Engineering a Water Filter

Objective:
Students will design and construct a water filter using household and recycled materials, test its effectiveness, and present their findings.

Water Filter Design ideas:
https://www.bellmuseum.umn.edu/activities-for-kids/exoplanet-exploration-grades-7-8/filter-your-water-experiment/

https://www.h2odistributors.com/info/how-to-make-a-water-filter/

Materials:
For each group of 4 students:
Graduated cylinder
Digital scale
Empty 1 L bottle (can substitute 2 L)
Scissors
Paper towels
Cheesecloth
Rubber bands
Metal scoopula
Weigh boats

To have available for all students:
Cotton balls
Old socks
Kitchen mesh strainer or screen
Coffee filters
Aquarium gravel
Sand
Uncooked macaroni noodles
Zeolite
Activated carbon
Paper/plastic cups
pH paper or pH probe
LaMotte Water Test Kit
small Secchi disk strip for lab use

OPTIONAL: Coliform Water Test Kit

Sample Wastewater:
In an empty 1-gallon jug add:
2 cups distilled white vinegar
½ cup of topsoil or sand
several drops of yellow food coloring
2 complete multivitamin tablets (adult 50+ is best)
dust swept from the floor
a handful of pet/ human hair
3 grams of Miracle Gro plant food
enough water to fill the jug

Students may choose to bring in their own water sample or you may collect creek or river water as well.

Time Frame: 1 week or 5 periods (could be slightly less if on block schedule)

Divide your class into groups of 4 using the following roles as guides:

1. Materials Manager:

- **Task:** Gather all materials needed for the project.
- **Responsibilities:** Ensure all team members have access to required materials, manage and distribute materials as needed, and ensure materials are used efficiently. Consider during peer review what other teams used and if your materials used are effective or need revision. Build and design the digital infographic used in your team's presentation after data is collected.

2. Science Recorder:

- **Task:** Document qualitative and quantitative observations and data. Make the data tables and graphs.
- **Responsibilities:** Record data for the initial state of the water and measure and record the pH level and clarity of the filtered water for all trials. Analyse data for efficiency and overall results of the water filter your team designed.

3. Engineering Recorder:

- **Task:** Record the design and building process.
- **Responsibilities:** Document each step of the design process, including sketches and any modifications, take notes on team discussions and decisions, and label all charts and graphs.

4. Engineering Builder:

- **Task:** Lead the construction of the water filter.
- **Responsibilities:** Assemble the water filter according to the team's design, ensure the filter is constructed safely and effectively, and make adjustments based on team or peer feedback.

Procedure:

1. Obtain your water sample to clean. Take qualitative observations first. What do you see? Smell? Reminder this water is not drinkable so there will be no tasting. Record all data. Insert any photographs of your original sample or particles within it you want to note as well.

Sample color (hold up a piece of White Paper behind it)	What do I see in the water? (hold with a piece of white paper behind it)	What smells come to mind?

2. Take quantitative observations. Use the water quality testing kits to measure for any potential contaminants, check the pH of your sample, etc. Place all of this information into a data table for comparison later. Include turbidity, pH, and all other water quality tests your group was given. This data table will not be given to you so it needs to go on separate paper or a separate document.

3. Brainstorm designs for a water filter using household and recycled materials. Discuss the importance of clean water and the basics of water filtration within your team, and conduct any research needed to justify your reasoning for this initial design. Make sure you draw and label this first design so that other groups can peer review your ideas.

Brainstorming Questions to consider

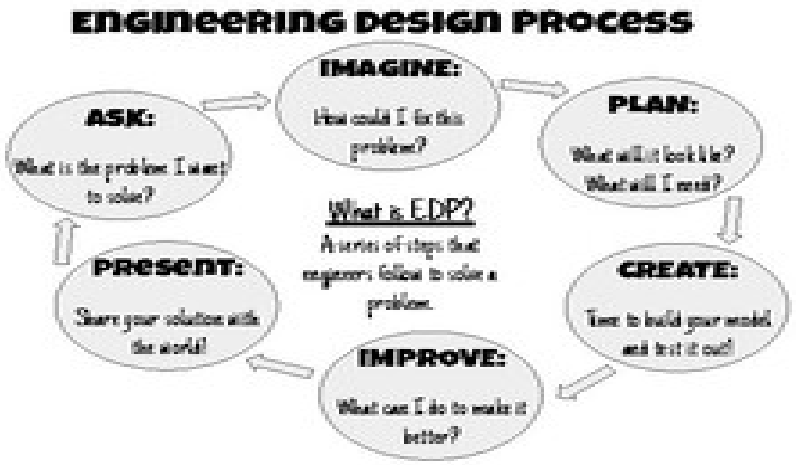
Content	Design Questions
What water tests should we consider?	What materials can we use?
Why does the pH matter?	How will it work?
Can we always see pollution?	What are our time constraints?
What references should we use?	How will we test the water?
What types of filtering could we use?	How will we see progress?

