Massachusetts STEM Week 2024

Engineering Plastic Filters

YES Elementary

EDUCATOR GUIDE

For Youth Ages 8—12

Museum of Science®

10.2024

The Museum of Science, Boston, and Youth Engineering Solutions are proud to support this year's Massachusetts STEM Week.

Learn more about MA STEM Week here: https://www.mass.gov/info-details/stem-week

About This Design Challenge

Engineering is the process of using creativity and an understanding of materials, tools, mathematics, and science to design things that solve problems.

In this hands-on design challenge for youth ages 8—12, kids work in teams and use the Engineering Design Process to design a plastic filter that will reduce the amount of plastic waste that enters into a model bay. The goal of the filter design is to capture plastic floating in the water.

During the activity, youth work in small groups to imagine, plan, and create unique solutions to the problem. They test and improve their designs, then share their engineering work with one another.

This challenge is an abbreviated version of a longer unit. For the complete Youth Engineering Solutions *Engineering Plastic Filters* unit, visit **https://yes.mos.org/unit/engineering-plastic-filters/**

Massachusetts STEM Week 2024
Engineering Plastic Filters

Lesson Outline

Preparation: 35 min.

Introduction: 15 min.

- Introduce engineering.
- Read and discuss *The Problem With Plastics* comic.

Exploration: 35 min.

- Create and test a plastic filter.

Wrap-Up: 10 min.

- Reflect on the engineering experience.

Optional Kahoot quiz:

- *Impacts of Plastic Pollution*

Guiding Question

How do engineers solve problems?

Learning Objective

Youth will be able to

Engineer a filter that reduces the amount of plastic pollution in a model bay.

The Massachusetts STEM Week 2024 engineering challenge is designed to be completed in **one hour** with an additional optional kahoot quiz.

The Materials and Preparation for the unit assume a group size of 24 youth. Adjust amounts as needed.

The Engineering Design Process

Engineers use a structured, iterative process called the Engineering Design Process (EDP). This is not a rigid process. Rather, engineers move back and forth among phases. After proceeding through the basic phases, youth improve their design by repeating the cycle.

Elementary youth engage with a simple, five-phase process.

Ask: Youth define the problem, then identify the requirements for the design (criteria) and how their choices may be limited (constraints). This phase includes considering the needs of users and implications of the solution. Youth explore materials and consider which are best suited to the challenge.

Imagine: Youth creatively brainstorm ways to solve the problem.

Plan: Youth share and select their best ideas to generate one design per group. They sketch their plan and list the materials it uses.

Create: Youth work in groups to make the solution they designed.

Test: Each group tests its solution. Groups share and analyze data to determine where they can improve.

Improve Cycle: Groups improve their designs by going through another iteration of the process.

Materials

Physical Materials

For the whole group:	For the Materials Table:
☐ pitcher(s) and access to water	☐ rulers ☐ scissors ☐ 1 roll of string ☐ 3 rolls of masking tape ☐ 10 burlap pieces, 5" x 5" ☐ 10 sheets of craft foam, 9" x 12" ☐ 15 mesh screens, 5" x 5" ☐ 30 plastic straws, regular ☐ 40 binder clips, medium, 1.25" ☐ 40 craft sticks, regular ☐ 40 twist ties ☐ 40 metal washers, 7/8" outer diameter ☐ 50 paper clips, regular ☐ 50 pipe cleaners ☐ 100 pony beads
☐ towels or paper towels	
☐ 1 permanent marker	
☐ 4 model bays (see Preparation) ○ 2 plastic cups, 10 oz ○ 4 round plastic containers, approx. 10" diameter ○ 8 binder clips, medium ○ 8 rubber bands, medium	
☐ 4 plastic straws cut into 20 pieces each (see Preparation: plastic pollutants)	
☐ 4 plastic cups, 3.5 oz	
☐ *Optional:* chart paper and markers	

Digital Resources

- ☐ Slides: *MA STEM Week: Engineering Plastic Filters*
- ☐ *Optional:* Kahoot quiz

Print Materials

For each group of 3:

- ☐ *Test Our Plastic Filter* (1 quarter sheet per group)
- ☐ *Materials Glossary*
- ☐ *Optional: Plan Our Plastic Filter*

For each youth:

- ☐ Comic: *The Problem With Plastics*

Preparation

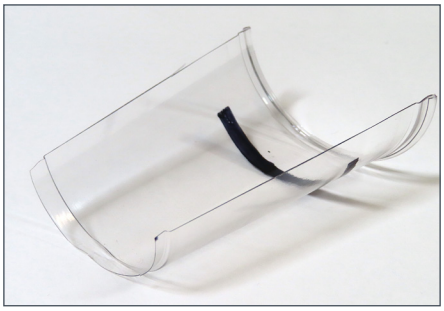
Create 4 model bays and rivers. (20 min.)

