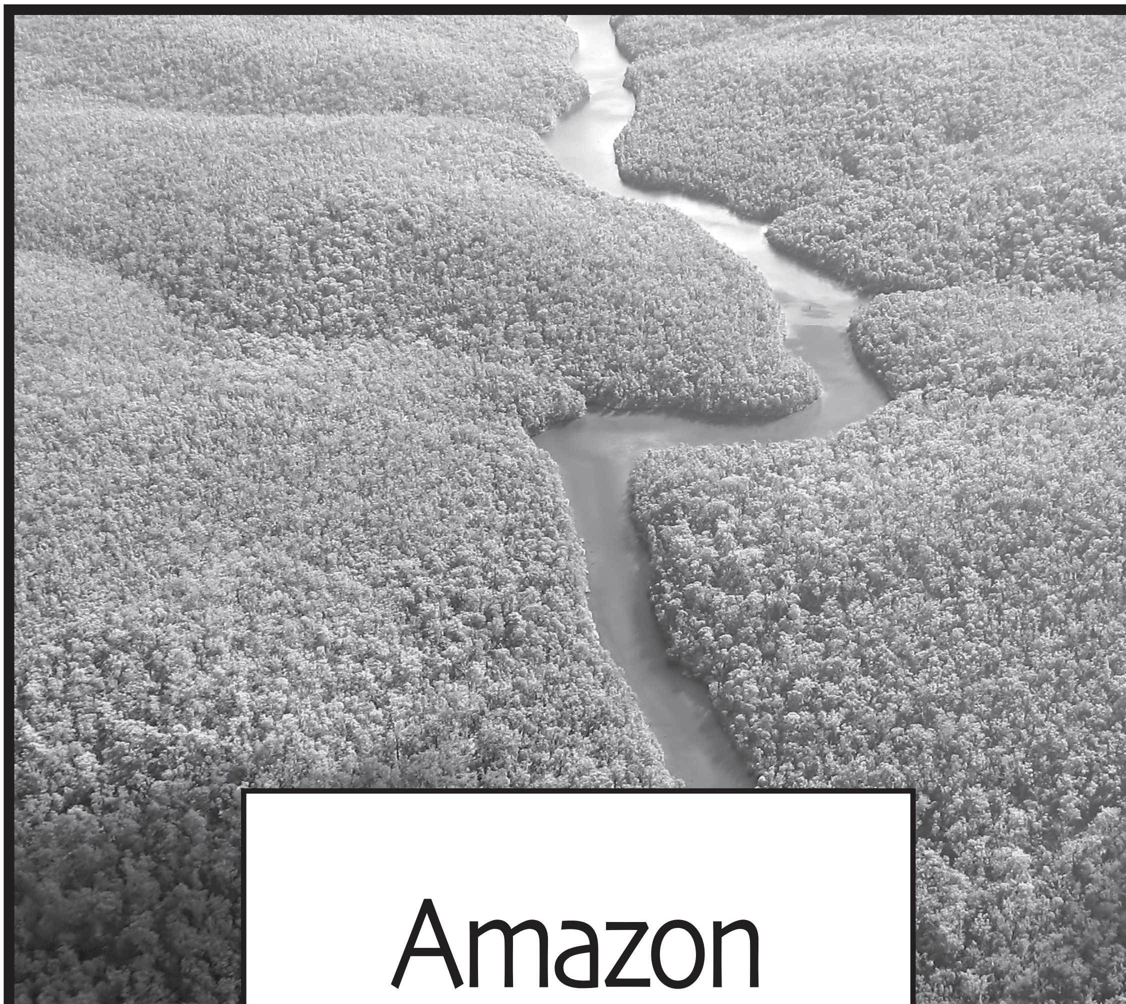

# Amazon Mission

Building Math

Integrating Algebra & Engineering

Name

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## *AMAZON MISSION* INTRODUCTION

Deep in the heart of the tropical rain forests of Brazil and Venezuela lives a group of indigenous people known as the Yanomami (Yah-no-mah-mee). From the time they first inhabited the earth, the Yanomami lived in harmony with the environment, isolated from the rest of the world. They thrived in the lush rain forest, abundant with natural resources and wildlife—that is, until recently. In just the last few decades, outsiders have entered the Yanomami territory. This contact now threatens their very existence, and the Yanomami need your help! Imagine that you are joining the community service team at your school on a mission to the Amazon rain forest. You will investigate, and hopefully solve, the problems of the Yanomami. The future of the Yanomami people depends on you and your classmates!

- **INTRODUCING THE ENGINEERING DESIGN PROCESS (EDP)**
  What is engineering? What does an engineer do?
- **DESIGN CHALLENGE 1: MALARIA MELTDOWN!**
  Design a medicine carrier that can safely transport malaria medicine while keeping it cool in a tropical climate.
- **DESIGN CHALLENGE 2: MERCURY RISING!**
  Design a water-filtration system to remove mercury from a river.
- **DESIGN CHALLENGE 3: OUTBREAK!**
  Design a virus intervention plan to contain the spread of the flu.

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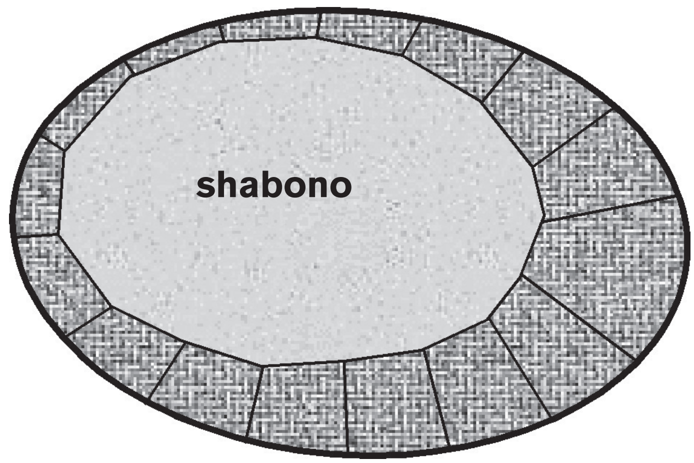
## *AMAZON MISSION* INTRODUCTION *(CONTINUED)*

### YANOMAMI WAY OF LIFE

The community service team has done some initial research on the Yanomami people. They've found that there are approximately 20,000 Yanomami people currently living in Amazonia. The Yanomami live together in villages that may have as few as 40, and as many as 400, inhabitants. There are about 250 independent villages in the Amazon rain forest. In each village, the Yanomami people live together in a single, circular structure called a *shabono.* Within the shabono, families cluster together around their handmade hammocks and hearth fires. With no walls separating the families, privacy is rare in a Yanomami village. The center of the shabono consists of a large open space where the children play and the adults engage in celebrations.

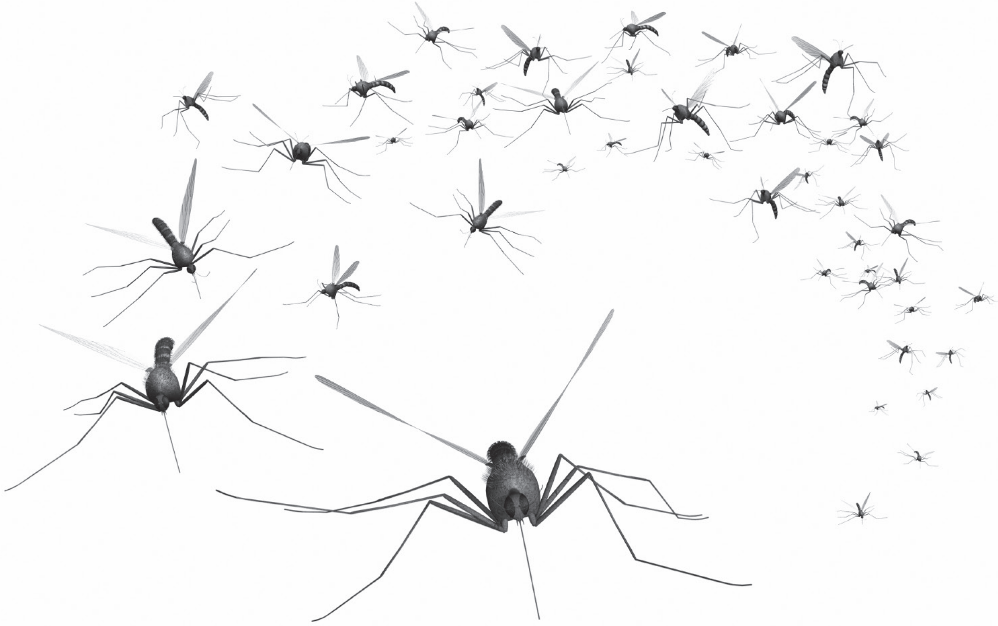



The Yanomami's simple way of life offers a glimpse into the way all humankind lived nearly 20,000 years ago. Their days consist of hunting, gathering, fishing, gardening, and making necessary items, including hammocks, baskets, and bows and arrows. In contrast to the industrialized world's digital age of music, television, and video, the Yanomami pass the time with storytelling and spiritual activities.

### THREATS TO YANOMAMI EXISTENCE

In the 1960s, gold was discovered in the Yanomami territory. At that time, gold miners did not have the technology to effectively mine in a tropical rain forest. However, advancements in mining and travel technologies in the late 1900s eventually gave gold miners the means to enter and mine in Amazonia. With no government regulations to stop outsiders from entering the Yanomami land, gold-mining activity in the Amazon rain forest grew quickly. Miners in Amazonia had little concern for the Yanomami villagers or their land while on their search for gold. They cut down trees to make way for mining pits, polluted the water and air with chemicals, and scared off game with loud drilling. They introduced life-threatening diseases to the Yanomami, and even shot and killed some of the Yanomami villagers who got in their way.

Indeed, if life for the Yanomami continues in this way, it is estimated that the Yanomami people will become extinct in the next decade. You and your community service team must do what you can to save them!



# Design Challenge 1

## Malaria Meltdown!

### INTRODUCTION

One of the Yanomami villages has already contacted the community service team at your school, requesting your help. More than half of the villagers are sick with malaria, suffering from severe fevers, chills, and fatigue. Some of the sickest villagers are on the verge of death. The only thing that can save them now is antimalarial medication, but the village has run out! The Yanomami people have asked that you bring a new supply of medicine to the village, and now desperately await your arrival!

Malaria is spread through the bite of the anopheles mosquito. Abandoned mining pits, which are filled with still, warm water, are a breeding ground for these mosquitoes. It seems impossible to stop the spread of the disease. For now, the Yanomami people must rely on antimalarial medicine to treat their symptoms and cure them of the disease. Scientists have just developed a new drug that is 98% effective in curing malaria. The Yanomami need a supply of this new medicine immediately. The drug is highly sensitive. It must be kept between 15°C and 30°C at all times. If the medicine's temperature drops below 15°C or goes above 30°C, it becomes permanently ineffective. You need to transport the medicine to the village while controlling its temperature carefully.

## 1. DEFINE THE PROBLEM: MALARIA MELTDOWN!

In order to get the medicine to the village, you and your classmates will first fly to Manaus, Brazil. From there, you will take a helicopter to a clearing that is approximately 13 km from the Yanomami village. The medicine will remain safe during the flights, stored in a large temperature-controlled refrigerator. However, once you've reached the helicopter landing, you must carry the medicine the rest of the way to the village by foot. The hike to the village will take 2 hours. The Amazon rain forest has an average temperature of 37˚C this time of year. In the heat of the rain forest, medical officials think that their current medicine carrier will not be able to keep the medicine below 30˚C for very long. They fear the medicine will spoil before it reaches the village. The hospital needs your engineering team's help to design a new medicine carrier that can keep the medicine between 15˚C and 30˚C for the entire hike!

### ENGINEERING CRITERIA

| | |
|---|---|
| GOOD INSULATOR → | In an environment that is 37°C, the inside of your model carrier must stay between 15°C and 30°C for 2 hours. *** |
| LOW COST → | Your model should be as low in cost as possible. |
| RUGGED AND PROTECTIVE → | You will place an egg inside of the carrier, and you will drop the carrier from a height of 1 meter. Both the egg and the carrier must remain intact. |

*** Due to time constraints, you will let 1 minute represent 2 hours. Your model will perform to the same level in 1 minute as a carrier that is 11 times thicker would in 2 hours. Therefore, your actual carrier design will be 11 times thicker than your model design.

