Mission Submersible

Safely Launching and Recovering Scientific Equipment at Sea

Timeframe
3-5 Fifty minute class periods

Target Audience
Grades 4th- 12th

Suggested Materials and Cost Points
- Strips and various size pieces of cardboard (1-2pts)
- Syringes (2pts)
- Plastic tubing (1pt per foot)
- Pulley wheel (2pts)
- Binder clips, brads, and paperclips (1pt)
- Clothespins (2pts)
- Popsicle sticks (1pt)
- Rubber bands (1pt)
- Tape (1pt per ft.)
- Fishing line, twine, and rope (1pt per ft.)
- Scientific Equipment (toy truck, net with fish, etc.)
- Mission Submersible PPT

Contact:
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http://smile.oregonstate.edu/

Description
Students will design and build a working model of a launch and recovery system from a set of everyday items. The goal is that whatever they develop has safety features that limit swinging on a moving research vessel. Systems must be able to pick up and launch/recover "scientific packages" of varying sizes and weights and safely place them into the "ocean" and bring them back aboard the vessel.

Objectives
Students will:
- Use the engineering design process as they design and build.
- Represent solutions to a design process in multiple ways.
- Describe and explain features and purpose of a design.

Essential Question
What is the best design solution for a launch and recovery system that can safely deploy scientific packages from a moving vessel?

Background Information
The ocean covers over 70% of our earth's surface, provides 90% of the earth's biosphere, and plays a key role in influencing the carbon cycle, climate change, and weather patterns - yet less than 5% of the ocean has been explored and even less has been studied. There are many tools and devices that researchers use at sea to help them better understand the ocean environment. These are often referred to as scientific packages or underwater robots depending on their capabilities.

Scientific equipment and underwater robots include: CTD's (Conductivity, Temperature, Depth), Coring Devices, Nets, ROVs (Remotely Operated Vehicles), AUVs (Autonomous Underwater Vehicle), Seagliders, Buoys, Wave gliders, and Drifters. Scientific packages and underwater robots are used by researchers for many purposes, including monitoring underwater habitats, observing organisms, collecting data on deepsea environments, investigating shipwrecks, and studying areas too dangerous for humans such as active underwater volcanoes.

In order to get these tools over the side of a vessel, boats must be equipped with "launch and recovery arms". Launch and recovery systems on research vessels have historically been labor intensive and dangerous for the operators and the vessel. They are operated using pulleys and manual labor. Because the research equipment being launched is not always properly stabilized, ocean waves can cause the equipment to swing in an uncontrolled manner. Scientific packages and underwater robots can weigh up to 2300 pounds. This amount of weight swinging freely can cause damage to the vessel and equipment and cause injury or death to the people handling the equipment. On newer vessels, such as the Regional Class Research Vessel (RCRV), launch and recovery systems have been improved making it safer to get equipment overboard.

In this lesson, students are challenged with building a model of a launch and recovery system that can be used to safely deploy research equipment of varying weights from a moving vessel. For older students "cost points" can be integrated to add an additional cost constraint to the project (HS-ETS1-3.)

Next Generation Science Standards

PERFORMANCE EXPECTATIONS:

3-5-ETS1-1.
MS-ETS1-1.
MS-PS2-1.
HS-ETS1-2.

DISCIPLINARY CORE IDEAS:

ETS1.A.: Defining and Delimiting Engineering Problems
ETS1.B.: Developing Possible Solutions
ETS1.C.: Optimizing the Design Solution

SCIENCE AND ENGINEERING PRACTICES:

Asking Questions and Defining Problems
Developing and Using Models
Constructing Explanations and Designing Solutions

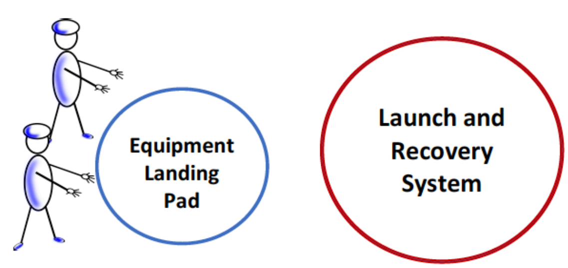
CROSSCUTTING CONCEPTS:

