Advanced Manufacturing & Prototyping Integrated to Unlock Potential

8TH GRADE MATH

Data Visualization

RESCUE THE HOTSHOTS!

Hotshot Challenge

Annotated Teacher's Edition

Updated 07/10/2017

Fall 2017

8DVM

SECTION 1 – THE HOTSHOT CHALLENGE

1.1 INTRODUCTION

Teacher note: provide a copy of SE to each student. Read out-loud. You can also distribute the student sheet packet.

Firefighters work hard to put out fires in forests all over the world. Because fires move quickly and can be very unpredictable and dangerous, firefighting requires a high level of skill. When a fire is particularly bad, the U.S. Forest Service and the National Park Service hire Interagency Hotshot Crews to help tackle the blaze. These Hotshots are the most elite wilderness firefighters in the country. As the U.S. Forest Service notes on their website, "These crews can really take the heat!"

In 2013, 19 Hotshot firefighters were tragically killed fighting an Arizona fire when they were trapped by the fire. This CNN video describes the job they were doing.

Teacher note: show video

Watch ***"What is a Hotshot Firefighter?"*** video #1.

Continue to read aloud

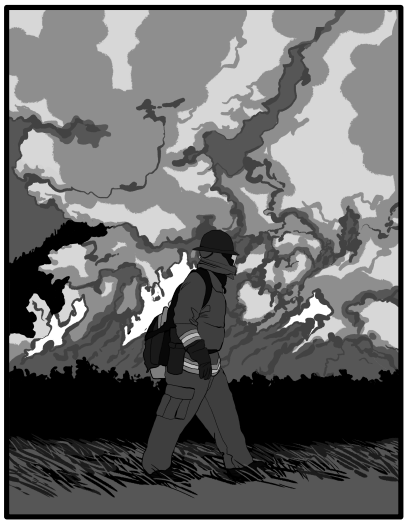
If the wind shifts and a large fire suddenly changes direction, the Hotshots' planned escape route can be blocked, as shown in the picture below. In these cases, the Hotshots might need to be rescued from the forest by helicopter. The Hotshots need to plan ahead for this type of a quick evacuation.

Continue to read aloud

Hotshots fight fires in teams that are spread out across the forest. For the helicopter to be able to pick up all of the firefighters in one trip, they have to plan to meet at an evacuation point at the same time. The picture below is of a helicopter rescuing a team of firefighters. They are on a mountain and taking turns getting into the helicopter. There are two teams in this image getting into the helicopter.

EVACUATE THE HOTSHOTS CHALLENGE

In this challenge, you will be working as part of the Hotshots Advance Planning Team. Your planning team will help a set of Hotshots create an evacuation plan that will ensure that they can be rescued together from the forest by helicopter.



PLEASE DO NOT WRITE IN THIS BOOK.

1.2 SIMULATING THE EVACUATION

Continue to read aloud. Highlight the idea of a simulation

A **simulation** is an imitation of a real process or thing. An example of a simulation is when a computer flight training software challenges a pilot with an emergency situation. The pilot can try out different ways of dealing with the emergency without the possibility of getting injured.

Firefighters do simulations to test a technique to fight a fire or to prepare for an emergency. By simulating the emergency, the firefighters will know how to react to the situation. Also, by simulating the emergency, there is no risk of anyone getting hurt by the decisions made in the simulation.

As members of the Hotshots Advance Planning Team, you will participate in an evacuation simulation. This simulation will require that you determine how fast your team can evacuate from different areas of a forest when fighting a fire. You will need to decide what you will do if the wind shifts and the fire jumps the line.

KEY TERMS

Simulation: imitation of a real process or thing

Conduct a class discussion using the questions below

Discuss these questions as a group:

1. What information does your Hotshot team need to know in order to safely go from where you are in the forest to the evacuation point? Where is the fire? What paths are there?
2. How might the terrain in the area affect your team's path to the evacuation point? Could slow you down. Force different paths.

1.3 DEFINING YOUR EVACUATION ROUTE: HOT SHOT ADVANCE PLANNING TEAM TRAINING

Make sure there are rulers for the students to use at this point

To plan an evacuation, you will first need to know your team's position, the evacuation point, and fire locations. Each Hotshots Advance Planning Team will begin by analyzing a training map of a region in danger of having a forest fire.

Part A: Defining Your Position on the Map

Procedure:

Each student should complete their own map. Remind them to read and follow the procedure.

AVAILABLE MATERIALS

- Ruler
- *Evacuation Training Investigation Sheet*

1. Determine the distance from your team's position (X) to the evacuation position (O) on the training map provided on your *Evacuation Training Investigation Sheet.* You will determine two distances: 1) if you travel only on roads, and 2) if you take a path through the brush.