### ENGINEERING CONSTRAINTS

You are limited to the following materials for your carrier design:

- corrugated cardboard
- foam board
- bubble wrap
- aluminum foil
- heavy-duty tape

# 2. RESEARCH THE PROBLEM: MALARIA MELTDOWN!

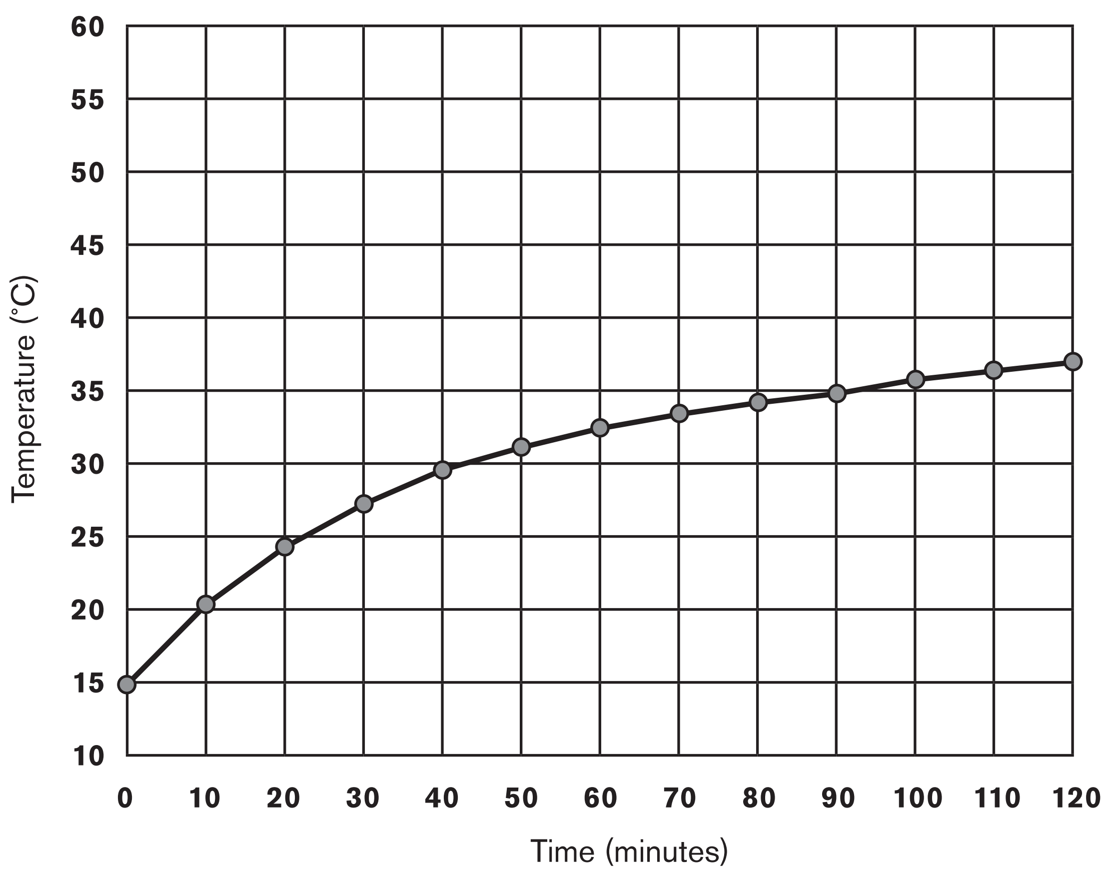
## RESEARCH PHASE 1: ANALYZE THE CURRENT MEDICINE CARRIER

A team of engineers has already done some initial testing on the current medicine carrier. The team cooled the medicine to the minimum temperature of 15°C and then placed it inside the carrier. The carrier was then placed in a 37°C laboratory room. The team checked the temperature of the medicine every 10 minutes for 2 hours. The results of their test are provided in Table 1.1 and Graph 1.1 below.

**Table 1.1: Temperature of Medicine Over Time in Current Container (in 37°C Lab Room)**

| TIME (MIN) | 0 | 10 | 20 | 30 | 40 | 50 | 60 (1 hr) | 70 | 80 | 90 | 100 | 110 | 120 (2 hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEMP (°C) | 15.0 | 20.2 | 24.2 | 27.2 | 29.4 | 31.2 | 32.5 | 33.5 | 34.3 | 34.8 | 35.3 | 35.6 | 35.9 |

**Graph 1.1: Temperature of Medicine Over Time in Current Container (in 37°C Lab Room)**



## 2. RESEARCH THE PROBLEM: MALARIA MELTDOWN!

### RESEARCH PHASE 1: ANALYZE THE CURRENT MEDICINE CARRIER

***(CONTINUED)***

Use Table 1.1 and Graph 1.1 to answer the questions below and on the next page.

1. Based on the graph, describe how the temperature is changing as time goes on.

____________________________________________________________

____________________________________________________________

____________________________________________________________

2. Using a ruler, draw a straight line that goes through the data points at 0 and 10 minutes.

   What is the slope of this line? ________

   What does this slope tell you about what is happening to the medicine's temperature between 0 and 10 minutes?

____________________________________________________________

____________________________________________________________

____________________________________________________________

3. Using a ruler, draw a straight line that goes through the data points at 110 and 120 minutes.

   What is the slope of this line? ________

   What does this slope tell you about what is happening to the medicine's temperature between 110 and 120 minutes?

____________________________________________________________

____________________________________________________________

____________________________________________________________

4. Based on the graph and your answers to questions 2 and 3, describe how the rate of change in the temperature changes over time.

____________________________________________________________

____________________________________________________________

____________________________________________________________

5. If the team of engineers left the medicine in the carrier in the 37˚C laboratory room for an entire day (24 hours), what do you think the medicine's temperature would be at the end of the day? _______˚C

   Explain your reasoning.

   ______________________________

   ______________________________

   ______________________________

6. The temperature of the medicine must not drop below 15°C and must not rise above 30°C. Using the variable $T$ to represent temperature, write these constraints in the form of a compound inequality on the line below.

   ______________________________

   Using a colored pencil, graph this inequality directly on Graph 1.1, and shade the region that represents all acceptable temperatures for the medicine.

7. Compare the graph of the current medicine carrier to the shaded region of acceptable temperatures. How would you rate the effectiveness of the current carrier? Explain your answer.

   ______________________________

   ______________________________

   ______________________________

8. Imagine a better medicine carrier that could keep the medicine between 15°C and 30°C for the entire 2-hour period. What might the graph of the temperature versus time look like for this carrier? Sketch one possible graph for this better medicine carrier directly on Graph 1.1, and label it "Better Carrier." There is more than one correct answer.

   How might you design a carrier that would match such a graph? Please describe your ideas in detail.

   ______________________________

   ______________________________

   ______________________________

## 2. RESEARCH THE PROBLEM: MALARIA MELTDOWN!

### RESEARCH PHASE 2: INVESTIGATING DIFFERENT MATERIALS

Now that you have completed some research on the old design, you are ready to investigate some new materials for your design. You will use your body temperature to simulate the 37°C tropical climate of the Amazon.

**Student jobs:** Assign each member of your group to one of the four jobs listed below.

**Heater:** ________________ **Timer:** ________________

**Cooler:** ________________ **Recorder:** ________________

**STEP 1: COOLER–**Place the uncovered thermometer stem in ice. Cool thermometer to 10°C or colder.

**STEP 2: HEATER–**For the "bare hands" trial, place the thermometer stem between your palms. For trials with materials, place one layer of material on each palm and then place the thermometer stem between the pieces of material. Make sure that the materials completely cover the thermometer stem, including the tip. Also, do not fold the materials. Press palms together. When the thermometer reads 15°C, say "Start timing!" Keep your palms pressed firmly together for 1 full minute.

**STEP 3: TIMER–**When you hear the **Heater** say "Start timing!" immediately click "start" on your stopwatch. Shout "Time!" at every 10-second interval (when the watch reads 10, 20, 30, 40, 50, and 60 seconds).

**STEP 4: HEATER–**Watch the thermometer. Each time the **Timer** shouts "Time!" read the temperature aloud. The **Recorder** should record the values that the **Heater** reports in Table 1.2 below.

**STEP 5:** Repeat steps 1–4 with a different material.

**Table 1.2: Temperature of Different Materials Over Time**

| MATERIAL | TEMPERATURE (°C) ON THERMOMETER | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 sec | 10 sec | 20 sec | 30 sec | 40 sec | 50 sec | 60 sec |
| 1. bare hands | 15°C | | | | | | |
| 2. corrugated cardboard | 15°C | | | | | | |
| 3. foam board | 15°C | | | | | | |
| 4. bubble wrap | 15°C | | | | | | |
| 5. aluminum foil | 15°C | | | | | | |

## 2. RESEARCH THE PROBLEM: MALARIA MELTDOWN!

### RESEARCH PHASE 2: INVESTIGATING DIFFERENT MATERIALS

1. Graph your data from Table 1.2 on the grid below. Remember to label the axes, color in the key, and give the graph a title. Use the rubric provided by your teacher to assess your work. Then use your graph to answer the questions that follow.

KEY

☐ = bare hands

☐ = corrugated cardboard

☐ = foam board

☐ = bubble wrap

☐ = aluminum foil

2. Which of the materials, if any, would be able to keep the medicine from spoiling?

3. Which material worked the best? ___________________

   Why do you think this material worked better than the others?

4. Do you think there would be any drawbacks or disadvantages to using this material? Explain.

## 2. RESEARCH THE PROBLEM: MALARIA MELTDOWN!

### RESEARCH PHASE 3: COMBINING DIFFERENT MATERIALS

Now that you have investigated how well individual materials keep out the heat, you will take a look at how different materials work in permutation. You will test _____________ and ______________.

1. Come up with four different ways that you could combine these two materials. Each permutation can have anywhere from 2 to 5 total layers of material. For each permutation, identify the innermost and outermost layers.

| | Permutation 1 | Permutation 2 | Permutation 3 | Permutation 4 |
|---|---|---|---|---|
| INNERMOST LAYER<br>↓<br>OUTERMOST LAYER | | | | |

2. Of the permutations you identified above, which do you think will be the best insulator? Explain your reasoning.

_______________________________________________________________

_______________________________________________________________

_______________________________________________________________

3. Using the same steps that you used to conduct the experiment in Research Phase 2, test all four permutations you identified above. You will need two sets of materials for each permutation to make a "sandwich." Record your results in the table below.

**Table 1.3: Temperature versus Time for Different Permutations of Materials**

| Material Permutations | Temperature (°C) on Thermometer | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 sec | 10 sec | 20 sec | 30 sec | 40 sec | 50 sec | 60 sec |
| 1. | 15°C | | | | | | |
| 2. | 15°C | | | | | | |
| 3. | 15°C | | | | | | |
| 4. | 15°C | | | | | | |

4. You will be presenting your results to the class. Decide as a group how to best display the results of your experiment. Then use the grid below to display your data. Use the rubric provided by your teacher to assess your work.

5. Based on the results of your experiment, what advice would you give to your classmates on designing their medicine carriers regarding the materials you tested?

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BRAINSTORM

# 3. BRAINSTORM POSSIBLE SOLUTIONS: MALARIA MELTDOWN!

You've done some great research and are ready to think about some possible medicine-carrier designs. As you brainstorm possible solutions, keep these design criteria and constraints in mind.

## ENGINEERING CRITERIA

| | |
| --- | --- |
| GOOD INSULATOR | In an environment that is 37°C, the inside of your model carrier must stay between 15°C and 30°C for 2 hours.*** |
| LOW COST | Your model should be as low in cost as possible. |
| RUGGED AND PROTECTIVE | You will place an egg inside of the carrier, and you will drop the carrier from a height of 1 meter. Both the egg and the carrier must remain intact. |

*** Due to time constraints, you will let 1 minute represent 2 hours. Your model will perform to the same level in 1 minute as a carrier that is 11 times thicker would in 2 hours. Therefore, your actual carrier design will be 11 times thicker than your model design.

## ENGINEERING CONSTRAINTS

You may combine the five available materials in whatever manner you choose. The cost of 1 square meter ($m^2$) of each material is listed in Table 1.4 below.

**Table 1.4: Cost per Square Meter ($m^2$) of Materials for Medicine Carrier**

| MATERIAL | COST FOR 1 SQUARE METER ($m^2$) |
| --- | --- |
| corrugated cardboard | $0.99 |
| foam board | $2.25 |
| bubble wrap | $2.85 |
| aluminum foil | $0.50 |

Name

STUDENT PAGE

BRAINSTORM

**INDIVIDUAL DESIGN**

Working on your own, use the results of your research and the cost information provided in Table 1.4 to imagine one possible medicine-carrier design. Sketch your idea in the space below. Label all materials and the dimensions (length, width, and height) of your carrier.

## 4. CHOOSE THE BEST SOLUTION: MALARIA MELTDOWN!

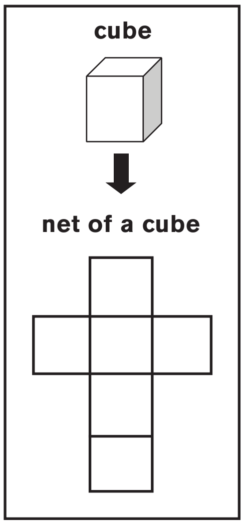
### TEAM DESIGN

1. Have each member of your team share his or her ideas with the group. For each idea, think about the following:
   - What do you like the most about the design?
   - Do you think the design will meet all of the engineering criteria and constraints?

2. As a group, decide on one "best" solution. Draw a three-dimensional sketch of the medicine-carrier design in the space below. Then label the materials and the dimensions of the carrier (length, width, height, and so forth). Draw a cross section of the carrier to show the order of materials you are layering. Use the rubric provided by your teacher to check the quality and completeness of your drawing. Practice using the rubric on the sample drawings provided by your teacher.

3. Look at the design you drew on page 58. Imagine what this carrier would look like if it were completely opened up and unfolded onto a single, flat surface. This is called the net of your three-dimensional design. Draw this net as best you can in the space below. Label all side lengths of your net. Use the rubric provided by your teacher to check the quality and completeness of your drawing. Practice using the rubric on the sample drawings provided by your teacher.