Cause and Effect
Structure and Function
Systems and Systems Models

Preparation

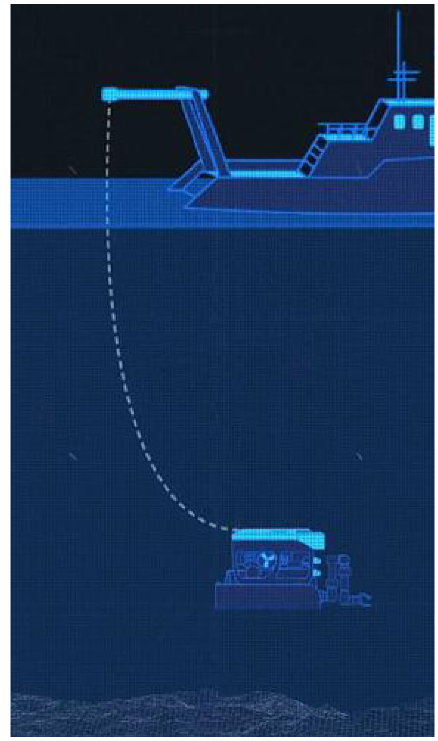
Build a test area where students can demonstrate that their launch and recovery system can safely deploy scientific equipment. Use tape to mark the parameter of the testing area and the landing pad on the "vessel" (table) and ocean (floor). Set up "crew members" (toy figures, marshmallows, or similar item). Let students know that the base of their model must fit within the defined area. They will demonstrate safely launching and recovering packages by staying within the given targets and not "injuring" any of the vessel crew. The dimensions are flexible. Larger would be easier and smaller dimensions are harder.

Identify/create at least four pieces of scientific equipment for students to launch and recover (toy truck, net with fish, etc.).

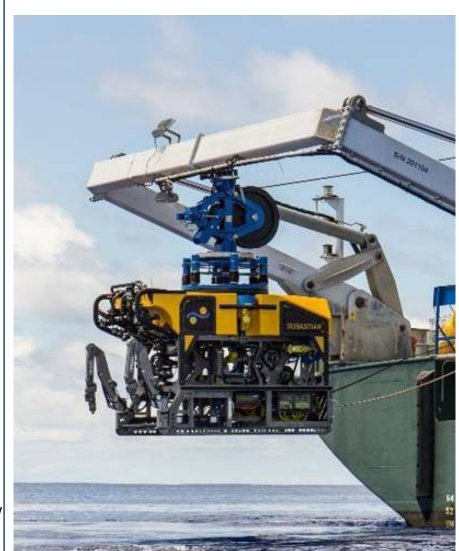


Activity Part 1: Planning

1. Use the "Mission Submersible" PPT (smile.oregonstate.edu) to go over the types of systems and the equipment that are used on vessels to launch and recover scientific packages. Show minutes 1-2 in the "Deploying ROCS" video (**https://www.youtube.com/watch?v=9GOpqHNezTI**) which demonstates heavy equipment while being launched. Discuss the importance of safety on vessels. Tell students that launch and recovery systems are used on research vessels to get scientific packages (ROV's, CTD's, Seaglider's, Nets, etc.) overboard and into the ocean. Because boats work on the ocean and are constantly moving, safely placing equipment over the side of a vessel and into the ocean can be a problem.



2. **Give students the following scenario:** *when scientists go out on a vessel they have a limited amount of time to conduct their research. This means that they work at all hours of the day or night and in all kinds of weather. This can lead to safety issues, especially when it comes to launching and recovering heavy and awkward scientific equipment over the side of a moving vessel. Large equipment swinging freely can cause damage to the vessel and science equipment and cause injury or death to the people handling it. There is a boat building company looking to invest in a new and improved launch and recovery system that will make it safer to get equipment overboard so that they can market and sell the improved technology to vessels. They are looking for creative solutions from engineers who will develop, design and build a model system that addresses how to safely get large research equipment over the side of a moving vessel.*



3. Let students know that they are the lucky group of engineers who will attempt to solve this problem! They will work in teams of 3-5 to come up with a design solution for safely deploying equipment. Explain that coming up with creative solutions to these kinds of problems often involves the Engineering Design process and can even lead to inventing a new device that hasn't been considered before. What they develop does not have to look like anything used in the past, they might come up with a new and creative launch and recovery system that hasn't been yet thought of or tried.

4. Divide students into groups of 3-5, and reiterate the problem they will work to solve: **How can scientists safely get large research equipment over the side of a moving vessel?** The challenge that each team is charged with is to design and build a device that can address this problem using the materials provided and any found items they determine necessary. Pass out "student handouts" and materials bags to each group.

5. Give students the project deliverables and parameters:
    - Each group must have: model sketches, materials list, cost analysis, and a working prototype.
    - Models must be able to launch and recover a minimum of 2 of 4 "science packages" of varying sizes and weights.
    - Models must demonstrate minimal movement when packages are being deployed by staying within given target and not "injuring" any of the vessel crew when launching and recovering equipment.
    - Groups should minimize cost of models in order to make reproduction and maintenance simpler and cheaper. This will be achieved by using minimal materials and acquiring fewer "cost points". **Note:** *do not introduce this parameter until after their first build has been completed. Having fewer constraints will allow students to be more creative.*

6. Show students the materials they will have to work with and the types of "scientific equipment" they can choose from to deploy with their launch and recovery device. Will they specialize and only launch some of the equipment or generalize and be able to launch a variety?

