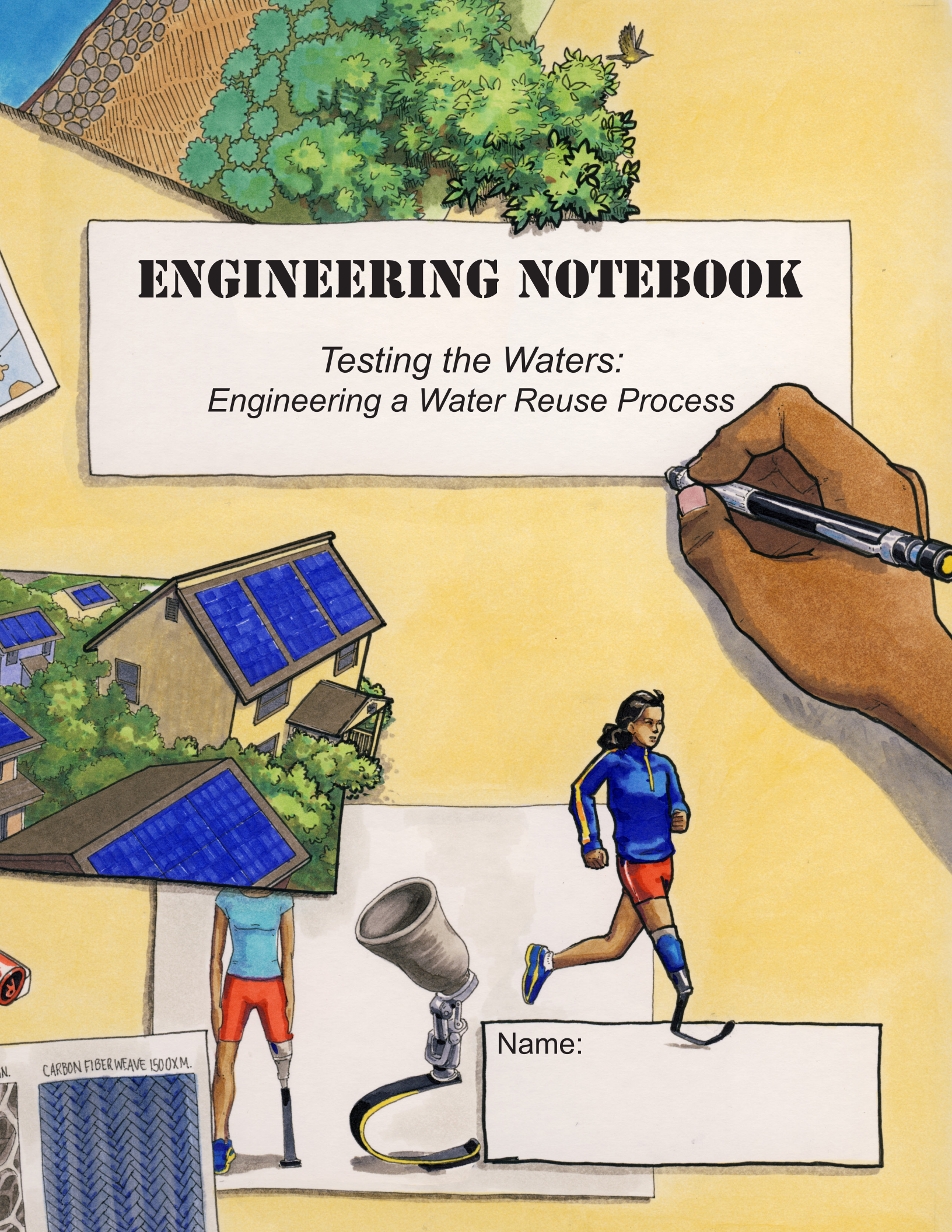


ENGINEERING NOTEBOOK

Testing the Waters:
Engineering a Water Reuse Process

Name:

Prep Activity 1

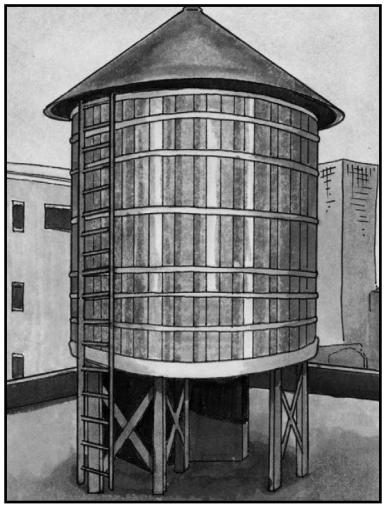
Criteria and Constraints

In engineering, guidelines for your design are called criteria and constraints.