**EXAMPLE**



4. Using the net you drew in problem 3, calculate the approximate surface area of your medicine-carrier design. This surface area will help you find the approximate cost of each layer of material in your carrier.

**SHOW YOUR WORK**

5. Using the table below, calculate the cost of each material and the total cost of your design.

**Table 1.5: Calculating Cost**

| MATERIAL | NUMBER OF LAYERS NEEDED | AREA OF EACH LAYER (YOUR ANSWER TO PROBLEM 4) | TOTAL AREA FOR ALL LAYERS OF THIS MATERIAL ($m^2$) | COST PER SQUARE METER ($m^2$) | TOTAL COST FOR EACH MATERIAL ($) |
|---|---|---|---|---|---|
| corrugated cardboard | | | | $0.99 | |
| foam board | | | | $2.25 | |
| bubble wrap | | | | $2.85 | |
| aluminum foil | | | | $0.50 | |

Total cost: ________________

## 5. BUILD A PROTOTYPE/MODEL: MALARIA MELTDOWN!

Following your design from Step 4, gather all necessary materials and construct a model of your medicine carrier. As you build your model, draw or use words to describe any changes to your original design in the space below. Use the rubric provided by your teacher to assess your work.

Name ______________________________________________
STUDENT PAGE

6
TEST

## 6. TEST YOUR SOLUTION: MALARIA MELTDOWN!

You may use the rubric provided by your teacher to assess your work on the next few pages.

### INSULATOR TEST

Student jobs: Assign each member of your team to one of the four jobs listed below.

**Heater:** ________________ **Timer:** ________________

**Cooler:** ________________ **Recorder:** ________________

**STEP 1: COOLER–**Place uncovered thermometer stem in ice. Cool thermometer to 10°C or colder.

**STEP 2: HEATER–**Get extra pieces of the materials you used for your design. Layer the materials as you did when you constructed your carrier. Place one stack of materials in each palm, and then place the thermometer stem between the stacks. Make sure that the materials cover the entire thermometer stem, including the tip. Press palms together. When the thermometer reads 15°C, say "Start timing!" Keep your palms pressed firmly together for 1 full minute.

**STEP 3: TIMER–**When you hear the **Heater** say "Start timing!" immediately click "start" on your stopwatch. Shout "Time!" after exactly 1 minute (60 seconds).

**STEP 4: HEATER–**Watch the thermometer. When the **Timer** shouts "Time!" read the temperature aloud.

**STEP 5: RECORDER–**Record the temperature after 1 minute: ______________ °C

Did the thermometer stay between 15°C and 30°C for 1 minute?

☐ yes ☐ no

### RUGGED/PROTECTIVE TEST

Place a raw egg in a sandwich bag inside your carrier. Seal the bag shut. Measure a height of 1 meter from the ground, and drop your medicine carrier from this height.

Did the egg remain intact (no cracks)? ☐ yes ☐ no

Did the carrier remain intact? ☐ yes ☐ no

### LOW-COST TEST

In order to keep the medicine at an acceptable temperature for 2 hours in the 37°C Amazon rain forest, the actual carrier would have to be 11 times thicker than your design that works for 1 minute. This means you will need 11 times more materials for the actual carrier than for your model. How much would this actual carrier cost? ______________________

Show your work below. Compare this cost to other teams' solutions.

Name

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COMMUNICATE

## 7. COMMUNICATE YOUR SOLUTION: MALARIA MELTDOWN!

1. Do you think that your medicine-carrier design was successful? Did it meet all of the criteria and constraints? Explain your answer.

2. Specifically, what are some strengths or advantages of your design? Explain.

3. What are some drawbacks or disadvantages of your design? Explain.

4. If you could use any materials on Earth, what materials would you use to make your medicine carrier?

   Explain why you would choose these materials.

5. If you were going to sell your medicine carrier, how much would you sell it for? How would you market your carrier? What advertising or slogans would you use to make people want to buy it?

Be prepared to present your answers to questions 1–5 to the class.

 

## 8. REDESIGN AS NEEDED: MALARIA MELTDOWN!

1. Based on the tests of your medicine-carrier design, what changes could you make to improve it?

   Explain how these changes would improve your design.

2. Identify one thing that you learned from another group's medicine-carrier design that you can use to improve your design.

   Explain how this will improve your design.

Name ______________________________

STUDENT PAGE

## INDIVIDUAL SELF-ASSESSMENT RUBRIC: MALARIA MELTDOWN!

Use this rubric to reflect on how well you met behavior and work expectations during this activity. Check the box next to each expectation that you successfully met.

| LEVEL 1 | LEVEL 2 | LEVEL 3 | LEVEL 4 | BONUS POINTS |
|---|---|---|---|---|
| Beginning to meet expectations | Meets some expectations | Meets expectations | Exceeds expectations | |
| ☐ I was willing to work in a group setting.<br>☐ I was respectful and friendly to my teammates.<br>☐ I listened to my teammates and let them fully voice their opinions.<br>☐ I made sure we had the materials we needed and knew the tasks that needed to be done. | ☐ I met all of the Level 1 requirements.<br>☐ I recorded the most essential comments from other group members.<br>☐ I read all instructions.<br>☐ I wrote down everything that was required for the activity.<br>☐ I listened to instructions in class and was able to stay on track.<br>☐ I asked questions when I didn't understand something. | ☐ I met all of the Level 2 requirements.<br>☐ I made sure that my team was on track and doing the tasks for each activity.<br>☐ I listened to what my teammates had to say and asked for their opinions throughout the activity.<br>☐ I actively gave feedback (by speaking and/or writing) to my team and other teams.<br>☐ I completed all the assigned homework.<br>☐ I was able to work on my own when the teacher couldn't help me right away.<br>☐ I completed all the specified tasks for the activity. | ☐ I met all of the Level 3 requirements.<br>☐ I helped my teammates understand the things that they did not understand.<br>☐ I was always focused and on task: I didn't need to be reminded to do things; I knew what to do next.<br>☐ I was able to explain to the class what we learned and did in the activity. | ☐ I helped resolve conflicts on my team.<br>☐ I responded well to criticism.<br>☐ I encouraged everyone on my team to participate.<br>☐ I encouraged my team to persevere when my teammates faced difficulties and wanted to give up.<br>☐ I took advice and recommendations from the teacher about improving team performance and used feedback in team activities.<br>☐ I worked with my team outside of the classroom to ensure that we could work well in the classroom. |

Approximate your level based on the number of checked boxes: __________ Bonus points: ______________________

Teacher comments: ____________________________________________

Name
STUDENT PAGE

## TEAM EVALUATION: MALARIA MELTDOWN!

How well did your team work together to complete the design challenge? Reflect on your teamwork experience by completing this evaluation and sharing your thoughts with your team. Celebrate your successes and discuss how you can improve your teamwork during the next design challenge.

**RATE YOUR TEAMWORK.** On a scale of 0–3, how well did your team do? 3 is excellent, 0 is very poor. Explain how you came up with that rating.

**LIST THINGS THAT WORKED WELL.** Example: We got to our tasks right away and stayed on track.

**LIST THINGS THAT DID NOT WORK WELL.** Example: We argued a lot and did not come to a decision that everyone could agree on.

**HOW CAN YOU IMPROVE TEAMWORK?** Make the action steps concrete. Example: We need to learn how to make decisions better. Therefore, I will listen and respond without raising my voice.

# Design Challenge 2

## Mercury Rising!

**INTRODUCTION**

As you approach the Yanomami village to deliver the antimalarial medicine, you notice a man mining for gold along the banks of the Amazon River. The miner does not seem to be disturbing anyone. However, as you approach the Yanomami village, you hear the following pieces of conversation:

"If the gold miners poison the water and kill the fish, where will we drink and what will we eat?"
—Jose Siripino, Yanomami

"We want progress without destruction. We want to study, to learn new ways of cultivating the land and living from its fruits. The Yanomami do not want to live from dealing with money, with gold."
—Davi Kopenawa, Yanomami

The Yanomami people have been expecting you, and are grateful for the medicine. After getting the medicine into the proper hands, they include you in their conversation about the gold miners. They explain that the gold miners are contaminating the freshwater of the Amazon. The miners use the chemical mercury to help them collect grains of gold along the river. However, not all the mercury is taken up by the gold, and some of it is released into the river. Fish, a main food source for the Yanomami, are being poisoned with the mercury. This poison passes on to the villagers through the food chain and leads to a variety of illnesses.

## 1. DEFINE THE PROBLEM: MERCURY RISING!

The Yanomami people presented their argument to the local miners. Reluctantly, the miners agreed to use a portion of their profits to fund a water-filtration system that will filter out at least 75% of the mercury in the freshwater near the mining operation. However, they will not provide any money for the filtration system until they receive a design plan that meets some requirements.

Your task is to design a small-scale water-filtration system that can be scaled up to an actual system. Your smaller model only has to filter 250 mL of water. For the actual system, the miners will hire contractors to build a system that is several thousand times larger.

| ENGINEERING CRITERIA | |
|---|---|
| **LOW COST** → | Your filter design should be as low in cost as possible. |
| **FILTERING RATE** → | Your design must filter at least 540 liters of water per day. |
| **FILTERING ABILITY** → | Your design should filter no more than 1 liter of water per minute (so that water is flowing slowly enough to ensure that 75% of the mercury is removed). |

**ENGINEERING CONSTRAINTS**

You may use any or all of the following materials to design and build your filter:

- plastic bag
- plastic stirrers
- plastic straws
- small and large cups
- tape
- scissors

 

# 2. RESEARCH THE PROBLEM: MERCURY RISING!

## RESEARCH PHASE 1: MINIMIZING COST

Scientists have discovered a material that absorbs mercury. This material has been coated over the surface of different sized spheres. These mercury-absorbing spheres are called *Mercatrons.* The costs per package of the different sized Mercatrons are listed in the table below.

**Table 2.1: Cost of Mercatrons**

| MERCATRON DIAMETER (CM) | COST PER PACKAGE OF 10 MERCATRONS |
|---|---|
| 0.4 | $0.15 |
| 0.8 | $0.30 |
| 1.2 | $0.60 |
| 1.6 | $1.20 |
| 2.0 | $2.40 |
| 2.4 | $4.80 |

The miners have agreed to pay for the removal of 75% of the mercury in a small region of the Amazon River near the mining operations. For your scaled-down model, scientists tell you that the contaminated water must have contact with a minimum of 400 square centimeters ($cm^2$) of the surface of the Mercatron before exiting the filter in order for at least 75% of the mercury to be dissolved.

1. Make a prediction about which size of Mercatron will give the miners the lowest cost for the filtration system: ___________________

   Explain your prediction.

   ______________________________________________________________________

   ______________________________________________________________________

   ______________________________________________________________________

Name ___

STUDENT PAGE

RESEARCH

2. Perform the necessary calculations to complete the table below. Show your work and round your answers to the nearest hundredth. To find the surface area of each Mercatron size, use the formula:

**surface area of a sphere = 4 • 3.14 • (radius)$^2$**
**(3.14 is an approximation of $\pi$ )**

**Table 2.2: Total Cost for Different Sized Mercatrons**

| Diameter of Mercatron (cm) | 0.4 | 0.8 | 1.2 | 1.6 | 2.0 | 2.4 |
|---|---|---|---|---|---|---|
| Radius of Mercatron (cm) | | | | | | |
| Surface area of Mercatron ($cm^2$) | | | | | | |
| Total number of Mercatrons needed for a total surface area of 400 $cm^2$ | | | | | | |
| Total number of packages needed (10 Mercatrons per package) | | | | | | |
| Cost per package of 10 Mercatrons | $0.15 | $0.30 | $0.60 | $1.20 | $2.40 | $4.80 |
| Total cost | | | | | | |

**WORKSPACE**

3. Which Mercatron size has the lowest total cost? ______________________
Compare this answer to your prediction in problem 1.

Name

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RESEARCH

# 2. RESEARCH THE PROBLEM: MERCURY RISING!

## RESEARCH PHASE 2: MINIMUM AND MAXIMUM FILTRATION RATES

You will test the model of your filter design with 250 mL of water. Therefore, it is important to figure out what is an acceptable amount of time to filter 250 mL, based on the engineering criteria.

1. **Minimum rate:** Your filter must filter at least 540 liters of water per day. Convert this flow rate into seconds per 250 mL.

| SHOW YOUR WORK |
|---|
| |

2. **Maximum rate:** The water must flow at a rate of less than 1 liter per minute. Convert this flow rate into seconds per 250 mL.

| SHOW YOUR WORK |
|---|
| |

3. Based on the flow rates you found in problems 1 and 2, write a compound inequality to represent the range of acceptable numbers of seconds to filter exactly 250 mL of water.

# 2. RESEARCH THE PROBLEM: MERCURY RISING!

## RESEARCH PHASE 3: INVESTIGATING FLOW RATE

Now that you have figured out the range of acceptable flow rates, you can try to figure out what type of filter will give you an acceptable flow rate. You will investigate how the size of the filter's outlet relates to flow rate.

Student jobs: Assign each member of your group to one of the four jobs listed below.

**Heater:** _________________ **Timer:** _________________

**Pourer:** _________________ **Measurer:** _________________

**STEP 1: MEASURER–**Get a cup, and poke a hole in the center of the bottom of the cup using one of the four instruments listed in Table 2.3. Then, using a ruler, measure the diameter of the hole you created in millimeters and record it in Table 2.3.

