

SCIENCE FAIR CENTRAL

Maker Corner Activity



HYDRAULICS IN ACTION

Grade Level: High School

MAKE. CREATE. EXPLORE.

www.ScienceFairCentral.com

#ScienceFairCentral





What do you think you know about hydraulics?

Overview

Students will learn how hydraulics work and the use of hydraulics in various industries. Students will use simple materials to build a working hydraulic arm that they can then test to move an object from one place to another. They will brainstorm ways that their hydraulic arm could be used and modifications that could be made to it to perform its specific function.

Have you ever wondered...

How does a hydraulic arm work?

Hydraulics are all about 2 things - fluid and force. A liquid can't be compressed into itself, so when force is applied to a liquid, that force is transferred through hydraulic power! Hydraulic equipment operates on Pascal's Law, which states that in a fluid at rest in a closed container, a pressure change in one part is transmitted without loss to every portion of the fluid and to the walls of the container. There are countless ways that hydraulics are utilized in industry and manufacturing; we use equipment such as hydraulic cranes, forklifts, jacks, and pumps to lift and lower objects. Airplanes use hydraulic mechanisms to operate their control panels, and elevators use hydraulic mechanisms to power the elevator's movement.

This activity focuses on the **"Creating or Prototyping"** stages of the Engineering Design Cycle.

Engineering Design Cycle

- Defining the Problem
- Designing Solutions
- **Creating or Prototyping**
- Refine or Improve
- Communicating Results

Objectives

Students will be able to:

Construct a working hydraulic arm that uses the water and pressure.

Discover that hydraulics are used in many fields, including industry, manufacturing, and medicine.

Materials

- [cardboard moving boxes](#)
- [latex tubing](#)
- [plastic syringes](#)
- [hot glue sticks](#)
- [glue guns](#)
- toothpicks
- [copper wire](#)
- [super glue](#)
- food coloring
- [utility knife or box cutter](#)
- [tape measure](#)



Make connections!

How does this connect to students?

There are many jobs available in fields where an understanding of and ability to operate hydraulic machines are necessary and valuable. Many industries depend on hydraulic presses and hydraulic technology including automotive and manufacturing, and even in the field of robotics!

How does this connect to careers?

Hydraulic Engineer:

Engineers that specialize in hydraulics study the effect of water as well as its uses. They design and supervise the construction of projects that can be used to harness water as a form of energy.

Hydraulic technicians install, maintain, and repair hydraulic components on equipment. They read blueprints and diagrams while diagnosing equipment problems and must read dials and meters to analyze part-performance in hydraulic machines.

Robotics engineers design, build, and test robots that are productive, safe, and economical. They use computer-aided design and drafting, and computer-aided manufacturing systems to perform their tasks.

How does this connect to our world?

Our lives are dependent on hydraulic technology every day! If you rode in a car today, hydraulic power was used to operate the breaks and the steering. If you traveled somewhere by air, hydraulic technology controlled the airplane wing flaps, stabilizers, and landing gear! Everywhere you look in transportation, hydraulic power is necessary to move from one place to another safely and get work done!



Blueprint for Discovery

Prior to the Activity

Depending on time and materials available, instructors may want to pre-cut and glue the cardboard pieces for the hydraulic arm. They also may want to assemble an example hydraulic arm for students to use as a reference as they build their own.

Whole and Small Group Activities

1. Begin by showing students the following video clip that highlights a new exoskeleton suit that has been designed using hydraulic power: <https://www.youtube.com/watch?v=VSzvVXiWkSg>
2. Ask students if they know how this suit could make lifting heavy objects easier. As groups share, the teacher should next play the following clip that explains how hydraulic power can be harnessed with some fluid and a little pressure: <https://www.youtube.com/watch?v=2eUkT1HngW0>
3. Ask the students if they've ever heard of hydraulic power? If not, they should be surprised that the probably benefit from hydraulic power nearly every day! Have students get with a partner or small group and give them 10 minutes to research how hydraulics are utilized in one the following activities or industries:
 - a. driving
 - b. construction
 - c. airplanes
 - d. farming
 - e. manufacturing
 - f. amusement parks
 - g. robotics
 - h. waste management
 - i. hydroelectric power (dams)

Each small group should briefly report their finding to the class after the research time is completed.

4. Next, explain to students that they will be getting into groups to construct a working hydraulic arm!
5. If you have made an example arm, demonstrate to students how your arm works. Ask them where hydraulic power is being utilized through Pascal's Law.
6. Next, give each student group the materials they need to construct their hydraulic arm.
7. groups should work together to construct their arm.



8. (While groups should be able to construct most of the hydraulic arm themselves, the teacher may need to give them guidance along the way.)
9. Once students have completed their arm, they should test it out! The teacher can provide some objects to see if their arm can pick them up or create a contest to see which groups' hydraulic arms are the most effective!
10. To end and reflect on this activity, the teacher should ask the students to brainstorm about other hydraulic models they could make with these simple materials, or how they could improve the design of their own hydraulic arm.