7. Once students have determined what equipment they plan to launch have them develop a collection of sketches that attempt to solve the problem. Record all ideas, the most "off-the-wall" design could be one that holds a solution for the problem! Give each student group sticky notes and tell them that each team member should sketch 3-5 ideas. There is no "right" answer to the problem and each team's creativity will likely generate a solution that is unique from the others designed.

8. Share drawings with other team members and look for commonalities between ideas. Identify promising designs and brainstorm how to bring them together. Critique (be nice, constructive) the designs and make a short list of pros (+) and cons (-) for each idea. Identify the best ideas and vote to decide on them.

9. Now that students have their idea they should identify which materials will be used in the build. Are there other materials that they need that can be easily obtained? Have students list out all of the items that they will use including ones that still need to be gathered. **Note:** *give students some parameters for "found" materials to make it equitable.*

10. Have students make final engineering sketches of their agreed upon design idea. Have them include all of the parts that are needed and clearly label their drawings.

11. Let students know that during the next session they will start building a working model of their design idea. If there are any additional found items that students need to build their creations make sure they plan to bring them.

Guiding Questions

- *How can your launch and recovery system be improved?*
- *What do you have to do to get your model to fail?*
- *Can you redesign it to prevent failure from happening?*
- *Have you "over engineered" the model? Can it be simplified while still meeting the project goals?*

Activity Part 2: Building and Testing

1. Have students review their design plan and the materials they have available. They can then start building their launch and recovery system! Review parameters.

2. Students can test their models by choosing 2 of 4 "science packages" of varying sizes and weights to launch and recover. Models must demonstrate minimal movement when launching or recovering equipment packages by staying within a given target and not "injuring" any of the vessel crew around the target.

3. REVISE, REVISE, REVISE! Have students compare their builds with other groups in the class to see what they can learn from other design solutions. Make your design the best it can be!

4. Remind students to note changes, modifications, failures and successes. It is perfectly fine to mark up your engineering sketches.

5. Introduce the cost points associated with items. Tell students that in their second build they should think about how they might lower cost. Are they trying to have their model do too much?

6. TEST, TEST, TEST!

Activity Part 3: Presenting

Once teams are done building their models/prototypes they should get ready to present them to the "investors" (aka: other teams). Have students use their handouts to guide their presentations. Have students describe and explain features and purpose of their designs.

Wrap Up

Once all groups have presented have students discuss:

- o What were the constraints that your team faced while trying to engineer your design solution?
- o What did you learn from the designs developed by other teams?
- o What trade-offs did you have to make to minimize cost?

This project is supported by the Regional Class Research Vessel Program in the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University.

Resources:

Try Engineering, "Build Your Own Robotic Arm": https://www.ieee.org/documents/Build_Your_Own_Robot_Arm_Lesson_Plan.pdf

NASA Jet Propulsion Labratory, "Robotic Arm Challenge": https://www.jpl.nasa.gov/edu/teach/activity/robotic-arm-challenge/

MESA Program, "Invention Toolkit": https://oregonmesa.org/

Teach Engineering, STEM curriculum for k-12: https://www.teachengineering.org/activities/view/wpi_hydraulic_arm_challenge

Hydraulic Crane Video: https://www.youtube.com/watch?v=QxkFrWXw9Mk

This video provides one idea to help generate ideas for powering launch and recovery systems.

Mission Submersible
Student Handout

The Problem: *How can scientists safely get large research equipment over the side of a moving vessel?*

Parameters for design and build:

a. Able to launch and recover 2 of 4 “science packages” of varying sizes and weights.
b. Must demonstrate minimal movement when packages are being deployed by staying within given target and not “injuring” any of the vessel crew when launching or recovering equipment.
c. Minimize cost and make reproduction and maintenance simpler and cheaper by using fewer materials.

What materials will you need to build a model of your vessel? List each item and how many you will use and revise as needed for the rebuild.

Build #1	*Build #2 (Include cost)*

Draw a detailed picture of your groups agreed upon design, include labels.

Design 1

How can your team improve your launch and recovery system and make it better? Have you "over engineered" your model? Can it be simplified while still meeting the goals of the project?

Design 2

Team presentation guiding questions

1. How does your model address the problem of safely deploying scientific equipment?

2. Which materials were most critical to your design build? Why?

3. How did your team re-design and improve your original model?