2. To determine these distances, use your ruler to draw and label the two paths below on the training map on your *Evacuation Training Investigation Sheet*.

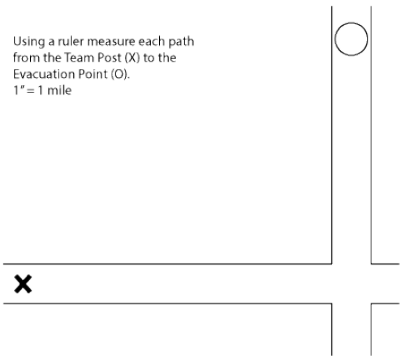
   - **Path 1**—From your team's posting spot to the evacuation point, traveling on roads.
   - **Path 2**—From your team's posting spot to the evaluation point, traveling by the shortest path.

   Note that together the two paths form a right triangle with the team's current posting position and the evacuation position as the two **vertices**, or corners, of the triangle.

3. Use your ruler to measure the length of each path, in inches, and record the numbers in the table on your *Evacuation Training Investigation Sheet.* For Path 1, measure and record the distance from your team's posting spot to the road intersection as "Leg 1," and the distance from the intersection to the evacuation point as "Leg 2."

4. The scale of this map is 1 inch represents 1 mile. Using this scale, calculate the length of each path, in miles, and record it on your *Evacuation Training Investigation Sheet*.

They should draw the lines in the middle of the roads to get the most accurate measurements



PLEASE DO NOT WRITE IN THIS BOOK.

5. Raise your hand when your group has identified your right triangle, the length of all sides of the triangle, and the length (in miles) of Path 1 and Path 2 on your *Evacuation Training Investigation Sheet*. We will call these distances $D_{path\ 1}$ and $D_{path\ 2}$.

The results they find should be a 3,4,5 triangle. You might need to explain the use of subscripts.

When all students have completed and verified, have a discussion with the questions below

Discuss these questions as a class:

1. Which route from the team location to the evacuation point is the shortest total distance to travel?
2. When traveling on foot, is the shortest distances always the quickest route to take?
3. If you only know the distances for the paths along the road (Leg 1 and Leg 2), using mathematics, how might you figure out the length of the path through the woods?

Part B: Verifying Distance Using Pythagorean Theorem

The three sides of a right triangle are called the legs and the hypotenuse. The hypotenuse is always the longest side of a right triangle and is across from the right angle. The Pythagorean Theorem can be used to find the length of one side of a right triangle if you know the other two sides.

Remember that on your map, Path 1 consists of two legs. "Leg 1" is the distance from where your Hotshot team is currently standing to the intersection of the two roads. "Leg 2" is the distance from the intersection, or right angle, to the evacuation point. The hypotenuse is Path 2, or your path directly through the woods.

If desired, you can have a class discussion to present the Pythagorean Theorem as you may have done before

Pythagorean Theorem

(Leg 1 distance)^2 + (Leg 2 distance)^2 = (Hypotenuse distance)^2

This formula is sometimes written as **$a^2 + b^2 = c^2$**.

Procedure:

6. Calculate the length of Path 2 using the Pythagorean Theorem on your *Evacuation Training Investigation Sheet* in Part B.

Use the questions below to have a discussion about the value of computation and measurement

Discuss these questions as a class:

1. Did your mathematical calculation of Path 2 exactly match your measured one?
2. If not, why might that be the case? What sources of error does measuring with a ruler introduce if you are not careful?

PLEASE DO NOT WRITE IN THIS BOOK.

SECTION 2 – DETERMING THE EVACUATION TIME

2.1 PACING DATA COLLECTION

Before class you should identify a location for the pacing activity. Find a space with room for at least 30-100 feet. Look below for the setup instructions

Your Hotshot Advance Planning Team has been charged with planning the possible routes for the evacuating fire fighters. You need to figure out how long it will take for each team to walk from where they are fighting the fire to the evacuation point where the helicopter will pick them up. To determine this, you must first figure out the average **rate**, or **pace**, that your team walks. Remember that in a real fire fight, each firefighter will be carrying many pounds of equipment and would not be able to run or sprint. To determine your pace in this activity, you need to walk, not run.

Follow the steps below to calculate the average pace of participating in different activities for your group. Your teacher will direct you to the designated area to conduct the activity and will determine the distance you will walk.

AVAILABLE MATERIALS

- Masking tape or chalk
- Measuring Tape
- Stopwatch
- *Pacing Data Collection Sheet*

Procedure:

Place a starting point/line on the ground with either tape or chalk. Then measure the length you are able and place a finish line.