**STEP 2: HOLDER–**Hold the cup over the measuring cup. The cup's hole should be facing directly downward into the measuring cup. Cover the hole with your finger.

**STEP 3: POURER–**Start pouring water into the cup until the cup is almost full. When the **Holder** releases his or her finger and water is coming out from the hole, say, "Start timing!" Keep pouring water into the cup to keep the water at the same level during the entire trial.

**STEP 4: TIMER–**When you hear the **Pourer** shout, "Start timing!" start the timer.

**STEP 5: MEASURER–**Watch the measuring cup. If the water is dripping out at a very slow rate, when the water level reaches 50 mL, shout, "Stop timing!" If the water is coming out at a fast rate, when the water level reaches exactly 250 mL, shout, "Stop timing!"

**STEP 6: TIMER–**When you hear the **Measurer** shout, "Stop Timing!" stop the timer. If the **Measurer** stopped the time when the water level reached 50 mL, multiply the time (in seconds) by 5 and record the time value in Table 2.3. If the **Measurer** stopped the time when the water level reached 250 mL, record the time (in seconds) in Table 2.3.

**STEP 7:** Repeat steps 1–6 with a new hole-poking instrument from Table 2.3.

 

**Table 2.3: Flow Rates for Different Size Outlet Holes**

| Outlet hole was made by | Diameter of outlet hole (mm) | Time for 250 mL to flow through cup (seconds) |
|---|---|---|
| pin | | |
| small nail | | |
| large nail | | |
| chopstick | | |

 

Name ______________________________

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## 2. RESEARCH THE PROBLEM: MERCURY RISING!

### RESEARCH PHASE 3: INVESTIGATING FLOW RATE

1. Graph your data from Table 2.3 on the grid below to show the relationship between the diameter of the outlet hole and the time it takes for 250 mL of water to flow through the cup. Remember to label the axes and give the graph a title. Use the rubric provided by your teacher to assess your work. Then use your graph to answer the questions that follow.

2. Describe the relationship between the diameter of the outlet hole and the time it takes for 250 mL of water to flow through the cup.

______________________________

______________________________

______________________________

3. Which diameter size(s) produce acceptable flow rates for the water filter? ___________

4. Based on your graph, what size diameter would create a flow rate that is exactly in the center of the range of acceptable flow rates?

_______________________________________________

5. What factors, other than outlet size, might affect the flow rate of the water through the filter? List at least four ideas.

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

6. Consider the factors you listed in question 5. Put a star next to the factor you would like to test. As a group, create an experiment you could do to test this factor. Then, describe, in step-by-step detail, how you will go about testing this factor (use additional paper if needed).

_______________________________________________

_______________________________________________

_______________________________________________

7. After you have received approval from your teacher, conduct the experiment you designed above. Draw a table in the grid below, give it the appropriate labels, and record the results of your experiment in the table.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

 

8. You will be presenting the results of your experiment to the class. Decide as a group how to best display your results. Then use the grid below to display your data. Remember to label the axes and give the graph a title. Use the rubric for graphs to assess your work.

9. Based on the results of your experiment, what advice would you give to your classmates about designing their water filters?

Use the rubric for experiment design provided by your teacher to assess your work for problems 6–9.

 

## 3. BRAINSTORM POSSIBLE SOLUTIONS: MERCURY RISING!

You've done some great research and are ready to think about some possible water-filter designs. As you brainstorm possible solutions, keep the design criteria and constraints in mind.

| ENGINEERING CRITERIA | |
|---|---|
| LOW COST → | Your filter design should be as low in cost as possible. |
| FILTERING RATE → | Your design must filter at least 540 liters of water per day. |
| FILTERING ABILITY → | Your design should filter no more than 1 liter of water per minute (so that water is flowing slowly enough to ensure that 75% of the mercury is removed). |

**ENGINEERING CONSTRAINTS**

You may use any or all of the following materials to design and build your filter:

- plastic bag
- plastic stirrers
- plastic straws
- small and large cups
- tape
- scissors

**Table 2.1: Cost of Mercatrons**

| MERCATRON DIAMETER (CM) | COST PER PACKAGE OF 10 MERCATRONS |
|---|---|
| 0.4 | $0.15 |
| 0.8 | $0.30 |
| 1.2 | $0.60 |
| 1.6 | $1.20 |
| 2.0 | $2.40 |
| 2.4 | $4.80 |

## INDIVIDUAL DESIGN

On your own, think about what your filter might look like and how it might work. What will be the overall shape of the filter? Where will the water go in? Where will the water come out? How big will the opening be? Where will the Mercatrons be located? Describe and draw your ideas in the space below. Label the inlet, the outlet, and the Mercatrons in your drawing.

 

Name

STUDENT PAGE

CHOOSE

# 4. CHOOSE THE BEST SOLUTION: MERCURY RISING!

### TEAM DESIGN

Discuss your ideas as a team, and then decide upon one "best" solution. Draw the water filter design in the space below. Then label the materials to be used and the functions of various parts of the design. Use the rubric provided by your teacher to check the quality and completeness of your drawing.

 

## 5. BUILD A PROTOTYPE/MODEL: MERCURY RISING!

Following the design you chose in Step 4, gather all necessary materials and construct a model of your water filter. As you build your model, draw or use words to describe any changes to your original design. Use the rubric provided by your teacher to assess your work.

 

Name ______________________________________________
STUDENT PAGE

8 1 2 7 6 3 5 4
TEST

# 6. TEST YOUR SOLUTION: MERCURY RISING!

You may use the rubric provided by your teacher to assess your work on the next few pages.

### FLOW-RATE TEST

Student jobs: Assign each member of your group to one of the four jobs listed below.

**Heater:** ________________ **Timer:** ________________
**Pourer:** ________________ **Measurer:** ________________

**STEP 1: HOLDER–**Place the measuring cup inside of the water basin. To begin, hold the water filter so that the opening where the water exits the filter is directed into the basin, but NOT into the measuring cup.

**STEP 2: POURER–**Pour water at a steady rate into the filter. Continue this for the entire test.

**STEP 3: HOLDER–**Watch the water exit your filter. Once the water seems to be flowing out of the filter at a steady rate, move the filter so that the water flowing out goes directly into the measuring cup and say, "Start timing!"

**STEP 4: TIMER–**When you hear the Holder shout, "Start timing!" start the timer.

**STEP 5: MEASURER–**Watch the measuring cup. When the water level reaches exactly 250 mL, shout, "Stop timing!"

**STEP 6: TIMER–**When you hear the Measurer shout, "Stop timing!" stop the timer.

How long did it take to filter 250 mL of water? ____________________

Is this time within the acceptable range? ☐ yes ☐ no

Would your filter be able to filter at least 540 liters of water per day? ☐ yes ☐ no

Does your filter design filter no more than 1 liter of water per minute? ☐ yes ☐ no

 

Name

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COMMUNICATE

## 7. COMMUNICATE YOUR SOLUTION: MERCURY RISING!

1. Do you think that your water-filter design was successful? Did it meet all of the criteria and constraints? Explain.

2. Specifically, what are some of the strengths or advantages of your filter design?

3. What are some drawbacks or disadvantages of your current design?

4. If you made a full-size version of your filter design, what materials would you use? Why would you choose these materials?

Be prepared to present your answers to questions 1–4 to the class.

Name

STUDENT PAGE

REDESIGN

## 8. REDESIGN AS NEEDED: MERCURY RISING!

1. Based on the test of your water filter-design, what changes could you make to improve it?

Explain how these changes would improve your filter design.

2. Identify one thing that you learned from another group's water-filter design that you could use to improve your filter design.

Explain how this would improve your filter design.

Name ______

STUDENT PAGE

## INDIVIDUAL SELF-ASSESSMENT RUBRIC: MERCURY RISING!

Use this rubric to reflect on how well you met behavior and work expectations during this activity. Check the box next to each expectation that you successfully met.

| LEVEL 1 | LEVEL 2 | LEVEL 3 | LEVEL 4 | BONUS POINTS |
|---|---|---|---|---|
| Beginning to meet expectations | Meets some expectations | Meets expectations | Exceeds expectations | |
| ☐ I was willing to work in a group setting.<br>☐ I was respectful and friendly to my teammates.<br>☐ I listened to my teammates and let them fully voice their opinions.<br>☐ I made sure we had the materials we needed and knew the tasks that needed to be done. | ☐ I met all of the Level 1 requirements.<br>☐ I recorded the most essential comments from other group members.<br>☐ I read all instructions.<br>☐ I wrote down everything that was required for the activity.<br>☐ I listened to instructions in class and was able to stay on track.<br>☐ I asked questions when I didn't understand something. | ☐ I met all of the Level 2 requirements.<br>☐ I made sure that my team was on track and doing the tasks for each activity.<br>☐ I listened to what my teammates had to say and asked for their opinions throughout the activity.<br>☐ I actively gave feedback (by speaking and/or writing) to my team and other teams.<br>☐ I completed all the assigned homework.<br>☐ I was able to work on my own when the teacher couldn't help me right away.<br>☐ I completed all the specified tasks for the activity. | ☐ I met all of the Level 3 requirements.<br>☐ I helped my teammates understand the things that they did not understand.<br>☐ I was always focused and on task: I didn't need to be reminded to do things; I knew what to do next.<br>☐ I was able to explain to the class what we learned and did in the activity. | ☐ I helped resolve conflicts on my team.<br>☐ I responded well to criticism.<br>☐ I encouraged everyone on my team to participate.<br>☐ I encouraged my team to persevere when my teammates faced difficulties and wanted to give up.<br>☐ I took advice and recommendations from the teacher about improving team performance and used feedback in team activities.<br>☐ I worked with my team outside of the classroom to ensure that we could work well in the classroom. |

Approximate your level based on the number of checked boxes: ______ Bonus points: ______

Teacher comments: ______

Name

STUDENT PAGE

## TEAM EVALUATION: MERCURY RISING!

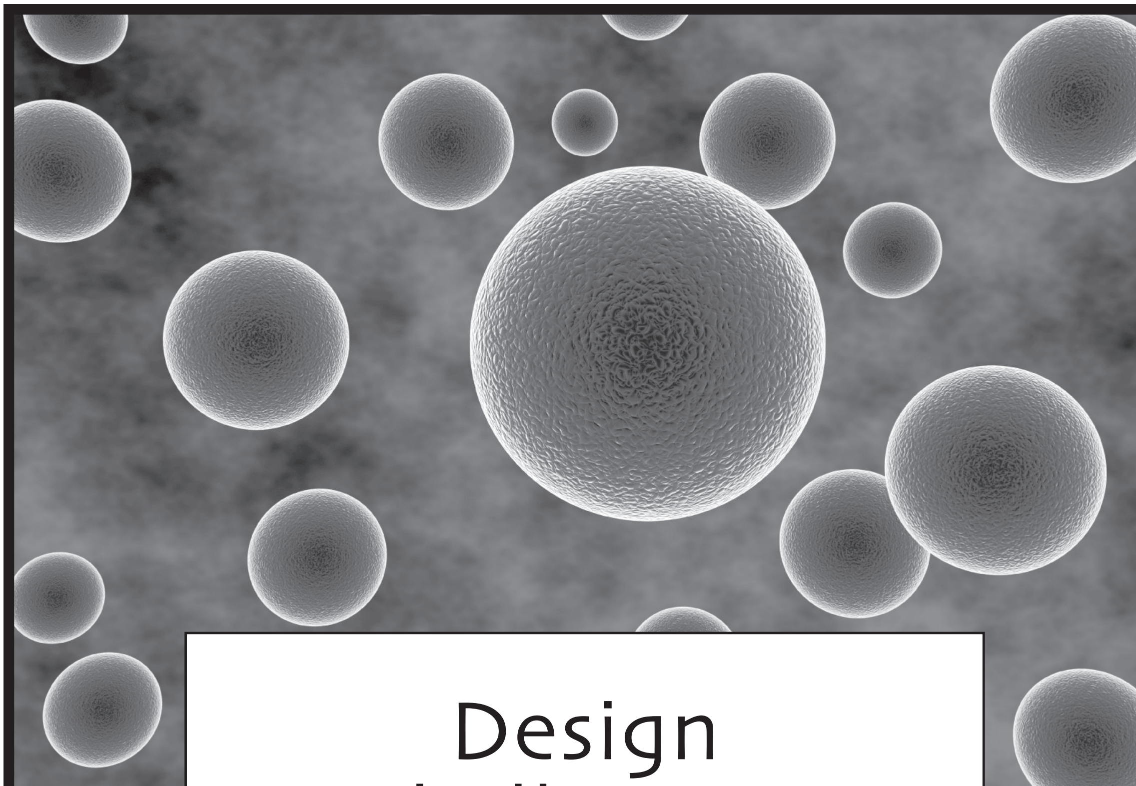
How well did your team work together to complete the design challenge? Reflect on your teamwork experience by completing this evaluation and sharing your thoughts with your team. Celebrate your successes and discuss how you can improve your teamwork during the next design challenge.

**RATE YOUR TEAMWORK.** On a scale of 0–3 how well did your team do? 3 is excellent, 0 is very poor. Explain how you came up with that rating. Was it the same, better, or worse than the last activity?