GOAL: Engineer a model tower that can support a water collection tank.

CRITERIA **Things you or your design needs to do**
You will work in groups to engineer your tower.
Your tower must be at least 1 foot tall, not including the water container.
Your tower must hold the plastic container filled with water for at least 10 seconds.

CONSTRAINTS **Ways you and your design is limited**
You will have 100 index cards, masking tape, a ruler, and a pair of scissors.
The scissors and the ruler cannot be used as a part of the tower.
You only have 20 minutes to *create* your tower.
You can hold the water container as you build, but you cannot *test* with it until the official testing time begins.



My Engineering Profile

Prep Activity 2

Check off the skills YOU bring to the table.

☐ **Communication**
- I give valuable feedback to others
- I like giving presentations

☐ **Creativity**
- I imagine lots of ideas
- I come up with new ways of doing something

☐ **Critical Thinking**
- I solve problems
- I make sense of complicated information

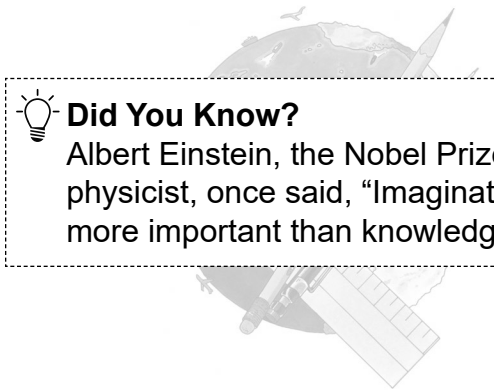
☐ **Leadership**
- I lead teams well
- I make sure everyone has a voice

☐ **Persistence**
- I learn from failure
- I keep trying until I succeed

☐ **Teamwork**
- I work well in teams
- I like giving and receiving feedback on my work

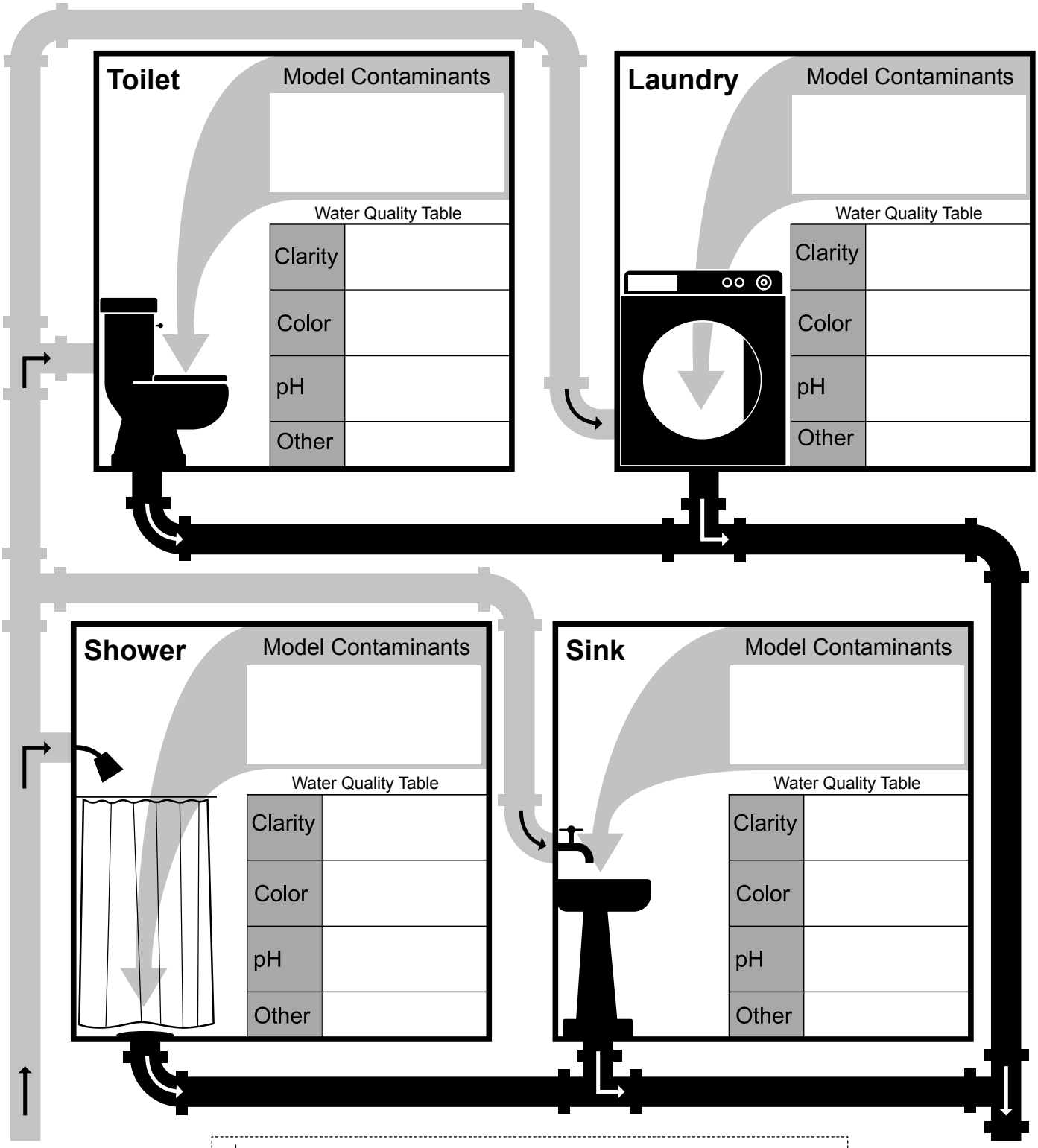
☐ **Technical Skills**
- I make things
- I like working with different materials