1. Have one member of your team pick up one stopwatch for your team.
2. To help you organize, count off so that each team member has a different number (i.e. use #1 through #4, for a team of four people). Each team member will perform two trials during this activity. Each trial will be different.

Students should record each team members' results on their own student sheet. They will perform each trial once per student. You will want to be able to have multiple or all groups able to do the activity at the same time to help with time and behavior.

Round One—Walking on the Road

3. Team member #1 lines up at the starting line.
4. Another team member instructs team member #1 when to start walking, and uses the stop watch to measure how long it takes team member #1 to walk at a normal pace (not running) from the starting line to the end.

5. All team members should record the time it takes for team member #1 to walk the designated distance on their *Pacing Data Collection Sheet* on round 1's data table.
6. Repeat steps 5-7 for team members #2, #3, etc., until you have measured and recorded the time it takes for all of your team members to walk the full distance. Be sure to rotate jobs so that all of your team members have a turn being the timer.
7. When all of your team members have completed the trial, calculate the total and average time, in seconds, required for all team members to walk the full distance.
8. Record the total and average time in seconds on your *Pacing Data Collection Sheet*.

Round Two— Walking through Brush

9. Repeat round one, except this round walk backwards instead of forwards. This will simulate the difficulty your team might encounter if you take the path through the brush instead of using the road. That path is slower than walking freely on the road.
10. All team members should record the time it takes for each team member to walk the designated distance backwards on their *Pacing Data Collection Sheet* on round 2's data dable.
11. When all of your team members have completed the trial, calculate the total and average time, in seconds, required for all team memebers to walk the full distance.
12. Record the total and average time in seconds on your *Pacing Data Collection Sheet*.

Discuss these questions as a class:

1. What are common measures of rate or pace? ft/sec m/hr
2. Why should you not run during this simulation? We have to make this as much like the real evacuation as possible
3. How does walking backwards simulate walking through brush? Slows down our pace

PLEASE DO NOT WRITE IN THIS BOOK.

2.2 PACING DATA ANALYSIS

Part A: Calculating Your Pace

You may choose to take a moment and show them how to solve for variables that are in the equation. They will be solving for r and t. They will also be converting some units in this.

In the previous section, you measured the time it took for you to walk a certain distance. Using this data, you can now calculate how fast your team walks. This is your team's **pace**, or **rate.** In this case, rate is expressed as a distance traveled in a set amount of time, such as feet per second or miles per hour. To calculate the rate, you will use the following formula below that describes motion.

$$d\ (\text{distance}) = r\ (\text{rate}) * t\ (\text{time})$$

d = the distance traveled, **r** = the average rate of travel, and **t** = the time it took

If you know your distance and time, you can solve for your rate.

Procedure:

1. On your *Pacing Analysis Student Sheet*, follow the instructions to calculate the average rate of travel for your team when walking along the road. We will call this R_{road}.
2. On your *Pacing Analysis Student Sheet*, follow the instructions to calculate the average rate of travel for your team when walking backwards. We will call this R_{brush}.

Part B: Determining Time to the Evacuation Point

As a Hotshot Advance Planner, you need to know how long it will take the members of your crew to walk a defined distance and to reach a destination point. To do that, you will again use the formula that describes motion: **d (distance) = r (rate) * t (time)**.

Help students understand that D_{path1} and R_{road} pair together and D_{path2} and R_{brush} pair together

Procedure:

1. Refer back to the diagram you drew on the *Evacuation Training Investigation Sheet*, and the distances that you calculated for Path 1 and Path 2 ($D_{path\ 1}$, and $D_{path\ 2}$).
2. Follow the instructions on your *Pacing Analysis Student Sheet*. You will use the rates that you calculated in Part A (R_{road}, and R_{brush}) to calculate the time it will take to walk on the road and the time it will take to walk on the path through the brush. To make the most sense of the information, your final time should be converted to minutes.

Your team has now completed training and is ready to work with the Hotshot teams!