**LIST THINGS THAT WORKED WELL.** Example: We got to our tasks right away and stayed on track.

**LIST THINGS THAT DID NOT WORK WELL.** Example: We argued a lot and did not come to a decision that everyone could agree on.

**HOW CAN YOU IMPROVE TEAMWORK?** Make the action steps concrete. Example: We need to learn how to make decisions better. Therefore, I will listen and respond without raising my voice.



# Design Challenge 3

## Outbreak!

### INTRODUCTION

The influenza virus (commonly known as the flu) was one of the illnesses that killed many Yanomami people in the 1980s. Influenza is particularly dangerous because it can spread so easily. When infected people cough or sneeze, they spray drops of the virus into the air. If other people breathe in these drops, or touch something that the drops have landed on (such as door handles or telephones), they are likely to become sick, too.

The influenza virus remains a threat to the Yanomami people because there are still outsiders near their villages, and the virus changes over time. Even if the villagers have been exposed to the flu in the past, they are not immune to new strains of the virus.

## 1. DEFINE THE PROBLEM: OUTBREAK!

The Yanomami people need you to design a plan to protect them from a new strain of the flu virus that has been introduced to their village. Your plan needs to contain the virus for 30 days, but it also needs to be as low in cost as possible since the Yanomami people have little access to money.

### ENGINEERING CRITERIA

| | |
|---|---|
| VIRUS CONTAINED → | The percent of villagers infected does not go above 25% for 30 days. |
| LOW COST → | The plan is as low in cost as possible. You have a maximum budget of $10,000, but try to find a lower cost plan that works. |
| HIGH CHANCE OF SUCCESS → | The plan must meet the virus-containment criterion at least four out of five trials. |

### ENGINEERING CONSTRAINTS

- There are a total of 40 people in the Yanomami village that you will be helping. All of the villagers live together in a circular shabono that has a radius of about 16 meters.
- For our purposes, we will assume that without any protection, villagers have a 100% chance of catching the virus if they come into contact with a sick person.
- You may include any or all of the following interventions in your plan:

| INTERVENTION | EFFECT OF INTERVENTION | COST OF INTERVENTION |
|---|---|---|
| doctor | can treat 1 person per day | $1,600 per doctor |
| air-filtration masks | reduces chance of getting virus by 50% | $750 for a village supply |
| antiviral hand gel | reduces chance of getting virus to 25% | $1,000 for a village supply |
| vaccinations | reduces starting chance of getting virus to 4% | $120 for 1 villager |

## 2. RESEARCH THE PROBLEM: OUTBREAK!

### RESEARCH PHASE 1: HOW DOES A VIRUS SPREAD?

1. Imagine that one person in the classroom has the virus. Every time interval ("day"), the infected person can spread the virus to one other person. Anyone that becomes infected with the virus can then spread the virus to one new person every time interval. How much time do you think it will take for the entire class to be infected? Explain your prediction.

2. You will conduct an experiment as a class. Record the results of the experiment in Table 3.1 below.

**Table 3.1: How Virus Spreads Through the Classroom**

| TIME (DAYS) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER OF SICK PEOPLE | | | | | | | | | | | | |

3. Describe any patterns that you notice about the data. Try to find more than one pattern.

4. Represent the pattern(s) you found using pictures, symbols, or variables.

5. How many people do you think would be sick after 20 days? ____________

   How did you determine this? ____________

Name ______________________________________________
STUDENT PAGE

RESEARCH

## 2. RESEARCH THE PROBLEM: OUTBREAK!

### RESEARCH PHASE 2: THERE'S A DOCTOR IN THE HOUSE

1. Imagine the same situation as in Research Phase 1, but now there is a doctor who can treat one person every day. What do you predict will happen as time goes on?

   ______________________________________________

   ______________________________________________

   ______________________________________________

2. You will conduct an experiment as a class. Record the results of the experiment in Table 3.2 below.

**Table 3.2: How Virus Spreads Through the Classroom When There Is a Doctor**

| TIME (DAYS) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER OF SICK PEOPLE | | | | | | | | | | | | |

3. How did having the doctor in the classroom affect the spread of the virus over time? Look for patterns.

   ______________________________________________

   ______________________________________________

   ______________________________________________

4. Represent the pattern(s) you found using pictures, symbols, or variables.

5. How many people do you think would be sick after 20 minutes? ______________

   How did you determine this? ______________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

## 2. RESEARCH THE PROBLEM: OUTBREAK!

### RESEARCH PHASE 3: EVERYONE HAS AN AIR-FILTRATION MASK

1. Imagine, once again, that the virus is spreading in the same way as in Research Phase 1. You no longer have a doctor. Now, each person in the classroom has an air-filtration mask. When a person is wearing the mask, he or she has a 50% chance of becoming sick when coming into contact with an infected person. What do you predict will happen as time goes on?

2. You will conduct an experiment as a class. Please record the results of the experiment in Table 3.3 below.

**Table 3.3: How Virus Spreads Through the Classroom When Everyone Wears an Air Mask**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME (DAYS) | | | | | | | | | | | | |
| NUMBER OF SICK PEOPLE | | | | | | | | | | | | |

3. How did wearing the air-filtration masks affect the spread of the virus over time? Look for patterns.

4. Compare your results in Table 3.2 and Table 3.3. Which was more effective in slowing the spread of the virus, the doctor or the air-filtration masks?

Name

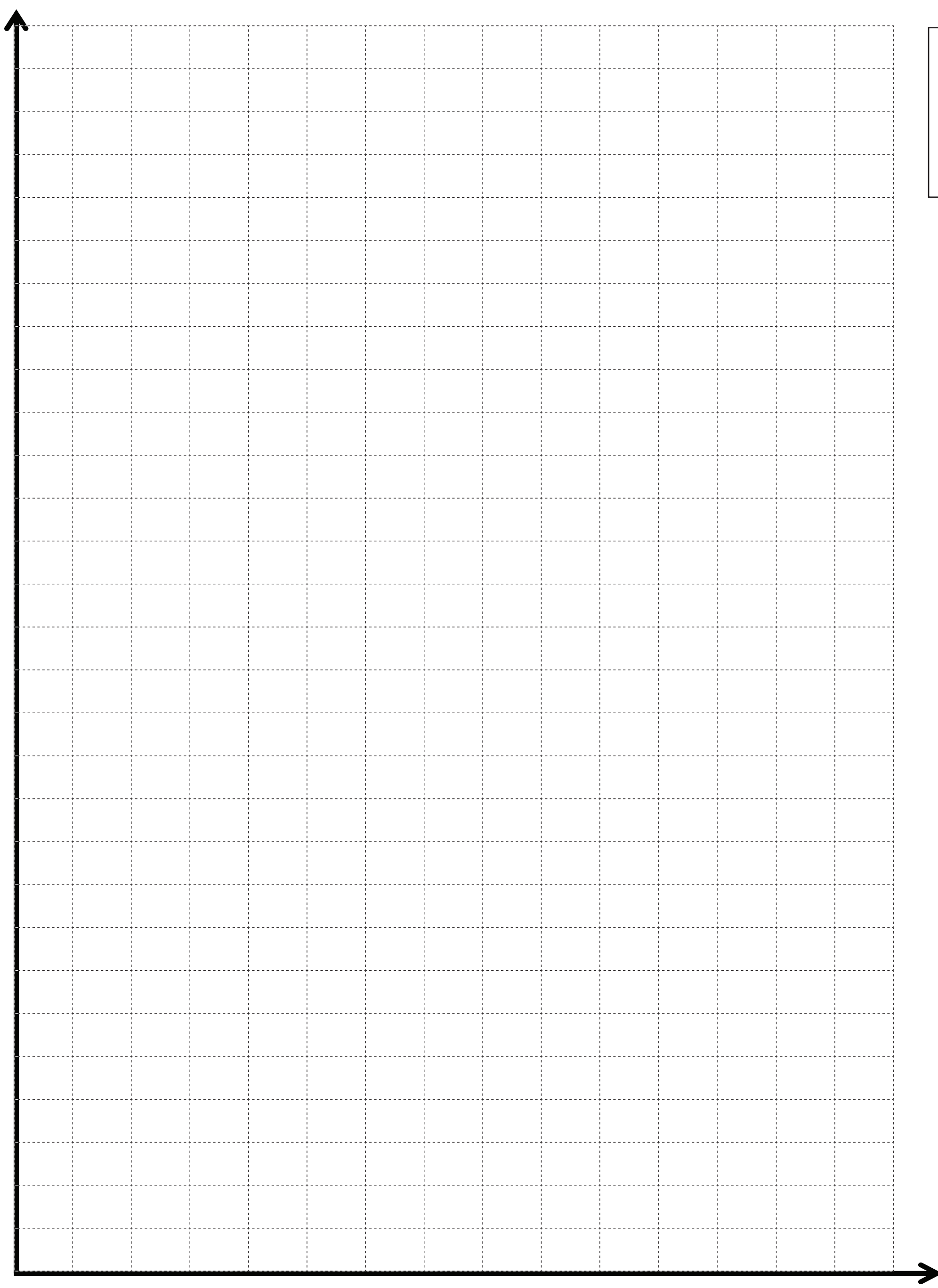
STUDENT PAGE

RESEARCH

## 2. RESEARCH THE PROBLEM: OUTBREAK!

### RESEARCH PHASE 4: GRAPHING THE DATA

Use the grid below to plot the results of your simulations from research phases 1 to 3. Use a different color to plot data from each phase. Label the axes and give the graph a title. Use the rubric provided by your teacher to assess your work.



KEY

☐ = no intervention

☐ = 1 doctor

☐ = air masks

## 2. RESEARCH THE PROBLEM: OUTBREAK!

### RESEARCH PHASE 5: COMBINING INTERVENTIONS

| INTERVENTION | EFFECT OF INTERVENTION | COST OF INTERVENTION |
|---|---|---|
| doctor | can treat 1 person per day | $1,600 per doctor |
| air-filtration masks | reduces chance of getting virus by 50% | $750 for a village supply |
| antiviral hand gel | reduces chance of getting virus to 25% | $1,000 for a village supply |
| vaccinations | reduces starting chance of getting virus to 4% | $120 for 1 villager |

The table above shows the effects of each intervention used alone. What would be the effects if you combined them? Complete the table of combined interventions below. Round all answers to the nearest tenth of a percent. Then, write the percentage as a decimal number between 0 and 1.

| INTERVENTIONS | CHANCE OF A HEALTHY PERSON GETTING SICK WITH THESE INTERVENTIONS | |
|---|---|---|
| | % | Decimal |
| 1. air-filtration mask and antiviral hand gel | | |
| 2. air-filtration mask and vaccination | | |
| 3. antiviral hand gel and vaccination | | |
| 4. air-filtration mask, antiviral hand gel, and vaccination | | |

Name ______________________________________________

STUDENT PAGE

RESEARCH

## 2. RESEARCH THE PROBLEM: OUTBREAK!

### RESEARCH PHASE 6: DOCTORS ONLY!

In this research phase, you will use a computer model to simulate the spread of the virus and find the lowest-cost plan that still successfully meets the virus-containment criterion (the number of sick villagers must not go above 25% of the village in 30 days). In this scenario, you may only use doctors from the list of interventions. This means that the infection rate is 100%!

1. First, make a prediction: How many doctors do you think you will need to successfully contain the virus in this scenario? Explain your reasoning for your estimate.

   ______________________________________________

   ______________________________________________

2. Start by testing your prediction. Then adjust your estimate up or down depending on the test results. Test each plan several times (up to five times). Put a tally mark in the appropriate column as you test the same plan. Then circle YES if the plan works at least four out of five times.

| NUMBER OF DOCTORS | COST OF PLAN | TRIALS THAT WORK | TRIALS THAT DIDN'T WORK | SUCCESSFUL PLAN? |
|---|---|---|---|---|
| | | | | YES NO |
| | | | | YES NO |
| | | | | YES NO |
| | | | | YES NO |

3. What was the lowest-cost and most successful plan you could find? ______________

4. What strategies did you use to find the lowest-cost and most successful plan?

   ______________________________________________

   ______________________________________________

5. Note how expensive it is to implement a successful plan that only uses doctors. What can you learn from your observations of how the flu spread in this scenario to help you design a successful plan that costs less than $10,000?

   ______________________________________________

   ______________________________________________

   ______________________________________________

Name
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BRAINSTORM

## 3. BRAINSTORM POSSIBLE SOLUTIONS: OUTBREAK!

You are now ready to design a plan to contain a virus spreading through the village of 40 people. Remember to keep these design requirements in mind!

**ENGINEERING CRITERIA**

| | |
|---|---|
| VIRUS CONTAINED → | The percent of villagers infected does not go above 25% for 30 days. |
| LOW COST → | The plan is as low in cost as possible. You have a maximum budget of $10,000, but try to find a lower cost plan that works. |
| HIGH CHANCE OF SUCCESS → | The plan must meet the virus-containment criterion at least four out of five trials. |

**ENGINEERING CONSTRAINTS**

Remember the interventions that are available for your plan:

| INTERVENTION | EFFECT OF INTERVENTION | COST OF INTERVENTION |
|---|---|---|
| doctor | can treat 1 person per day | $1,600 per doctor |
| vaccinations | reduces starting chance of getting virus to 4% | $120 for 1 villager |
| antiviral hand gel | reduces chance of getting virus to 25% | $1,000 for a village supply |
| air-filtration masks | reduces chance of getting virus by 50% | $750 for a village supply |

 

Name ____________________________________________

STUDENT PAGE

BRAINSTORM

**INDIVIDUAL DESIGN**

1. On your own, come up with one possible solution. Record the interventions you chose.
   - number of doctors: ______
   - number of vaccinations: ______
   - antiviral hand gel: ☐ yes ☐ no
   - air-filtration masks: ☐ yes ☐ no

   a. What is the cost of this solution? ________________________________

   b. What makes this a good solution? What are its advantages?