Which skills do you want **to use**?	Which skills do you want **to learn**?



Did You Know?
Albert Einstein, the Nobel Prize-winning physicist, once said, “Imagination is more important than knowledge.”

Water in the Home



Did You Know?
According to the United States Geological Survey, the average person uses 80-100 gallons of water per day.

How to Test Water Quality

Activity 1

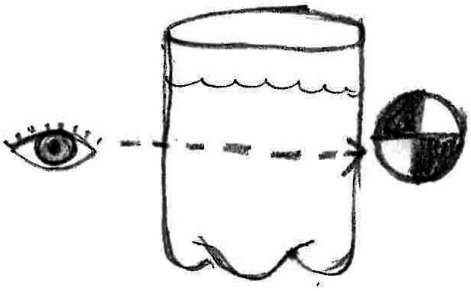
Clarity

Use a Secchi disk:

1. Place the Secchi disk on one side of the container and look through the water sample at the Secchi disk.

2. How clearly can you see the Secchi disk on the other side? Score the clarity.

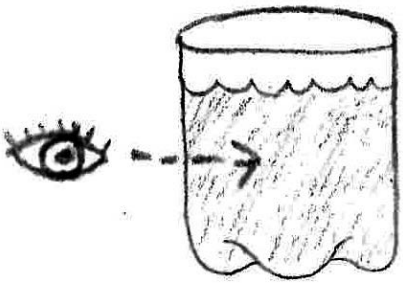
not clear	cloudy	clear
0	1	2



Color

1. Look at the water sample.
2. Score the color.

has color	colorless
0	1

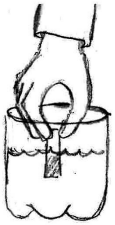


Acidity

Use a pH strip:

1. Dip the end of the pH strip into the water sample.
2. The pH strip will turn a color. Compare it with the color scale on the pH packet.
3. Score the acidity.

acid	neutral	base
0-5	6-8	9-14



Optional:

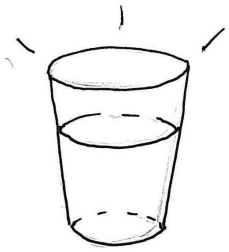
_____

Activity **1**

How Clean Does It Need to Be?

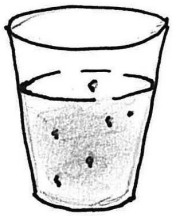
Water can be categorized in three ways: pure water, greywater, and waste water. Use the key below to see how clean water need to be for each category.

PURE WATER	
Clarity	2
Color	1
pH	6–8



*Can be used at **any** location*

GREYWATER	
Clarity	1–2
Color	0
pH	5–9



Can be used for:

TOILET

WATERING EDIBLE PLANTS

WATERING LANDSCAPE PLANTS

WASTE WATER	
Clarity	0
Color	0
pH	0–4 or 10–14

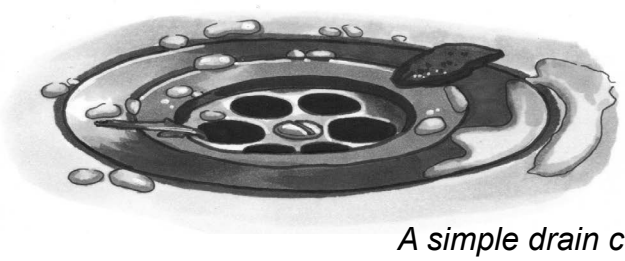
Can be used for:

WATERING LANDSCAPE PLANTS

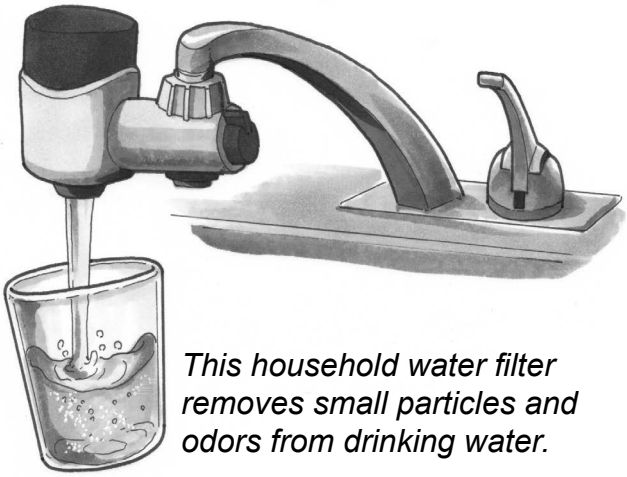
Water Filters

Activity 2

Engineers design water filters in many shapes and sizes! Take a look at some water filter technologies.

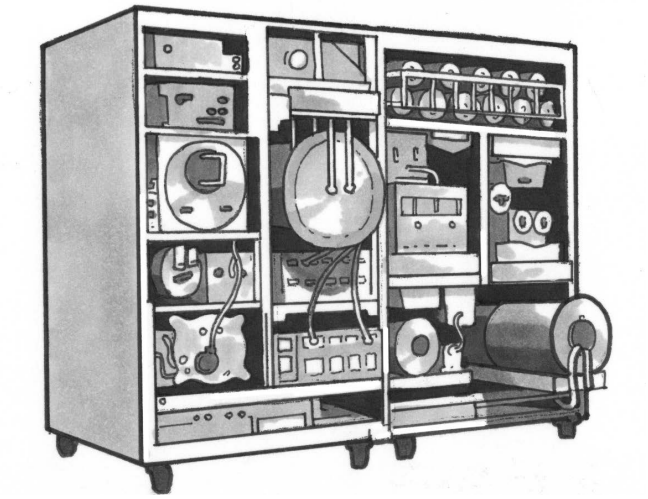


A simple drain cover in a kitchen sink can catch large pieces of food and prevent them from clogging pipes.



This household water filter removes small particles and odors from drinking water.

This filter technology, inspired by a straw, was engineered to provide quick and portable water filtration.



This water filtration system uses complex processes to remove salt and body waste from water in space.

Did You Know?
American astronauts on the International Space Station will filter and reuse their own pee to drink the next day!

Using a Filter Base

1. Place filter material in the top of the Filter Base. (In this example, cheesecloth is used to keep the charcoal from falling through the funnel.)

2. Pour a dirty water sample into the open top of the Filter Base.

3. Water flows through the filter material into the bottom of the bottle.

4. Remove the top of the Filter Base and place used filter materials in the foil trays.

5. Measure the quality of the water sample in the bottom of the bottle.

6. Repeat with each filter material by pouring a new sample of dirty water through each filter material.

Investigating Filters

Activity 2

We are filtering water from the:

Shower Bathroom sink Laundry Toilet

Water Quality BEFORE Filtering	Clarity	Color	pH	_____ Optional

Water Quality AFTER Filtering				
Filter Material Tested	**Clarity**	**Color**	**pH**	_____ Optional
5 cotton balls				
1 square of cheesecloth				
1 paper towel, half-sheet				
1/4 cup sand (with cheesecloth lining)				
2 Tbsp limestone (with cheesecloth lining)				

How were you able to *improve* the water quality of your sample using the filters?

Which filters could you combine to *improve* the water quality even more?