Here are teacher instructions for correctly building a hydraulic arm:

1. Use a ruler, utility knife or box cutter, and cardboard to cut 2 squares that are 8"x8", label these as BASE and use super glue to glue them together, 1 on top of the other. Allow them to dry
2. Next, cut 2 pieces of cardboard that are 10"x2". Glue these together, 1 on top of the other, label them as FOREARM and allow to dry. Repeat this to make an additional FOREARM.
3. Cut 2 pieces of cardboard that are 12"x2". Glue these together, 1 on top of the other, label them as ARM and allow to dry. Repeat this to make an additional ARM.
4. Next, cut 2 pieces of cardboard that are 8" x 2" x 4" x 6". (This will be a trapezoid shape.) Glue these together, 1 on top of the other, label them as SUPPORTING PLATFORM and allow to dry. Repeat this to make an additional SUPPORTING PLATFORM and allow to dry.
5. Cut a piece of cardboard that is a triangle shape and label it GRIPPER BODY
6. Finally, cut 2 pieces of cardboard that will make up your gripper for your arm. You can decide on the shape of these. A claw-like shape is recommended. They should be close to the size of your other pieces to be functional. Label each of these pieces GRIPPER.
7. Cut a small square of cardboard (4"x4" - 6"x6"). Use glue to attach the two GRIPPER BODY pieces to opposite edges of this piece, with the smallest end of the trapezoid free.
8. Use a drill to drill small holes (that a toothpick can fit through easily) at the end of the FOREARM, ARM, the narrow end of the SUPPORTING PLATFORMS, and at 2 pairs of holes on the base (widest part) of the GRIPPER BODY. You should also drill holes at one end of each of your GRIPPER PIECES that will attach to the GRIPPER BODY.
9. In the ARM, also drill 2 holes 1" apart in the middle of the piece.
10. Line up the holes in the SUPPORTING PLATFORM pieces with the holes in the ARM pieces. Push a toothpick through the holes and add superglue to secure the toothpick in the holes.
11. Repeat this process with the other holes in the ARM pieces and one set of holes in the FOREARM pieces. Push a toothpick through the holes and add superglue to secure the toothpick in the holes.



12. Take four syringes, these will be the ones attached to the ARM.
 13. Cut the plastic piece on top of the syringe to be narrower (as it can cause unnecessary width) and drill a hole around $\frac{1}{2}$ cm from the top that a toothpick will fit through.
 14. In one the four syringes, drill two holes at the top. This will be the syringe for the gripper.
 15. Get two zip ties and close them in a "figure eight" shape. Tighten one loop around the syringe then slip in a toothpick on the other one and tighten it till it bits tightly, finally clip the extra bit of the zip tie.
 16. Attach the syringe between the ARM and SUPPORTING PLATFORM by inserting the toothpick through the holes you drilled earlier. Attach the 2nd syringe between the FOREARM and ARM in the same manner. Attach the 3rd syringe between the two FOREARM PIECES.
 17. Next, attach the GRIPPER PIECES to each side of the GRIPPER BODY using toothpicks as dowels and superglue.
 18. At the end of the GRIPPER PIECES (the non-gripping end), drill or poke a small hole and loop two pieces of copper wire through the holes. (Pulling on these wires should move the GRIPPER PIECES.)
 19. Use glue to attach the GRIPPER BODY to the FOREARM pieces. Attach the free ends of the copper wire to the hole in the end of the FOREARM syringe.
 20. Use glue to attach the SUPPORTING PLATFORM to the BASE.
 21. Fill three syringes with different colored water.
 22. Use plastic tubing to connect the ends the free syringes to each of the syringe ends on the hydraulic arm.
 23. Now pull in and out on the free syringes to see how your arm moves!
-

Take action!

Now that students have learned about hydraulics, they may want to explore how the principles of hydraulics are used in nature! Students can read about how two unlikely (and one unpopular) species use hydraulics to get moving!

- Your Favorite Sandwich Filler is Powered by Nature's Finest Hydraulic System
https://www.vice.com/en_us/article/kza57v/tuna-natural-hydraulic-system-stanford-monterey-bay-aquarium-science
- The Fascinating Relationship Between Hydraulics and Spiders
<https://petroleumservicecompany.com/blog/hydraulic-spider-legs/>



National Standards

Science

[Next Generation Science Standards](#)

[HS-PS3-3 Energy](#)

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

[HS-ETS1-1 Engineering Design](#)

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Technology Education

[Next Generation Science Standards](#) and [International Technology and Engineering Educators Association](#)

Students will develop an understanding of Technology and Society. This includes learning about:

- The cultural, social, economic, and political effects of technology.
- The effects of technology on the environment.
- The role of society in the development and use of technology.
- The influence of technology on history.

Students will develop an understanding of the Designed World. This includes selecting and using:

- Agricultural and related biotechnologies.
- Energy and power technologies.
- Manufacturing technologies.

Mathematical Practice

[Common Core](#)

English Language Arts

[Common Core](#)

Links

<https://www.exploratorium.edu/snacks/hydraulic-arm>

<https://www.bestjobdescriptions.com/construction/hydraulic-engineer-job-description>

<https://www.agexplorer.com/career/hydraulic-technician>