   ________________________________________________

   ________________________________________________

   c. What are the drawbacks, or disadvantages, of this solution?

   ________________________________________________

   ________________________________________________

2. Each member of your team should now describe his or her idea to the group. As you discuss your ideas, fill in the chart below.

| TEAM MEMBER NAME | COST OF SOLUTION | BENEFITS OF SOLUTION | DRAWBACKS OF SOLUTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

# 4. CHOOSE THE BEST SOLUTION: OUTBREAK!

### TEAM DESIGN

1. Consider the chart you filled out on page 131. As a group, choose the "best" solution. Record the interventions you chose.
   - number of doctors: ______
   - number of vaccinations: ______
   - antiviral hand gel: ☐ yes ☐ no
   - air-filtration masks: ☐ yes ☐ no

2. For your solution, what is the chance that healthy villagers will get sick if they come into contact with an infected person?

   ______

3. If you are giving out vaccinations to some but not all of the villagers, how will you decide which villagers will get the vaccinations? Explain your reasoning.

   ______
   ______
   ______
   ______

4. If you are hiring doctors, where should they be located within the shabono? Explain your reasoning.

   ______
   ______
   ______
   ______

Name
STUDENT PAGE

BUILD

## 5. BUILD A PROTOTYPE/MODEL: OUTBREAK!

You do not "build" anything in this design step because you will use a computer simulation model to test your plan. In this model, each villager and any doctors move randomly on a roughly circular background that is 16 units in diameter. When a healthy villager and a sick villager are in adjacent squares, the healthy villager has a percent chance of getting sick according to your intervention plan. Doctors can successfully treat one sick villager in one of the adjacent squares per day. Computer models use the speed of computers to easily and quickly execute complex rules. They also allow users to manipulate variables in the model to test what happens in different scenarios.

## 6. TEST YOUR SOLUTION: OUTBREAK!

You may use the rubric provided by your teacher to assess your work on the next few pages.

### ORIGINAL PLAN

number of doctors: _______________ antiviral hand gel: ☐ yes ☐ no
number of vaccinations: _____________ air-filtration masks: ☐ yes ☐ no

| | TRIAL NUMBER | | | | | |
|---|---|---|---|---|---|---|
| Number of sick people at the end of 30 days | 1 | 2 | 3 | 4 | 5 | Did the plan work 4 out of 5 times? |
| | | | | | | ☐ yes ☐ no |

### NOTES

1. Complete the table below using your answers from Research Phase 5. Find the infection rate for vaccinated and unvaccinated villagers by clicking "Edit Settings."

| | NO INTERVENTION | MASK ONLY | HAND GEL ONLY | MASK AND HAND GEL |
|---|---|---|---|---|
| **Unvaccinated infection rate** | | | | |
| **Vaccinated infection rate** | | | | |

 

**Challenge 1:** If your original plan did not work, discuss how you can redesign your plan to make it work. Test your plan and record your results. Use the following table to determine the variables for your new plan and to test your new plan.

**Challenge 2**: If your original plan works, redesign your plan to find a lower-cost plan.

### CHANGES TO YOUR ORIGINAL PLAN

#### Redesigned Plan 1

number of doctors: _______________ antiviral hand gel: ☐ yes ☐ no
number of vaccinations: _____________ air-filtration masks: ☐ yes ☐ no

| | TRIAL NUMBER | | | | | |
|---|---|---|---|---|---|---|
| Number of sick people at the end of 30 days | 1 | 2 | 3 | 4 | 5 | Did the plan work 4 out of 5 times? |
| | | | | | | ☐ yes ☐ no |

#### Redesigned Plan 2

number of doctors: _______________ antiviral hand gel: ☐ yes ☐ no
number of vaccinations: _____________ air-filtration masks: ☐ yes ☐ no

| | TRIAL NUMBER | | | | | |
|---|---|---|---|---|---|---|
| Number of sick people at the end of 30 days | 1 | 2 | 3 | 4 | 5 | Did the plan work 4 out of 5 times? |
| | | | | | | ☐ yes ☐ no |

#### Redesigned Plan 3

number of doctors: _______________ antiviral hand gel: ☐ yes ☐ no
number of vaccinations: _____________ air-filtration masks: ☐ yes ☐ no

| | TRIAL NUMBER | | | | | |
|---|---|---|---|---|---|---|
| Number of sick people at the end of 30 days | 1 | 2 | 3 | 4 | 5 | Did the plan work 4 out of 5 times? |
| | | | | | | ☐ yes ☐ no |

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COMMUNICATE

## 7. COMMUNICATE YOUR SOLUTION: OUTBREAK!

1. Do you think that your plan to contain a virus was successful? Did it meet all of the criteria and constraints? Explain.

2. Specifically, what are some of the strengths or advantages of your plan? Explain.

3. What are some drawbacks or disadvantages of your plan? Explain.

4. If you had an unlimited amount of money, what would you do differently? How would you change your plan?

5. How would your plan work if the village was larger? Do you think it would be successful for a village of 100 people? 200 people? 300 people? Explain your reasoning.

Be prepared to present your answers to questions 1–5 to the class.

## 8. REDESIGN AS NEEDED: OUTBREAK!

1. Based on the test of your virus-containment plan, what changes could you make to improve your plan?

   Explain how these changes would improve your virus-containment plan.

2. Identify one thing that you learned from another group's virus-containment plan that you can use to improve your virus-containment plan.

   Explain how this will improve your virus-containment plan.

 

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## INDIVIDUAL SELF-ASSESSMENT RUBRIC: OUTBREAK!

Use this rubric to reflect on how well you met behavior and work expectations during this activity. Check the box next to each expectation that you successfully met.

| LEVEL 1 | LEVEL 2 | LEVEL 3 | LEVEL 4 | BONUS POINTS |
|---|---|---|---|---|
| **Beginning to meet expectations** | **Meets some expectations** | **Meets expectations** | **Exceeds expectations** | |
| ☐ I was willing to work in a group setting.<br>☐ I was respectful and friendly to my teammates.<br>☐ I listened to my teammates and let them fully voice their opinions.<br>☐ I made sure we had the materials we needed and knew the tasks that needed to be done. | ☐ I met all of the Level 1 requirements.<br>☐ I recorded the most essential comments from other group members.<br>☐ I read all instructions.<br>☐ I wrote down everything that was required for the activity.<br>☐ I listened to instructions in class and was able to stay on track.<br>☐ I asked questions when I didn't understand something. | ☐ I met all of the Level 2 requirements.<br>☐ I made sure that my team was on track and doing the tasks for each activity.<br>☐ I listened to what my teammates had to say and asked for their opinions throughout the activity.<br>☐ I actively gave feedback (by speaking and/or writing) to my team and other teams.<br>☐ I completed all the assigned homework.<br>☐ I was able to work on my own when the teacher couldn't help me right away.<br>☐ I completed all the specified tasks for the activity. | ☐ I met all of the Level 3 requirements.<br>☐ I helped my teammates understand the things that they did not understand.<br>☐ I was always focused and on task: I didn't need to be reminded to do things; I knew what to do next.<br>☐ I was able to explain to the class what we learned and did in the activity. | ☐ I helped resolve conflicts on my team.<br>☐ I responded well to criticism.<br>☐ I encouraged everyone on my team to participate.<br>☐ I encouraged my team to persevere when my teammates faced difficulties and wanted to give up.<br>☐ I took advice and recommendations from the teacher about improving team performance and used feedback in team activities.<br>☐ I worked with my team outside of the classroom to ensure that we could work well in the classroom. |

Approximate your level based on the number of checked boxes: __________ Bonus points: ______________________

Teacher comments: ______________________________________________

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## TEAM EVALUATION: OUTBREAK!

How well did your team work together to complete the design challenge? Reflect on your teamwork experience by completing this evaluation and sharing your thoughts with your team. Celebrate your successes.

**RATE YOUR TEAMWORK.** On a scale of 0–3, how well did your team do? 3 is excellent, 0 is very poor. Explain how you came up with that rating. Was it the same, better, or worse than the last activity?

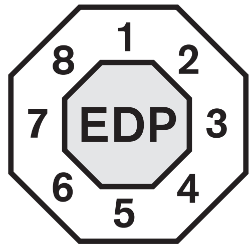
**LIST THINGS THAT WORKED WELL.** Example: We got to our tasks right away and stayed on track.

**LIST THINGS THAT DID NOT WORK WELL.** Example: We argued a lot and did not come to a decision that everyone could agree on.

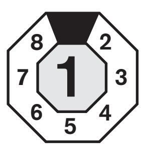
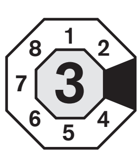
**HOW CAN YOU IMPROVE TEAMWORK?** Make the action steps concrete. Example: We need to learn how to make decisions better. Therefore, I will listen and respond without raising my voice.

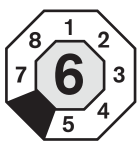
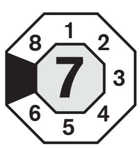
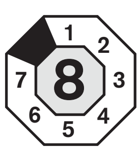
# EDP: ENGINEERING DESIGN PROCESS




Engineers all over the world have one thing in common. They use the engineering design process (EDP) to solve problems. These problems can be as complicated as building a state-of-the-art computer or as simple as making a warm jacket. In both cases, engineers use the EDP to help solve the problems. Although engineers may not strictly follow every step of the EDP in the same order all the time, the EDP serves as a tool that helps to guide engineers in their thinking process and approach to a problem. Below is a brief outline of each step.

| | |
|---|---|
|  DEFINE | The first step is to **define** the problem. In doing so, remember to ask questions! What is the problem? What do I want to do? What specifications should my solution meet to successfully solve the problem (also called "criteria")? What factors may limit possible solutions to this problem (also called "constraints")? |
|  RESEARCH | The next step is to conduct **research** on what can be done to solve the problem. What are the possible solutions? What have others already done? Use the Internet and the library to conduct investigations and talk to experts to explore possible solutions. |
|  BRAINSTORM | **Brainstorm** ideas and be creative! Think about possible solutions in both two and three dimensions. Let your imagination run wild. Talk with your teacher and fellow classmates. |

| | |
|---|---|
|  CHOOSE | **Choose** the best solution that meets all the criteria and constraints. Any diagrams or sketches will be helpful for later engineering design steps. Make a list of all the materials the project will need. |
|  BUILD | Use your diagrams and list of materials as a guide to **build** a model or prototype of your solution. |
|  TEST | **Test** and evaluate your prototype. How well does it work? Does it satisfy the engineering criteria and constraints? |
|  COMMUNICATE | **Communicate** with your peers about your prototype. Why did you choose this design? Does it work as intended? If not, what could be fixed? What were the trade-offs in your design? |
|  REDESIGN | Based on information gathered in the testing and communication steps, **redesign** your prototype. Keep in mind what you learned from one another in the communication step. Improvements can always be made! |

## MATH AND ENGINEERING CONCEPTS

In these three *Amazon Mission* activities, you will integrate engineering with math to solve problems and design prototypes. Specifically, you will:

- collect, represent, and analyze nonlinear data
- represent exponential functions graphically and algebraically
- solve problems involving proportions and scaling, and build scale models
- solve problems involving rates and unit conversions
- use formulas to calculate geometric measurements of a sphere
- draw nets, and calculate the surface area of three-dimensional objects
- apply the engineering design process to solve problems

## IMPORTANT VOCABULARY TERMS

**AMAZONIA**
the Amazon River Basin region, located in northern South America

**ANTIMALARIAL MEDICINE**
a medicinal drug used to treat and cure a person suffering from malaria by destroying the malaria parasite that is in the sick person's body

**ENDANGERED**
in danger of becoming extinct

**ENGINEERING**
the applications of math and science to practical ends, such as design or manufacturing

**ENGINEERING CONSTRAINTS**
limiting factors to consider when designing a model

**ENGINEERING CRITERIA**
specifications met by a successful solution

**EXTINCT**
no longer existing or living

**INHABIT**
to live, reside, or dwell in

**INDIGENOUS**
originating from or native to a region

**MALARIA**
a disease transmitted to humans by a bite from a female anopheles mosquito; may cause fever, chills, fatigue, confusion, anemia, and even coma or death

**MERCATRON**
a fictional, spherical object coated with a mercury-absorbing material

**MERCURY**
a silvery-white, poisonous metallic element

**PROTOTYPE**
a test model that contains only the essential features of the design, and serves as a basis or standard for later stages of the design

**RAIN FOREST**
a forest in a tropical region that has heavy annual rainfall

**SCALE**
a proportion used as a constant relationship between the dimensions of a model and the real object it represents

**SCALE MODEL**
an object that has been built to represent another, usually larger, object (the model is the same shape and has the same proportions, but is not the same size)