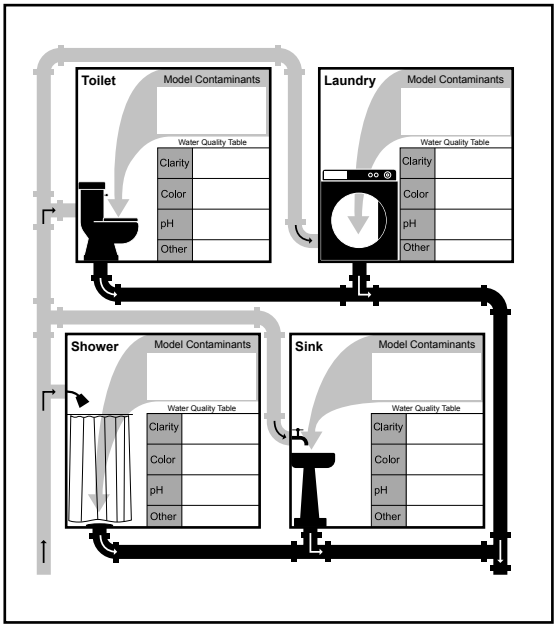
Made to Order

A family would like to reconfigure their home to use less pure water.

GOAL: Design a process for reusing water in their home.

CRITERIA **Things you or your design needs to do**
You will work in groups to design your process.
Each location must have water going in and coming out.
Greywater must be used at one or more locations.
You must represent filters with modeling clay.

CONSTRAINTS **Ways you and your design is limited**
You will have only five straws of each color and half a stick of modeling clay.
One filter can *improve* water quality by only one level.
You cannot reuse toilet water.



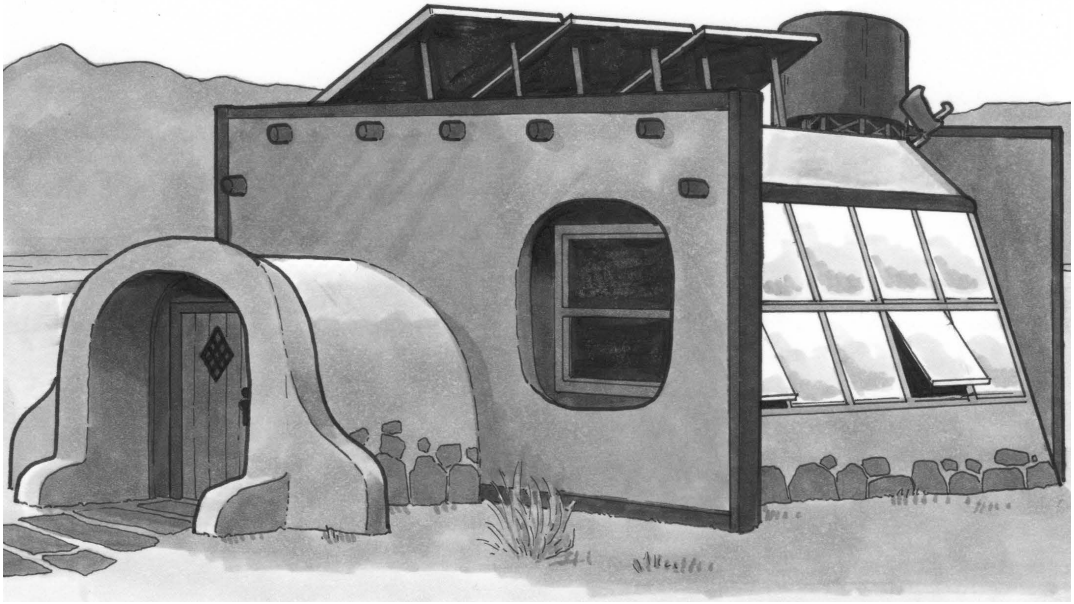
The old pipes

Extreme Environment 1: Eco-Friendly Home

Activity 4

Your team is building an off-the-grid home in the American Southwest, so all resources (water and electricity) will come from the environment. These homes are specially designed to collect and reuse water. You will need to create *a process that filters enough water to reuse in the toilet.*

Did You Know?
Sources of drinking water on Earth include rain, groundwater, lakes, rivers, and springs. Off-the-grid homes—even the ones in the driest deserts—don't have to be as efficient as NASA space missions because they can get more water from these sources.