Watch the preparation: https://youtu.be/moO7lSeOHIs

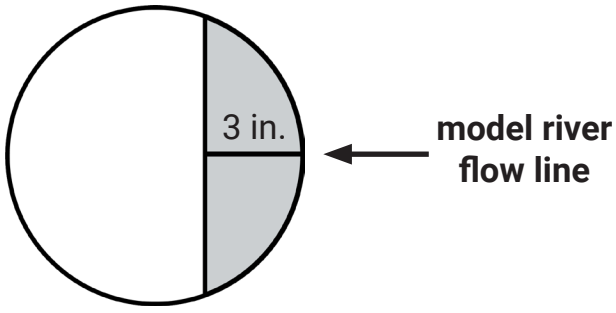
Materials for 4 model bays:

Quantity	Material
2	plastic cup, 10 oz
4	round plastic container, 10" diameter
8	binder clips, medium, 1.25"
8	rubber bands, medium (size #16)

- ☐ Prepare the model rivers.
  - ○ Use scissors to cut the 10 oz plastic cups in half vertically and remove the round bottoms.
  - ○ Measure 1" from the top of the cup and draw a line with a permanent marker. Do this on each cup half.



- ☐ Prepare the model bays.
  - ○ Turn a round plastic container upside down.
  - ○ On the bottom, use a permanent marker to mark a point 3" from the side of the container. Draw a straight line from the outer edge to this point. This is the **model river flow line**.



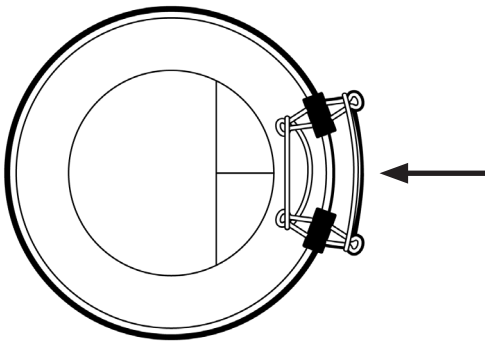
  - ○ Draw a second line across the container so it goes through the 3" point and is perpendicular to the first line.

Preparation

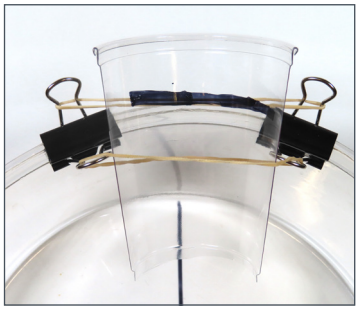
- Repeat this for the remaining three round plastic containers.

☐ Attach the model rivers to the model bays.

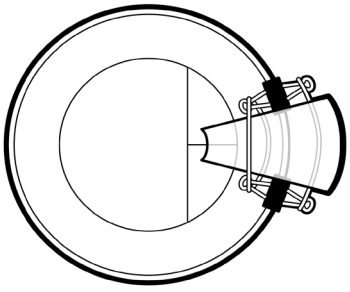
- Turn a plastic container right-side up.
- Attach two binder clips to the side of the container, about 2" apart. Center the binder clips above the **model river flow line**.

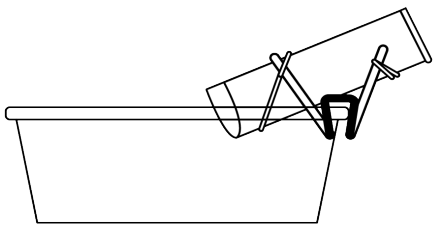


- Place two rubber bands around the arms of the binder clips, stretching from one binder clip to the other. One rubber band will go around the outer binder clip arms, and one will go around the inner binder clip arms.
- Position the model river (cup) so it is held by the rubber bands. The bottom of the cup will go through the inner rubber band while the top of the cup will rest on top of the outer rubber band.



- Adjust the position of the cup so the 1" line rests on the outer rubber band. This ensures the river will enter the bay at the correct angle, which is about 45 degrees.