**SHABONO**
a large, wooden, circular structure surrounding an open area, which houses an entire Yanomami village

**SPHERE**
a three-dimensional geometric figure, shaped like a perfectly round ball

**VIRUS**
a microorganism that can only grow and multiply in the living cells of hosts such as humans, animals, and plants, and can cause diseases to spread in its hosts

**YANOMAMI**
an ethnic group native to the rain forests of Venezuela and Brazil

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## RUBRIC FOR GRAPHS: MALARIA MELTDOWN!, MERCURY RISING!, AND OUTBREAK!

| | EXPERT (4) | COMPETENT (3) | BEGINNER (2) | NOVICE (1) |
|---|---|---|---|---|
| **Labeling** | ☐ Clearly and appropriately labels the *x*- and *y*-axes<br>☐ Labels graph with a title that correctly identifies the data being represented<br>☐ Correctly identifies independent and dependent variables | ☐ Appropriately labels the *x*- and *y*-axes<br>☐ Labels graph with a title that correctly identifies the data being represented<br>☐ Correctly identifies independent and dependent variables | ☐ Leaves out one of the axis labels or inappropriately labels one axis (e.g., forgets to include units)<br>☐ Leaves out title or uses a title that partially identifies the data being represented<br>☐ Does not correctly identify independent and dependent variables | ☐ Leaves out both axis labels or inappropriately labels both axes<br>☐ Leaves out title or uses title that does not identify the data being represented<br>☐ Does not correctly identify independent and dependent variables |
| **Scales and intervals** | ☐ Uses scales and intervals for *x*- and *y*-axes that show the entire range of data; data is well spread out<br>☐ Shows equal intervals | ☐ Uses scales and intervals for *x*- and *y*-axes that show the entire range of data, but data may not be well spread out<br>☐ Shows mostly equal intervals (one or two minor errors) | ☐ Scales on *x*- and *y*-axes may not reflect the range of data needed, or intervals may not be appropriate to precisely show data<br>☐ Shows some equal intervals (a few major errors on one or both axes) | ☐ Missing scale on one or more axes, scales on *x*- and *y*-axes do not reflect the range of data needed, or intervals are not appropriate to show the data<br>☐ Shows unequal intervals (e.g., uses data values as intervals) |
| **Data Representation** | ☐ Graph accurately reflects data in the data table | ☐ Graph mostly reflects data in the data table (one or two minor errors) | ☐ Graph reflects some of the data in the data table (many minor errors or a few major errors) | ☐ Graph reflects few to none of the data in the data table (major errors) |
| **Type of graph** | ☐ Type of graph is appropriate for the kind of data | ☐ Type of graph is appropriate for the kind of data | ☐ Type of graph may not be appropriate for the kind of data | ☐ Type of graph is not suitable to represent the kind of data |

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# RUBRIC FOR EXPERIMENT DESIGN (STEP 2): MERCURY RISING!

| | EXPERT (4) | COMPETENT (3) | BEGINNER (2) | NOVICE (1) |
|---|---|---|---|---|
| **Overall completeness** | ☐ Selects a factor to test and gives rationale for why that factor can significantly affect the flow rate<br>☐ Discusses and writes out a set of test procedures<br>☐ Uses the procedures to test the factor<br>☐ Creates and completes a data table<br>☐ Creates a graph of the data<br>☐ Analyzes graph and comes up with a rule of thumb based on test results | ☐ Completes at least 5 of the 6 parts | ☐ Completes at least 3 of the 6 parts | ☐ Completes fewer than 3 of the 6 parts |
| **Quality of test procedures** | ☐ Designs test procedures that clearly and explicitly test a single variable while keeping all other conditions the same<br>☐ Writes out detailed step-by-step procedures that can be easily understood and followed<br>☐ Selects at least four to five variables that are appropriately spaced in value<br>☐ Creates clearly labeled data collection table<br>☐ Uses data labels that are appropriate to the factor being tested<br>☐ Carefully follows the testing procedures, and collects and records precise data in the data table | ☐ Designs test procedures that test for a single variable, but may not explicitly explain how the variable is controlled<br>☐ Writes out step-by-step testing procedures<br>☐ Selects at least three to four variables that are mostly appropriately spaced in value<br>☐ Creates data collection table with data labels that are relevant to the factor being tested<br>☐ Follows most of the testing procedures, and collects and records data in the data table | ☐ Designs test procedures, but may not design a controlled experiment that tests only one variable<br>☐ Writes out testing procedures that may be incomplete or missing key procedures<br>☐ Selects at least two to three variables, but some may not be appropriately spaced in value<br>☐ Creates a partial data collection table<br>☐ Uses some inappropriate data labels or leaves out some data labels<br>☐ Follows some of the testing procedures<br>☐ Collects and records some data in the data table | ☐ Designs test procedures that are not controlled and does not test only one variable<br>☐ Does not write out testing procedures, or procedures are very vague and sketchy<br>☐ Does not create a data collection table<br>☐ Does not select variables that are appropriately spaced in value, or only tests one or two variables<br>☐ Does not use appropriate data labels or any labels<br>☐ Does not follow testing procedures.<br>☐ Incorrectly records data or does not collect data |

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## RUBRIC FOR EXPERIMENT DESIGN (STEP 2): MERCURY RISING! *(CONTINUED)*

| | EXPERT (4) | COMPETENT (3) | BEGINNER (2) | NOVICE (1) |
|---|---|---|---|---|
| **Graph completeness and quality** | ☐ Clearly and appropriately labels the *x*- and *y*-axes<br>☐ Labels graph with appropriate title<br>☐ Uses appropriate scales for *x*- and *y*-axes<br>☐ Graph accurately reflects data in the data table<br>☐ Type of graph is appropriate to the kind of data | ☐ Appropriately labels the *x*- and *y*-axes<br>☐ Labels graph with appropriate title<br>☐ Uses mostly appropriate scales for *x*- and *y*-axes (may not use the most appropriate intervals)<br>☐ Graph mostly reflects data in the data table (one or two minor errors)<br>☐ Type of graph is appropriate to the kind of data | ☐ Leaves out one of the axis labels or inappropriately labels one axis (e.g., forgets to include units)<br>☐ Leaves out title or uses inappropriate title<br>☐ Scales on *x*- and *y*-axes may not reflect the range of data needed, or intervals may not be appropriate to precisely show data<br>☐ Graph reflects some of the data in the data table (many minor errors or a few major errors)<br>☐ Type of graph may not be appropriate to the kind of data | ☐ Leaves out both axis labels or inappropriately labels both axes<br>☐ Leaves out title or uses inappropriate title<br>☐ Missing scale on one or more axes, scales on *x*- and *y*-axes do not reflect the range of data needed, or intervals are not appropriate to show the data |
| **Data analysis** | ☐ Thoughtfully analyzes data to draw conclusions that are directly relevant to successfully meeting design criteria and constraints<br>☐ Supports conclusion with evidence from the experiment results OR thoughtfully explains how data results are insufficient to support drawing any conclusions<br>☐ Shows a reasonable amount of skepticism in own results | ☐ Analyzes data to draw conclusions that help students meet design criteria and constraints<br>☐ Supports conclusion with evidence from the experiment results OR explains how data results may be insufficient evidence to support drawing any conclusions | ☐ Draws conclusions that somewhat help students meet design criteria and constraints<br>☐ Does not support conclusions with evidence from the experiment OR states that data results are not able to support drawing any conclusions but explains the reason in vague terms | ☐ Draws conclusions that are not relevant to helping students meet design criteria and constraints<br>☐ Does not support conclusions with evidence from the experiment OR states that data results cannot support drawing any conclusions but does not explain why |

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## RUBRIC FOR ENGINEERING DRAWINGS (STEP 4): MALARIA MELTDOWN!

| | EXPERT (4) | COMPETENT (3) | BEGINNER (2) | NOVICE (1) |
|---|---|---|---|---|
| **Quality of idea** | ☐ Selects a design that addresses the problem<br>☐ Uses materials efficiently and with purpose<br>☐ Chooses design as a team through thoughtful deliberation<br>☐ Is able to express rationale for each part of the design | ☐ Selects a design that addresses most of the problem<br>☐ Uses material mostly efficiently and with purpose<br>☐ Chooses design as a team after some deliberation<br>☐ Is able to express rationale for most parts of the design | ☐ Selects a design that somewhat addresses the problem<br>☐ Uses materials with some purpose<br>☐ Chooses design as a team after a little discussion<br>☐ Is able to express rationale for some parts of the design | ☐ Selects a design that does not address the problem<br>☐ Does not use materials with purpose<br>☐ Chooses design hastily without much discussion<br>☐ Is not able to express rationale for design |
| **Communication** | ☐ Accurately draws a 3-D representation of the carrier<br>☐ Accurately draws a net of the carrier<br>☐ Labels all dimensions<br>☐ Uses appropriate units<br>☐ Labels all the materials used in the design | ☐ Draws a 3-D representation of the carrier with minor errors<br>☐ Draws a net of the carrier with minor errors<br>☐ Labels most dimensions<br>☐ Uses appropriate units<br>☐ Labels most of the materials used in the design | ☐ Attempts to draw a 3-D representation of the carrier<br>☐ Attempts to draw a net of the carrier<br>☐ Labels some dimensions<br>☐ Uses somewhat appropriate units<br>☐ Labels some of the materials used in the design | ☐ Missing one or both 3-D representation and net drawing of the carrier<br>☐ Does not label dimensions.<br>☐ Units are not included or are inappropriate<br>☐ Does not label materials used in the design |

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## RUBRIC FOR ENGINEERING DRAWINGS (STEP 4): MERCURY RISING!

| | EXPERT (4) | COMPETENT (3) | BEGINNER (2) | NOVICE (1) |
|---|---|---|---|---|
| **Quality of idea** | ☐ Selects a design that addresses the problem<br>☐ Uses materials efficiently and with purpose<br>☐ Chooses design as a team through thoughtful deliberation<br>☐ Is able to express rationale for each part of the design | ☐ Selects a design that addresses most of the problem<br>☐ Uses material mostly efficiently and with purpose<br>☐ Chooses design as a team after some deliberation<br>☐ Is able to express rationale for most parts of the design | ☐ Selects a design that somewhat addresses the problem<br>☐ Uses materials with some purpose<br>☐ Chooses design as a team after a little discussion<br>☐ Is able to express rationale for some parts of the design | ☐ Selects a design that does not address the problem<br>☐ Does not use materials with purpose<br>☐ Chooses design hastily without much discussion<br>☐ Is not able to express rationale for design |
| **Communication** | ☐ Draws a detailed design of the filter, including the number of holes, size of holes, where the water goes in and out, and where the Mercatrons are located<br>☐ Labels the functions of all parts of the design.<br>☐ Labels all the materials used in the design | ☐ Draws a mostly detailed design of the filter, missing one of the following: number of holes, size of holes, where the water goes in and out, or where the Mercatrons are located<br>☐ Labels the functions of most parts of the design<br>☐ Labels most of the materials used in the design | ☐ Draws a partial design of the filter, missing two of the following: number of holes, size of holes, where the water goes in and out, and where the Mercatrons are located<br>☐ Labels the functions of some parts of the design<br>☐ Labels some of the materials used in the design | ☐ Draws a rough design of the filter; missing three or more of the following: number of holes, size of holes, where the water goes in and out, and where the Mercatrons are located<br>☐ Does not label the functions of the parts of the design<br>☐ Does not label materials used in the design |

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## RUBRIC FOR PROTOTYPE/MODEL (STEP 5): MALARIA MELTDOWN!, MERCURY RISING!, AND OUTBREAK!

| | EXPERT (4) | COMPETENT (3) | BEGINNER (2) | NOVICE (1) |
|---|---|---|---|---|
| **Completeness** | ☐ Builds a model that meets all criteria and constraints<br>☐ Follows the design sketch<br>☐ Follows cleanup procedures | ☐ Builds a model that addresses most of the criteria and constraints<br>☐ Follows most of the design sketch<br>☐ Follows cleanup procedures | ☐ Builds a model that addresses some of the criteria and constraints<br>☐ Follows some of the design sketch<br>☐ Partially follows cleanup procedures | ☐ Builds an incomplete model<br>☐ Does not follow the design sketch<br>☐ Does not follow cleanup procedures |
| **Craftsmanship** | ☐ Takes care in constructing model; is adept with tools and resources, and makes continual adjustments to optimize the model/prototype<br>☐ Demonstrates persistence with minor problems | ☐ Uses tools and resources with little or no guidance<br>☐ Refines model to enhance appearance and capabilities | ☐ Uses tools and resources with some guidance; may have difficulty selecting the appropriate resource<br>☐ Refines work, but may prefer to leave model as first produced | ☐ Needs guidance in order to use resources safely and appropriately<br>☐ Model/prototype is crude, with little or no refinements made |

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## RUBRIC FOR TEST, COMMUNICATE, AND REDESIGN STEPS: MALARIA MELTDOWN!, MERCURY RISING!, AND OUTBREAK!