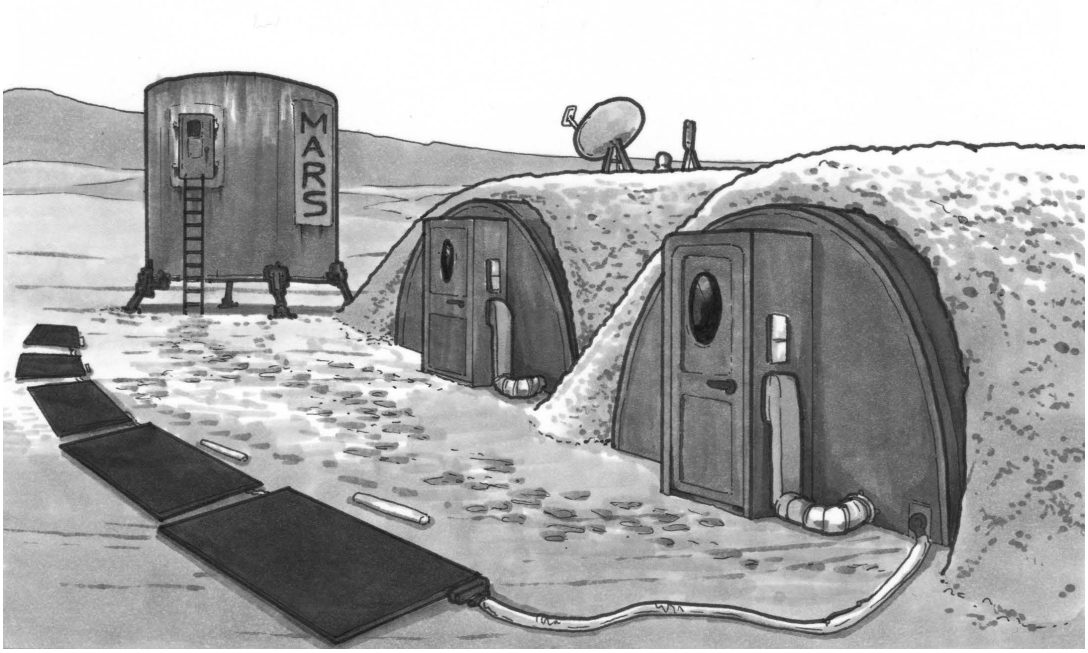
Criteria	Constraints
Must filter water from each source: • bathroom sink • shower	You can use two Filter Bases.
Must produce: • greywater for use in toilet	

Activity **4**

Extreme Environment 2: Mars Habitat

Your team is designing a process for reusing water on Mars. This process needs to reuse as much water as possible and still produce enough water for the plants in the greenhouse.

Did You Know?
Most of the surface of Mars is almost completely dry. There are reservoirs of ice in the north and south polar regions and under the surface near the poles.



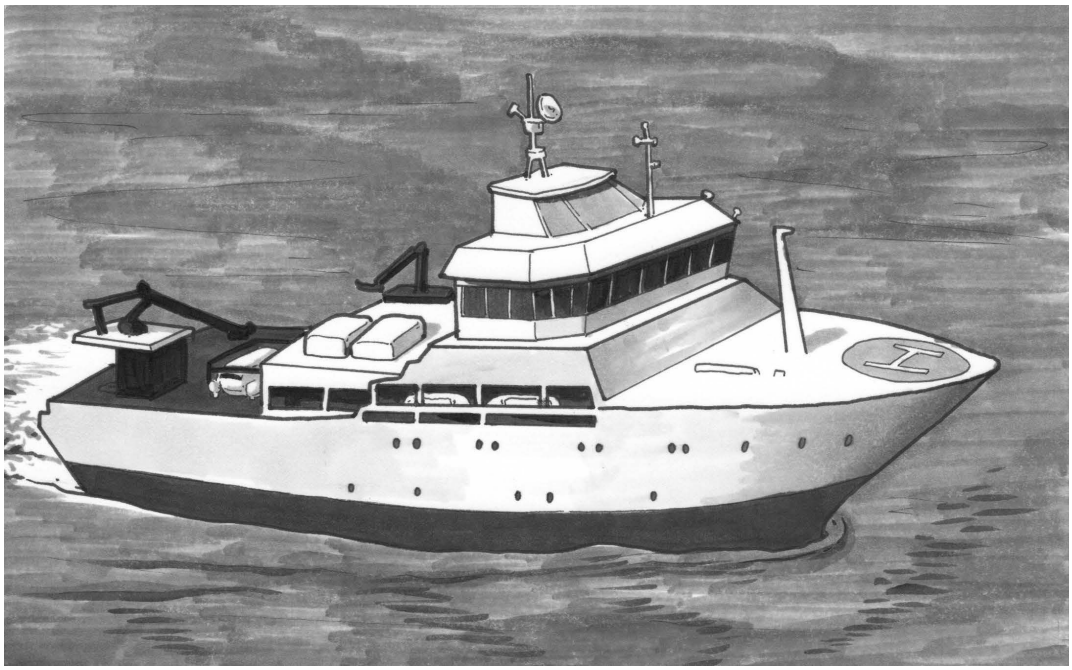
Criteria	Constraints
Must filter water from each source: • laundry • shower • space toilet	You can use two Filter Bases.
Must produce: • greywater for watering edible plants	

Extreme Environment 3: Floating Research Lab

Activity 4

Your team is living on a boat. You will have to filter and reuse as much water as you can on-board, or you'll risk polluting the surrounding waters.