- Repeat this process for the remaining three model rivers and bays.

Prepare the Testing Stations. (10 min.)

- ☐ Place the completed model bays in four different areas around your space.
- ☐ Make four sets of plastic pollutants.
  - ○ Cut four straws into about 20 pieces each, approx. 0.5" pieces.
  - ○ Place each set of 20 pieces into a 3.5 oz plastic cup.
  - ○ Place 1 cup of plastic pollutants beside each bay.

- ☐ Fill each model bay with about 2.5" of water.

Set up the Materials Table. (5 min.)

- ☐ Organize the materials on a table in an easily accessible location in your space.
- ☐ Designate an area for drying materials at the end of the activity.

Optional: Prepare the Chart.

- ☐ Title the chart paper *Counting Pollutants*. This chart will be completed during the Exploration.

Introduction (15 min.)

Introduce "engineer."

Tip: If your youth are familiar with engineering, start with Step 4.

1. Tell youth that today they will be engineers and make something that solves a problem. Ask:
   - **Have you ever heard of the word "engineer," or do you know anyone who is an engineer?** *Accept all answers.*
   - **What do you think engineers do?** *Accept all answers.*
2. Explain that an engineer is **a person who thoughtfully designs something to solve a problem.**
3. Define engineer using the slide.

Tip: Include the verb form of the word "engineer": *To thoughtfully use a process to design something to solve a problem.*

Read the comic.

4. Show the cover of *The Problem With Plastics*.
5. Explain that it is a comic-style story about siblings named Antoine and Kayla, who work together to solve a problem near their town of Mobile, Alabama.
6. Distribute the comic and have youth read it.
7. Display the Slide: *Think About It*. Have youth turn and talk to discuss:
   - **What is the problem in the town's bay?** *There is plastic pollution in the water.*
   - **Who or what is impacted by the plastic pollution problem?** *Fishermen, people enjoying the water, animals, people who eat fish and shellfish, etc.*
   - **How did Antoine and Kayla engineer a solution to the problem?** *They created a filter that can catch plastic pollution as it travels from the river into the bay. They*

Embedded Equity:

Antoine and Kayla serve as role models by demonstrating that young children can be engineers.

Tip: Consider pairing youth who need reading support with those who can read aloud or read the comic aloud to the entire group as youth follow along.

used the Engineering Design Process to ask, imagine, plan, create, test, and improve a plastic filter design.

8. Explain that, just like the characters in the story, youth will be engineers and try to stop plastic pollution from entering a body of water.

Introduce the Engineering Design Process.

9. Display the Slide: *Engineernig Design Process*. While pointing to the appropriate icon, explain that engineers follow a process to

   - **ask** questions and gather information about the problem.
   - **imagine** many possible solutions.
   - **plan** one design as a team.
   - **create** a working design.
   - **test** and evaluate the success of their design.
   - continually **improve** by repeating the design process.

Optional: Use Slide: *Engineering Chant* and the suggested gestures to reinforce the phases of the Engineering Design Process.

LD

Promoting Equity:

While the EDP includes visuals to represent each phase, you can also use gestures to provide multiple access points for youth.

Exploration (35 min.)

Introduce the design challenge and testing procedure.

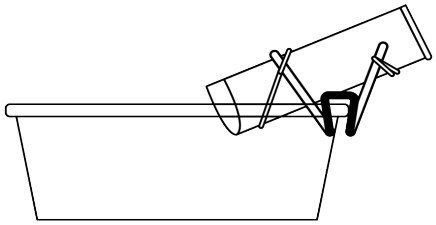
1. Explain that youth will work in groups of three to imagine, plan, create, and test a plastic filter design that can reduce the amount of plastic pollution entering a model bay.

2. Review the definition of **model** using the slide.

3. Explain that engineers often use models to test their designs before creating the final design. Since they cannot use real bodies of water, they will use models of the river and bay.

4. Show students the model bay they will use:

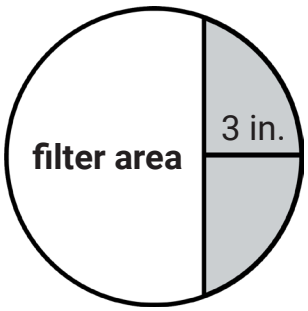
   - The clear bin is a model for the bay.
   - The cup is a model for the river.



