

**Select all the OET materials you used in your instruction:**

- ❏ STEM Learning Modules. Which ones? ____________________
- ❏ Digital Resource Library materials. Which ones? ____________________
- ❏ Nautilus Live website: photo albums ☐ highlight videos ☐ live stream
- ❏ Meet the Team STEM mentor profiles
- ❏ Facebook (NautilusLive) ☐ Twitter (@EVNautilus) ☐ Instagram (@nautiluslive)
- ❏ Other. Tell us more: ____________________

____________________

**What made working with OET resources valuable to your instruction (select all that apply)?**

- ❏ Hands-on activities ☐ STEM career connections
- ❏ Easy to use lessons ☐ Standards-based lessons
- ❏ Website resource access ☐ Real world application of curricula topics
- ❏ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❏ Another reason. Tell us more: ____________________

____________________

| | | |
|---|---|---|
| Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects. | ☐ Yes | ☐ No |
| OET provided me with helpful and relevant teaching resources. | ☐ Yes | ☐ No |
| Using OET resources increased my awareness of STEM careers. | ☐ Yes | ☐ No |
| If yes, how so? How can we improve? | | |

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

**THANK YOU FOR ALL YOU DO!**