Did You Know?
Ocean water is not usable to sailors on most ships. The Navy is working with NASA to *improve* its ability to use and reuse ocean water for human activities.

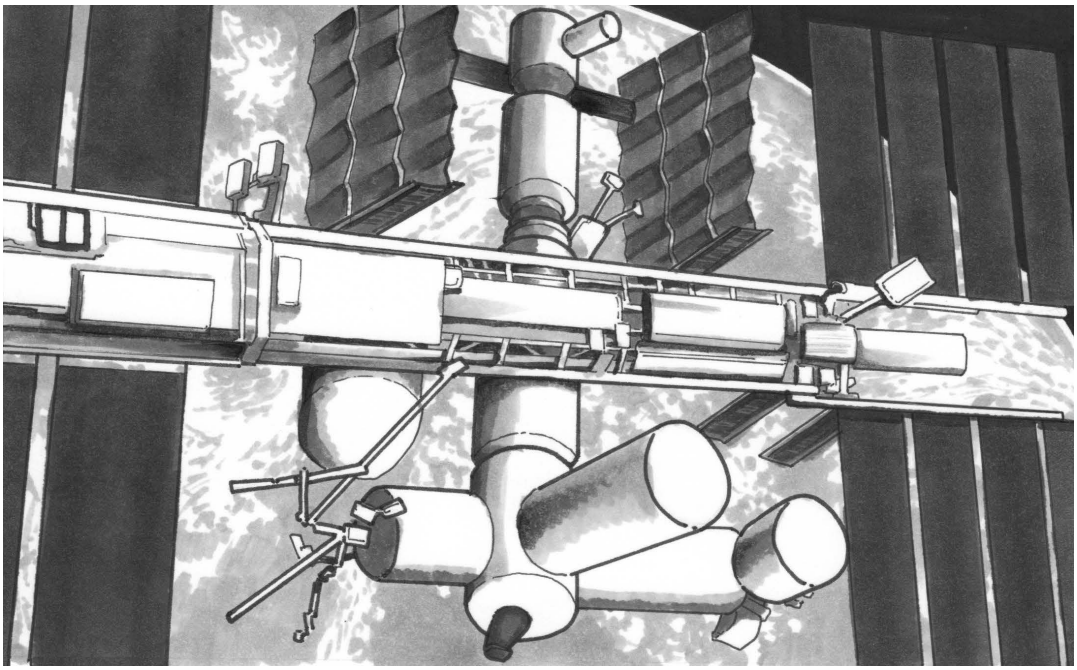


Criteria	Constraints
Must filter water from each source: • bathroom sink • laundry • shower	You can use two Filter Bases.
Must produce: • greywater for toilet	

Activity 4 Extreme Environment 4: International Space Station

Your team is creating *a process for reusing water for the International Space Station. You need to reuse all the water you use on board. The next shipment of freshwater won't arrive for another 3 months!*

Did You Know?
A space toilet is different from a toilet on Earth because solid waste is disposed of separately, while liquid waste is collected for reuse.



Criteria	Constraints
Must filter water from each source: • bathroom sink • laundry • shower • space toilet	You can use two Filter Bases.
Must produce: • greywater • pure water	

Planning a Process

Activity 4

Extreme Environment: _____

The goal is to produce:

_____ cups of greywater _____ cups of pure water

How will you order your water samples and Filter Bases? Consider these questions when *planning* your water reuse process:

Which water sample(s) should go into the first filter?

Which water sample(s) should go into the second filter?

Which materials should be used in the first filter?

Which materials should be used in the second filter?

Draw a detailed *plan* of your group's water reuse process. Make sure to label the locations in your drawing and the materials you would like to use in your filter(s).

Testing a Process

Record the results of your water reuse process here. If you only used one filter, record the results in the first column. If you used a second filter, record the results after filtering the water a second time in the second column.

Test	Water Quality (After Filter 1)				Final Water Quality (After Filter 2)			
	Clarity	Color	pH	_____	Clarity	Color	pH	_____
1				Optional				Optional
2								
3								

Does the **final water sample** meet the water quality goal?

How can you *improve* your process?

Cost Sheet

Activity 5

Use this page to determine which filter materials you can use without going over budget.

