

Water Filtration

August 9, 2021- August 15, 2021

SPONSOR BACKGROUND

FIRST at Yale is a student organization on a mission to increase access to STEM education through FIRST robotics programs. FIRST, or For Inspiration and Recognition of Science and Technology, is a nonprofit organization that runs international robotics competitions for students from Kindergarten to 12th grade. To learn more, please visit firstatyale.org and firstinspires.org.

CHALLENGE OBJECTIVE

Design and build a low-cost water filtration system. Your goals are to minimize water turbidity (i.e. a measure of the relative clarity of the water), maximize flow rate through the system, and minimize manufacturing costs.

DESIGN AND CONSTRUCTION RULES

- Water filtration systems may be constructed from any materials, provided that the design complies with all the rules listed below.
- The following materials and tools are prohibited for reasons of safety:
 - Hazardous materials, such as mercury, lead, or lead containing compounds.
 - Any item that stores a large amount of potential energy, such as large springs.
 - Any item that produces an open flame.
- Handle sharp edges with great care and/or supervision.
- The water filtration system must not exceed 30 centimeters in width, 30 centimeters in length, or 45 centimeters in height.
- All filtration system designs should be mechanical (i.e. chemical solutions are prohibited).
- Commercial off-the-shelf (COTS) water filtration equipment is prohibited. Prohibited products include filter cartridges for water filtration pitchers, faucet-mounted filters, reverse osmosis systems, or any other product explicitly designed for the purpose of removing impurities from water.
- Any submissions **exceeding a total cost of \$20 will be disqualified** from the competition.
- **Do not under any circumstances consume the filtered water.**

TESTING RULES

- Mock wastewater should be made according to the following recipe (multiply the amounts if more wastewater solution is needed):
 1. Collect $\frac{1}{4}$ cup of grass clippings, making sure to compress the grass clippings into your measuring vessel.
 2. Combine 2 cups cold tap water, $\frac{1}{2}$ cup topsoil, and the grass clippings in a large container.
 3. Mix until well combined.
- No human interaction with the filter is allowed during testing (with the exception of adding additional wastewater).

- Video recorded test runs should last 3 minutes in length. The entire filtration system should be in frame during the 3 minute test run, during which you should attempt to filter at least one cup (8 fl oz) gallon and up to one gallon (128 fl oz) of wastewater.

CONTENT REQUIRED FOR SUBMISSIONS

- **Video** of the filtration system filtering mock wastewater for 3 minutes. The filtered water should be visible at the end of the video.
- A **written description** (200 words or fewer) of the filtration system and its primary components/materials. *The written description must also include the **calculated flow rate** and **total cost** (see the Submission Process section below for details).*
- A **photograph** of the filtered water in a clear plastic bag (e.g. sandwich bag) against a white background.
- A **Bill of Materials** listing each item used in the construction of the final water filtration system (all entries must be accompanied by their costs).

SUBMISSION PROCESS

- Record a video of a 3 minute test run and upload it to [HERE](#).
- Upload the completed written description [HERE](#).
 - To calculate the flow rate, measure the total volume (in ounces) of the filtered water and then divide by 3 minutes. This value is the amount of water that the filter can process in one minute.
- Take a photograph of a sample of the filtered water in a clear plastic sandwich bag against a white background (e.g. printer paper). Upload it [HERE](#).
- Write the Bill of Materials in a spreadsheet format (e.g. Microsoft Excel, Google Sheets). One column should contain the name of the item, and the column next to it should contain the costs to purchase each item. If an item was purchased in bulk and only a portion is used, allocate the cost proportionally (e.g. if a 12-pack of wooden dowels cost \$8 and you only use 3 dowels, record \$2 for the cost of wooden dowels). For items found in your home, find the cost online (either from the manufacturer or an ecommerce site) and record accordingly.

HOW WILL WINNERS BE SELECTED?

- Submissions will be ranked primarily according to the turbidity of the filtered water (as determined by judges' visual inspection of the submitted photographs and videos). See the rubric below for details.
- Submissions will be ranked secondarily according to the flow rate of the filtration system (higher flow rate leads to a higher ranking)
- Any ties will be broken on the basis of cost (i.e. the filtration system with the lowest manufacturing cost among tied submissions wins the tiebreaker and is ranked the highest of the previously tied submissions)

Visual Inspection of Turbidity - Rubric

5	4	3	2	1
Filtered water is indistinguishable from plain tap water. Full marks awarded.	Filtered water is slightly tinted. White background is clearly visible through the bag. No pieces of sediment are visible.	Filtered water is light brown. Little to no pieces of sediment are visible. White background is visible through the bag but is partially obstructed due to the color of the water.	Filtered water is very dark in color; white background is not visible through the bag. Some pieces of sediment may be visible.	Filtered water is very dark in color and contains visible and identifiable pieces of waste (e.g. clumps of soil or blades of grass)