4. **Challenge**

   Design and build a relatively inexpensive homemade water filter from materials your teacher has provided or recycled materials in your classroom. The water filter system will be used to filter the water sample you chose and you will be testing the water using the water quality tests to see if the water is cleaner after you filter it.

   Design Constraints

   - Materials must be inexpensive, easy to obtain, and durable enough to last through several filtering cycles.
   - Designs must use one or more of the types of filtering we discussed in class: mechanical, microfiltrations, activated carbon, or membrane separation.
   - Your design must include a minimum of 5 materials.



   Sketches

   Each team member should contribute their original sketch to the engineering recorder. Each sketch should be discussed and the engineering recorder will draw the initial design below.

Alternatives
The group should then decide on alternative designs if the above does not work as planned.
#1 sketch

#2 sketch

#3 sketch

Implement Solution
Build your water filter prototype, include a detailed drawing of your plan, and write a description of how it will work. Once it is built, filter your water sample and retest the water so that you can see if you filtered anything out. The data tables will match the original tests done. Insert any photos of filtered water to compare to the original as well here.

Sample color (hold up a piece of White Paper behind it)	What do I see in the water? (hold with a piece of white paper behind it)	What smells come to mind?

Water Quality Test and pH Data

Evaluate your results
After filtering your water once through your prototype, reflect on what could be improved. Use the rubric below for the test criteria to determine if the prototype will be accepted or needs redesign. Drinking Water Reference Sheet

Is the water filter prototype

- Effective at removing particle matter?
- Effective at making the water clearer?
- Effective at making the water colorless?
- Effective at making the water closer to neutral?
- Effective at removing metals such as chromium?
- Effective at removing phosphates and nitrates?
- Effective in reducing ammonia levels?
- Does this appear safe to drink? Justify your answer.

Refine
Describe any changes you plan to make in your design below including repeating the filtering process or adding or changing the prototype at all.

Communicate

Student groups will now design an infographic to communicate their finding to the class and school. This will happen as a gallery walk. It must include as a design model, the effectiveness of your team's design, and a graph that shows which contaminants and how much was removed, create an advertisement as being the best water “cleaners” in the area or that your water source is now the “cleanest in town” Be sure to incorporate models, graphs, and calculate the efficiency of their water filter to clean the water.

Design challenge Rubric

Category	Exemplary (4)	Proficient (3)	Developing (2)	Beginning (1)
Criteria and Goals	All physical criteria are met by the product and the product easily meets the functional goals from the description.	All physical criteria are met by the product and the product mostly meets the functional goals from the description.	Most physical criteria are met by the product and the product does not meet the functional goals from the description.	All physical criteria are not met by the product and the product does not meet the functional goals from the description.
Engineering Design Process	Thoroughly documented process; includes brainstorming, sketches, detailed steps, and modifications.	Well-documented process includes brainstorming, sketches, and most steps and modifications.	Basic documentation of process; some steps and modifications included.	Minimal documentation; many steps and modifications missing.
Performance of water filter	Highly effective at improving water quality; significant reduction in contaminants and improved clarity.	Effective at improving water quality; noticeable reduction in contaminants and improved clarity.	Somewhat effective at improving water quality; some reduction in contaminants and slight	Ineffective at improving water quality; minimal or no reduction in contaminants and clarity.

			improvement in clarity.	
Participation and Teamwork	All team members actively contribute and collaborate; roles and responsibilities well-executed.	Most team members actively contribute and collaborate; roles and responsibilities executed.	Some team members contribute and collaborate; roles and responsibilities are somewhat executed.	Few team members contribute; roles and responsibilities are poorly executed.
Data and Graph	Accurate, detailed, and well-organized data and graphs; clear analysis of results.	Accurate and well-organized data and graphs; analysis of results.	Basic data and graphs; some inaccuracies or lack of organization; limited analysis of results.	Inaccurate or minimal data and graphs; poor organization and analysis of results.
Infographic Presentation	Creative, comprehensive, and visually appealing; effectively communicates data and process.	Creative, comprehensive, and visually appealing; effectively communicates data and process.	Basic presentation; communicates some data and process but lacks detail or creativity.	Minimal presentation; lacks clarity and fails to effectively communicate data and process.

Teacher note: Review and edit the rubric to meet your guidelines. Update the student page as needed.