| | EXPERT (4) | COMPETENT (3) | BEGINNER (2) | NOVICE (1) |
|---|---|---|---|---|
| **Completeness** | ☐ Carefully follows the testing procedures and documents all testing results | ☐ Follows the testing procedures and documents most of the testing results | ☐ Follows some of the testing procedures and documents some of the testing results | ☐ Does not follow the testing procedures and does not document the testing results |
| **Model performance** | ☐ The model fully meets the design constraints and criteria. | ☐ The model meets most of the design constraints and criteria. | ☐ The model meets some design constraints and criteria completely but ignores others. | ☐ The model fails to meet design criteria and constraints. |
| **Quality of reflection** | ☐ Specific improvement ideas are generated and documented | ☐ Some general improvement ideas are generated and documented. | ☐ The need for improvements is recognized and some ideas are generated, but documentation is not complete. | ☐ Little interest is taken in improving the prototype or model, despite problems detected during testing. There is no evidence of inclination or ability to generate refinement solutions. |

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# STUDENT PARTICIPATION RUBRIC

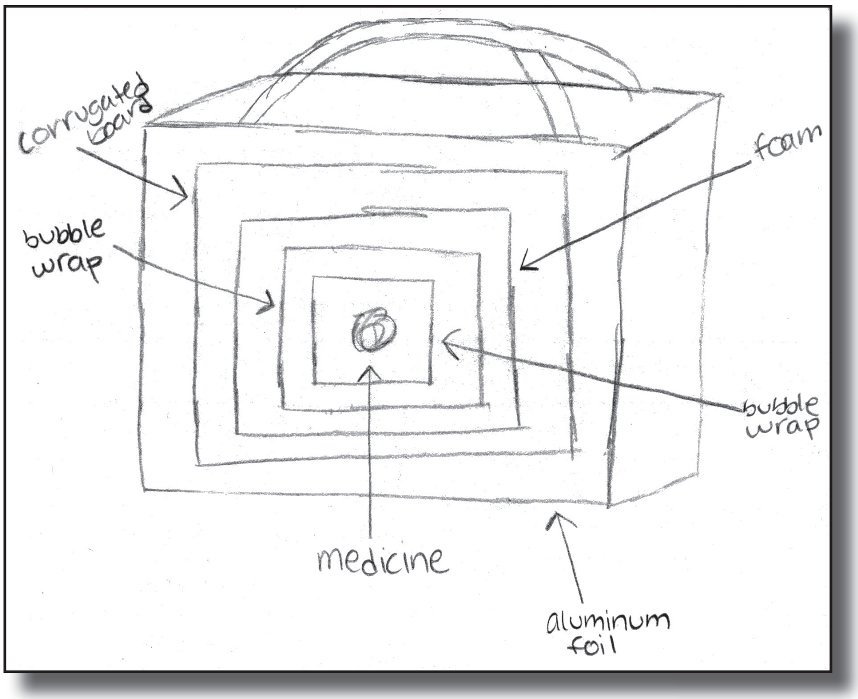
| | 0 POINTS<br>JUST BEGINNING | 1 POINT | 2 POINTS | 3 POINTS | SCORE |
|---|---|---|---|---|---|
| **CONTENT CONTRIBUTION** | | | | | |
| **Sharing information** | Discussed very little information related to the topic | Discussed some basic information; most related to the topic | Discussed a great deal of information; all related to the topic | Discussed a great deal of information showing in-depth analysis and thinking skills | |
| **Creativity** | Did not contribute any new ideas | Contributed some new ideas | Contributed many new ideas | Contributed a great deal of new ideas | |
| **RESPONSIBILITY** | | | | | |
| **Completion of assigned duties** | Did not perform any assigned duties | Performed very few assigned duties | Performed nearly all assigned duties at the level of expectation | Performed all assigned duties; did extra duties | |
| **Attendance** | Was never present or was always a negative influence when present | Attended some group meetings; absence(s) hurt the group's progress | Attended most group meetings; absence(s) did not affect group's progress or made up work | Attended all focus group meetings | |
| **Staying on task** | Not productive during group meetings; often distracted the team | Productive some of the time; needed reminders to stay on task | Productive most of the time; rarely needed reminders to stay on task | Used all of the focus group time effectively; productive at all times | |
| **TEAMWORK** | | | | | |
| **Cooperating with teammates** | Was rarely talking or always talking; usually argued with teammates | Usually did most of the talking, rarely allowing others to speak; sometimes argued | Listened, but sometimes talked too much; rarely argued | Listened and spoke a fair amount; never argued with teammates | |
| **Making fair decisions** | Always needed to have things his or her way; easily upset | Usually wanted to have things his or her way or often sided with friends instead of considering all views | Usually considered all views | Always helped team to reach a fair decision | |
| **Leadership** | Never took lead; needed to be assigned duties | Took a lead at least once; volunteered for duty | Took a lead more than once; volunteered for duties and helped others | Played essential role in organizing the group; frequently took lead; always helped others | |

Teacher: ______________________ Total score: ________ / 24

## STUDENT WORK SAMPLE 1

### MALARIA MELTDOWN! STEP 4: ENGINEERING DRAWING

Use the rubric provided by your teacher to assess the following student work sample. Write a brief explanation for the grade you assign and how the work can be improved.




1. Grade: ________

2. Reasons for grade: ____________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

3. How work can be improved: ____________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

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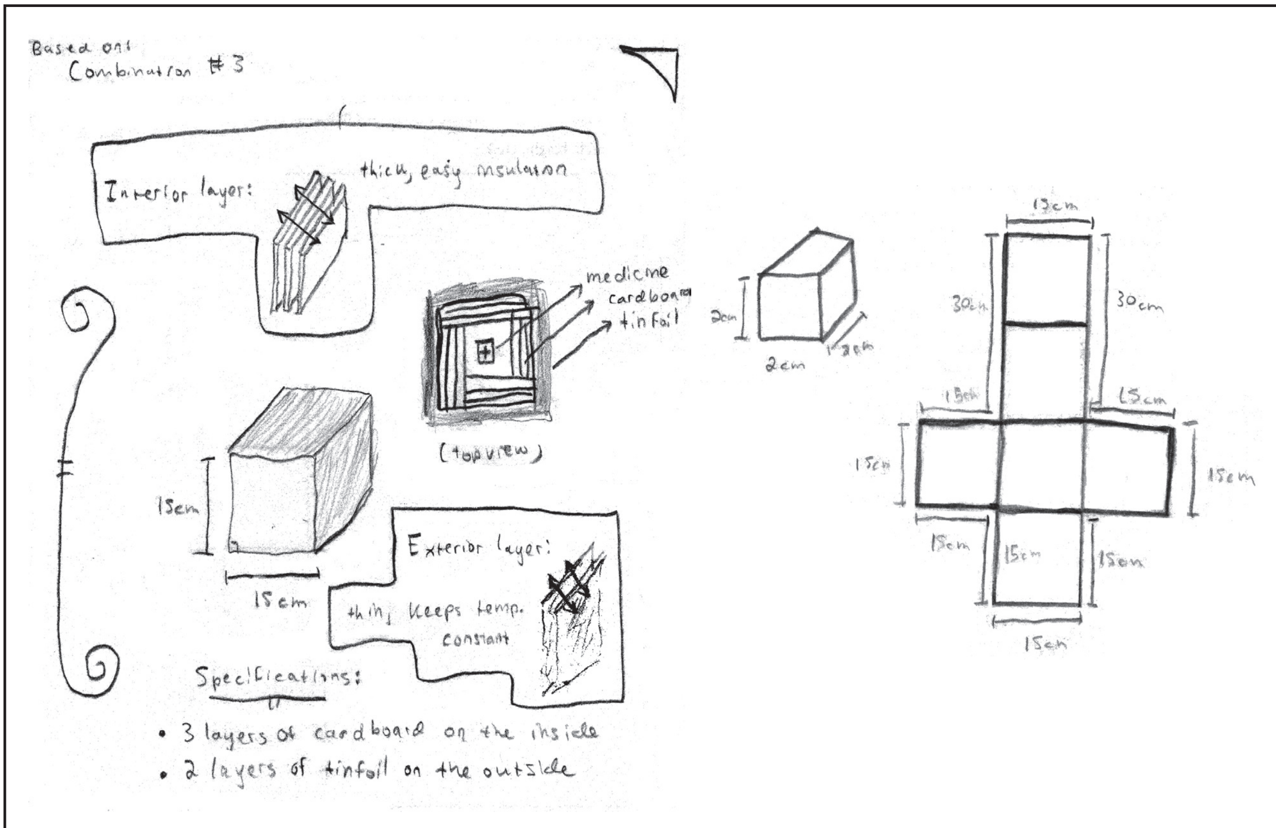
## STUDENT WORK SAMPLE 2

### MALARIA MELTDOWN! STEP 4: ENGINEERING DRAWING

Use the rubric provided by your teacher to assess the following student work sample. Write a brief explanation for the grade you assign and how the work can be improved.




1. Grade: ________

2. Reasons for grade: ____________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

3. How work can be improved: ______________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

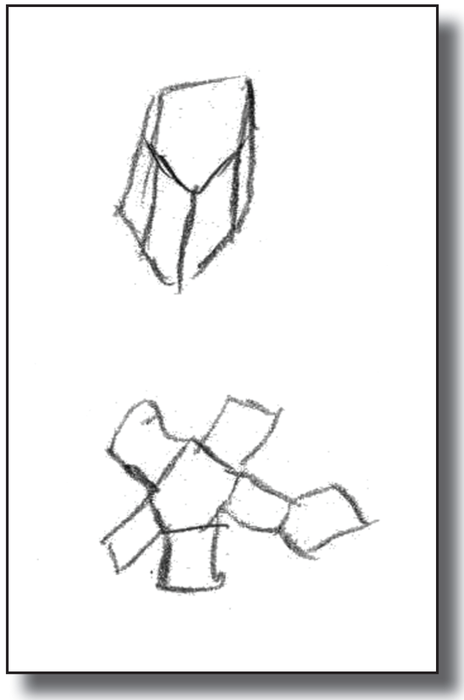
Name

STUDENT PAGE

## STUDENT WORK SAMPLE 3

### MALARIA MELTDOWN! STEP 4: ENGINEERING DRAWING

Use the rubric provided by your teacher to assess the following student work sample. Write a brief explanation for the grade you assign and how the work can be improved.



1. Grade: ________

2. Reasons for grade: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

3. How work can be improved: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

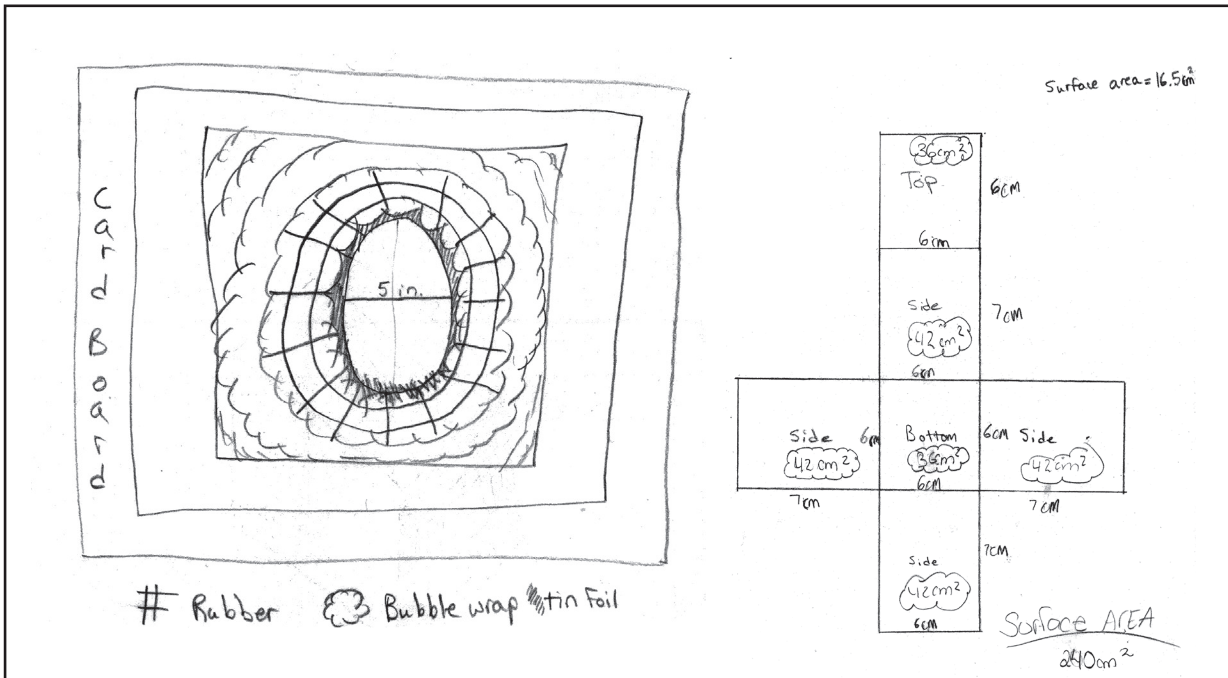
Name

STUDENT PAGE

## STUDENT WORK SAMPLE 4

### MALARIA MELTDOWN! STEP 4: ENGINEERING DRAWING

Use the rubric provided by your teacher to assess the following student work sample. Write a brief explanation for the grade you assign and how the work can be improved.




1. Grade: ________

2. Reasons for grade: ______________________________________________

______________________________________________

______________________________________________

______________________________________________

3. How work can be improved: ______________________________________________

______________________________________________

______________________________________________

______________________________________________