5. Explain that there are 4 Testing Stations set up, each with a model bay. As groups are ready to test, they can go to one of the testing stations.

6. Show youth the cup of model plastic pollutants. Tell them that the pollutants will flow from the river into the bay.

7. Display Slide: *Test Procedure.* Play the video and talk through the testing procedure:



   - One person will place the filter inside the model bay. The plastic filter can be placed anywhere past the black line in the filter area.
   - One person will take the cup of plastic pollutants with water from the bay. Then, that person will pour the plastic pollutants and water down the river into the bay.
   - One person will count the number of pollutants caught by the filter and record it on *Test Our Plastic Filter.*

Imagine and Plan.

8. Show youth the Materials Table and review the available materials.

9. Give youth a few minutes to independently imagine some plastic filter designs that could be made using the materials. Use the questions on Slide: *Imagine a Plastic Filter* to guide their thinking:

   - **How can you use the materials to create a plastic filter?**
   - **Where would you place the filter in the model bay?**

10. Assign youth to groups of three and distribute a *Materials Glossary* and *Test Our Plastic Filter* page to each group.

11. Have each small group talk about their design ideas, then select one of their ideas to plan, create, and test.

12. Display Slide: *Working Together,* and tell youth they may use the sentence frames to help support their discussions and come to decisions.

Embedded Equity:

Sentence frames provide students with examples of how they can verbally share ideas with their peers.

Optional: Distribute *Plan Our Plastic Filter* for groups to complete as they discuss and finalize their plans.

Support groups as they create and test their designs.

13. Allow groups to collect materials, create, and test their designs.

14. Remind groups to record the number of plastic pollutants caught during each test on *Test Our Plastic Filter.*

15. As groups test their designs, support their engineering and collaboration by asing questions like:

   - **Does your plastic filter work the way your group planned? Why or why not?**

Engaging Families:

Take photos! Sharing the process and final products with families and others helps youth connect engineering to their lives.

- **What parts of your plastic filter are working well?**
- **How could you improve your design?**
- **Why do you think these changes will improve your plastic filter's test results?**

16. As time allows, allow groups to improve and retest their plastic filter designs.

OPTIONAL:

17. If youth are having difficulty coming to consensus about counting plastic pollutants, lead a class discussion:
    - **How can we ensure that we all count the number of plastic pollutants collected in the same way?**
    - **How long should we wait before counting the pollutants caught in the filter?**
    - **How do we determine what has been "caught"?**
18. On the *Optional: Counting Pollutants Chart*, record the agreed-upon process using words and images. Some ideas include
    - Count to 10 to allow the pollutants to settle.
    - Anything touching the filter has been "caught."
    - Anything in front of the filter has been "caught."
    - When you pick up and remove the filter, anything that is removed with it has been "caught."

Wrap-Up (10 min.)

Have youth do a gallery walk of designs.

1. Congratulate youth on their creative engineering solutions.
2. Tell groups that, just like Antoine and Kayla, they will share their designs by participating in a gallery walk. Establish norms, such as
   - Respect others' designs by only looking and not touching.
   - Travel with a partner or independently.
3. Have each group place their plastic filters and *Test Our Plastic Filter* pages in a designated location.
4. Display Slides: *Learning From Others* and review the questions and sentence frames.
5. Give youth time to look at the displays and discuss their observations.
6. Distribute *Materials Glossary* to groups. Have youth return to their groups to discuss their observations:
   - **What did the designs have in common?**
   - **Did any design surprise you? Why?**
   - **If you had more time to improve, which idea would you use in your design?**
7. Have youth share what they observed with the whole group. Reinforce that there were many solutions to the same problem and that by learning from each other, engineers can continue to improve technologies.

Interested in more? Check out the complete *Engineering Plastic Filters* unit here:

https://yes.mos.org/unit/engineering-plastic-filters/

Optional Kahoot quiz (10 min.)

What is Kahoot!?

Kahoot! is a game-based learning platform that makes it easy to create, share and play learning games or trivia quizzes in minutes.

The Museum of Science partners with Kahoot! to pair content from the museum with curricula designed for students and learners.

Kahoots require a free account. Have youth follow the instructions to join the kahoot and play along.

Play the *Impacts of Plastic Pollution* Kahoot.

1. Use the link to open the kahoot connected with this activity: *Impacts of Plastic Pollution*.
    - https://create.kahoot.it/details/c243c6fe-3543-47f5-acf6-086b89aa1994