Discuss these questions as a class:

1. Which route has the shortest distance? The one through the woods
2. What side of the right triangle is always the longest side? Hypotenuse
3. Is the shortest route always the fastest? No, obstacles may be more difficult
4. How can your pace be affected when planning evacuation routes? Terrain

SECTION 3 – RESPONDING TO THE CALL

3.1 EVALUATING THE POSSIBLE ESCAPE ROUTES

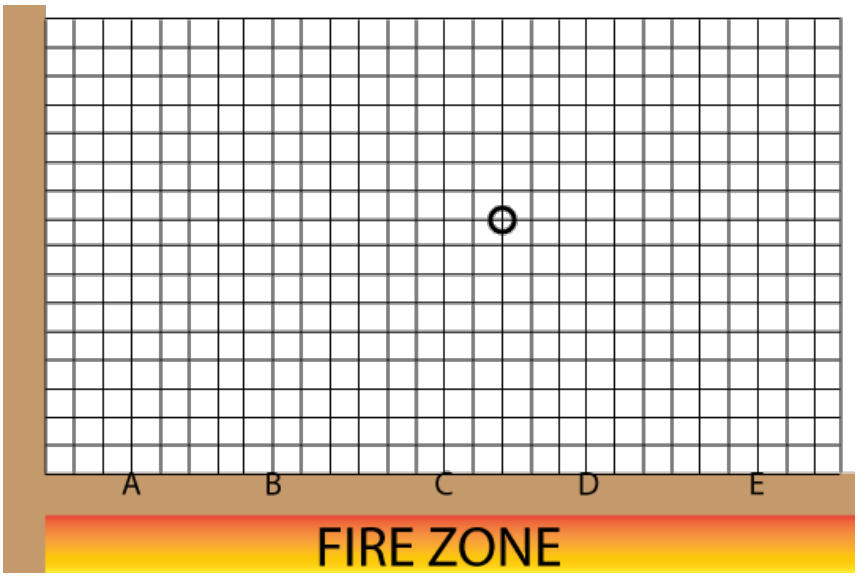
Read out loud

Your Hotshot Advance Planning Team has received a call about a new wildfire. You have been assigned to create the evacuation plan for some teams of Hotshots who are working along the fire line.

The Hotshot teams will be positioned along the road by the fire line in an area illustrated in the map below and on your *Evacuation Route Map*. The teams will be dropped off by truck on the road. If all goes well, the vehicles will return to pick up the teams when the fire is controlled. However, if there is an emergency and the trucks cannot retrieve the fire fighters, a helicopter will evacuate the Hotshots from a point north of Oak Lane and east of Summit road. This location is marked with an O on the map.

Part A: Find the Distances

On the map, there are five trails that lead from the road to the helicopter evacuation point. The trails go through various types of terrain, some more difficult and slower than others. The trailheads (where the trails meet the road) are marked on the map with the letters A-E. To avoid getting lost, Hotshot teams must stay either on roads or on marked trails.



Procedure:

1. Follow the instructions on the *Evacuation Route Data Sheet* and use the Pythagorean Thereom to determine the distance from the road to the evacuation point for each of the five trails.
2. Label each trail on your *Evacuation Route Map* with the proper distance.

PLEASE DO NOT WRITE IN THIS BOOK.

Part B: Adjusting the Rates

The trail length is not the most important piece of information you need for evacuating the Hotshots safely. The most important number is the length of time it will take the firefighters to get to the evacuation spot by walking along the trail, which depends upon how fast they can walk on that trail. During training, you walked backwards to simulate your rate or pace when walking through the brush instead of on the road. The brush rate (R_{brush}) was probably slower than the road rate (R_{road}).

Rangers with the U.S. Forest Service have flown drones over these new trails, and have estimated a **terrain rate factor** for each trail. This factor gives you a measure of how difficult the trail is and how much slower you will walk than on the road. You will multiply your normal walking rate (R_{road}) by this factor to adjust for that particular trail's brush, rocks, and steep climbs.

Example: Your team's normal walking rate, R_{road}, is 500 ft/min. Trail A has a terrain rate factor of 1/2, meaning that you can only walk half as fast as on the road. To find your rate on Trail A, you would use the formula below.

$$\mathbf{R_{trail\ A} = (Terrain\ rate\ factor) * R_{road}}$$

$$R_{trail\ A} = 1/2 * R_{road}$$

$$R_{trail\ A} = 250 \text{ ft/min}$$

Each trail on your map has a different terrain factor.

Procedure:

1. Follow the instructions on your *Evacuation Route Data Sheet* to calculate the rate your group of Hotshots can walk on each of the five trails.
2. Label each trail on your *Evacuation Route Map* with the proper rate for that trail.

Part C: Calculating the Time

You now have the length of each trail as well as the speed, or rate, that your Hotshots can walk along each trail.

Procedure:

1. Follow the instructions on your *Evacuation Route Data Sheet*. Use the equation of motion, D (distance) = R (rate) * T (time), to calculate the length of time it will take your Hotshots to walk along each trail if they have to evacuate that way.
2. Label each trail on your *Evacuation Route Map* with the proper time it will take to walk that trail.