Extreme Environment	Budget
1. Eco-Friendly Home	$125
2. Mars Habitat	$250
3. Floating Research Lab	$250
4. International Space Station	$325

Materials List

Material	Cost	Number Needed	Total Cost
Rubber bands	$15	_____	_____
Paper towel (half sheet)	$20	_____	_____
Cheesecloth (1' x 1')	$25	_____	_____
Cotton ball (1)	$25	_____	_____
Sand (1/4 cup)	$30	_____	_____
Charcoal (2 Tbsp)	$50	_____	_____
Limestone (2 Tbsp)	$75	_____	_____

Grand Total _____

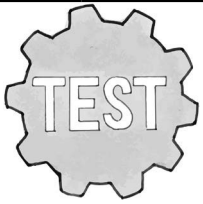
Did You Know?
Water filters that help kill germs were invented by NASA in the 1970s. Your dentist now uses that same technology so they don't spray bacteria-filled water into your mouth!

Activity **5**

Improving a Process

Draw a detailed plan for the improvements your group would like to make to your water reuse process. Make sure to label your drawing and keep track of any new materials you use.

Test	Water Quality (After Filter 1)				Final Water Quality (After Filter 2)				Final Amount of Water
	Clarity	Color	pH	_____	Clarity	Color	pH	_____	
				Optional				Optional	
1									
2									



Communicate

Activity 6

During the Showcase, you will get to share information about your engineering challenge with people who are not familiar with the problem. What are some things you might want to tell them about engineering a water reuse process?

Activity **6**

My Engineering Profile 2

Think about how you have changed as an engineer, and update your engineering profile.

☐ **Communication**
- I give valuable feedback to others
- I like giving presentations

☐ **Creativity**
- I imagine lots of ideas
- I come up with new ways of doing something

☐ **Critical Thinking**
- I solve problems
- I make sense of complicated information

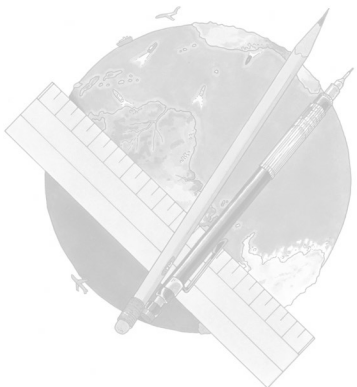
☐ **Leadership**
- I lead teams well
- I make sure everyone has a voice

☐ **Persistence**
- I learn from failure
- I keep trying until I succeed

☐ **Teamwork**
- I work well in teams
- I like giving and receiving feedback on my work

☐ **Technical Skills**
- I make things
- I like working with different materials

Which skills did you **use**?	Which skills have you **learned**?



Water Reuse Glossary

Constraints: Ways that your design is limited.

Contaminant: A substance that makes water dirty or unsafe to drink.

Criteria: Things your design needs to do.

Engineering Design Process: The steps that engineers use to design technologies to solve a problem.

Extreme environment: A place where it is difficult for people to survive.

Greywater: Water that has been used at least once and can be used again.

Process: A series of steps completed in a certain order to solve a problem.

Pure water: Water that is clean and safe enough to drink.

Technology: Any thing or process designed by people to solve a problem.

Waste water: Water that is too dirty to be used again.

Water quality: The characteristics that let us know if water is safe to use.

Water resource engineer: Someone who uses his or her creativity and knowledge of math and science to design technologies that solve problems related to providing people with access to clean and safe water.

Water scarcity: When people do not have enough water to complete all the tasks they need to live.

Engineering Design Process

Understand the engineering problem.

- Define the problem in your own words.

Gather details.

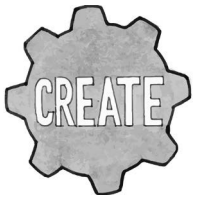
- Learn about what others have done.
- Explore possible materials or processes you could use for your design.
- Conduct science experiments to gather data.

Come up with different ways to solve the problem.

- Use your creativity to think of lots of ideas that could work.
- Evaluate the pros and cons of each idea.
- Pick one idea that is a good starting point.

Figure out the details of your design.

- Discuss how it will work.
- Draw diagrams and list materials.
- Decide how you will test and evaluate.



Build your design.

- Follow your plan.
- Fix small problems.
- Record any changes to your plan.

Evaluate how well your design works.

- Test multiple times.
- Record your observations and findings.
- Figure out which parts are working well and which parts are not.

Make changes to your design based on testing.

- Decide what to change.
- Put your changes into a new plan.
- Build your improved design and test again.

Share your solution with others.

- Explain strengths and weaknesses of your solution.
- Share how you used the Engineering Design Process.
- Ask people for feedback.


lines for streamlining and shock absorption
frontal view
lateral view
Wind Power Turbine
Gear box
Rotor blade
Nacelle
Hub
Brake