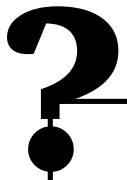
Teams now have a time for each trail. You are now able to assign each team to a specific starting location. You can do this based on ability and the point should not be located at a trail head unless needed for students level. Remember that each grid line is 500ft.

3.2 PREPARING THE PLAN

Your teacher will tell your Hotshot Advance Planning Team the location along the road where your Hotshots will be working. Your challenge will be to determine how long it will take your Hotshots to reach the emergency evacuation point using the five different possible trails. Use your original rate for walking along the road (R_{road}) for any leg of the route that falls along the road.

Procedure:

1. Brainstorm and decide a team name for your hot shots.
2. Record that name on your *Emergency Evacuation Route Planning Sheet.*
3. Follow the instructions on the *Emergency Evacuation Route Planning Sheet* to calculate the time it will take your Hotshot team to evacuate using each of the five trails.



Discuss these questions as a class:

1. Was the trail that was closest always the one that was the fastest?
2. Was the shortest route always the fastest? Why or why not?

PLEASE DO NOT WRITE IN THIS BOOK.

3.3 COMMUNICATING YOUR RESULTS

Part A: Visualizing data

Distribute green and yellow pencils for this part

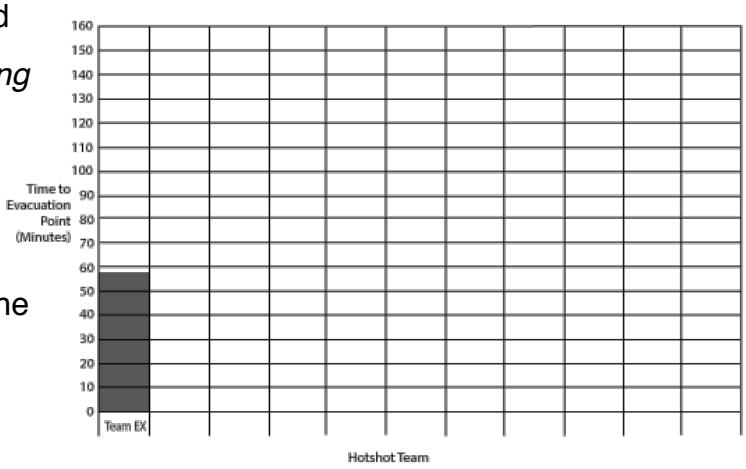
In sections 3.1 and 3.2, you created several data tables that include information about the times, rates, and distances for the five trails. Data tables are useful for providing people with large amounts of data in a compact form. However, data tables are often not the best way to visually communicate important results to other people. If you want your Hotshot team to quickly understand which route will be the fastest for them to use when evacuating, it would probably be better to give them the information in a different form.

One way to visually communicate data in a way that makes the information easier to understand is to make a graph or map and to use easily understood colors.

Procedure:

1. Using the data that you computed, complete your *Evacuation Route Map* by color coding the different paths, showing the fastest route in **green**, and the second fastest in **yellow**.
2. Label your map with your Hotshot team name.
3. When all groups have completed their maps, each team will share the following results with the class:
   - your Hotshot Team Name,
   - the coordinates where your Hotshot team started,
   - which route was the fastest, and
   - how long it will take for your team to reach the evacuation point.

   Use the board or piece of chart paper to create a class bar graph of times to evacuation point. This provides a time reference for helicopter arrival
4. As each team reports their results, record each group's results on your *Arrival Timing Data Sheet*.
5. Graph the time for each team to evacuate on the bar graph on the *Arrival Timing Data Sheet*, as shown to the right.



3.4 EVACUATE!!!!!

You will now tell the students a time that the evacuation is being called. The helicopter can arrive before that last team arrives but not too early as that can create additional hazards.

Your teacher will tell you what time you get the signal to evacuate.

Procedure :

The time can be during the class so that each class will be at a different time

1. Using the data in your bar chart on your *Arrival Timing Data Sheet*, predict what time the helicopter should be at the evacuation site in order to pick everyone up.

Have a good discussion using their results using the following questions

Discuss these questions as a class:

1. What time will your Hotshot team get there? Which team will be first? Which will be last?
2. What will happen if one of the trails is blocked by fire?
3. If you really need to get out quicker, what would you do? Can you change your rate? How?

Georgia Tech

Center for Education Integrating Science, Mathematics & Computing

This curriculum is produced by Advanced Manufacturing & Prototyping Integrated to Unlock Potential (AMP-IT-UP) supported by National Science Foundation Award #1238089 through Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing (CEISMC).

For more information about AMP-IT-UP
and to download our curriculum,
please visit our website at www.ampitup.gatech.edu.