



Stranded!



Building Math

---

Integrating Algebra & Engineering

## TABLE OF CONTENTS

|   |             |
|---|-------------|
| <i>Introduction</i> . . . . .   | <i>v</i>    |
| Organization and Structure of <i>Stranded!</i> . . . . .                  | <i>vii</i>  |
| <i>Building Math</i> : Pedagogical Approach, Goals, and Methods . . . . . | <i>viii</i> |
| Enduring Understandings . . . . .   | <i>ix</i>   |
| <i>Stranded!</i> Overview: Story Line and Learning Objectives . . . . .   | <i>x</i>    |
| Assessment Opportunities and Materials Lists . . . . .                    | <i>xii</i>  |
| <i>Stranded!</i> Master Materials List . . . . .                          | <i>xiv</i>  |
| Common Core and ITEEA Standards Correlations . . . . .                    | <i>xv</i>   |
| Pacing Planning Guide . . . . .   | <i>xx</i>   |
| Shipwreck Survivors Team-Building Activity . . . . .                      | 1           |
| <i>Stranded!</i> Prerequisite Math Skills . . . . .                       | 5           |
| Writing Heuristics, or Rules of Thumb . . . . .                           | 10          |
| <i>Stranded!</i> Introduction . . . . .                                   | 11          |
| Where Are We? . . . . .   | 13          |
| A True Tale of Survival . . . . .   | 16          |
| Introducing the Engineering Design Process (EDP) . . . . .                | 18          |
| Design Challenge 1: A Storm Is Approaching! . . . . .                     | 24          |
| Design Challenge 2: We Need Water! . . . . .                              | 53          |
| Design Challenge 3: Balancing Act! . . . . .                              | 94          |
| <i>Resources &amp; Appendices</i> . . . . .                               | 124         |
| EDP: Engineering Design Process . . . . .                                 | 125         |
| Math and Engineering Concepts . . . . .                                   | 127         |
| Important Vocabulary Terms . . . . .                                      | 127         |
| Rubrics . . . . .   | 128         |
| Student Work Samples . . . . .  | 134         |
| Appendix A: Boxes . . . . .   | 142         |
| Appendix B: Cylinders . . . . .   | 158         |
| Appendix C: Other Cylinder Sets . . . . .                                 | 163         |
| Appendix D: Square Prisms . . . . .                                       | 168         |
| <i>Answer Key</i> . . . . .   | 174         |

# STRANDED! OVERVIEW: STORY LINE AND LEARNING OBJECTIVES

|                                      | DESIGN CHALLENGE OVERVIEW   | STUDENTS WILL:   |
|--------------------------------------|---|--|
| <b>WHERE ARE WE?</b>                 | <p>Students imagine that they are on a school field trip to New Zealand to see where The Lord of the Rings movies were filmed. The plane is on course for New Zealand until a severe thunderstorm causes both the engine and radio to fail. The plane is forced to crash down somewhere in the South Pacific. The students climb into the emergency raft and drift in the ocean. Eventually, they wash ashore on what seems to be a deserted island. Students will use airplane speeds, flight durations, and a drawn-to-scale map to determine their approximate location in the South Pacific.</p>                                | <ul style="list-style-type: none"> <li>• Interpret a scale on a map.</li> <li>• Use proportional reasoning to calculate actual distance and drawn distance on a map according to a scale.</li> <li>• Use the relationship <math>\text{speed} = \text{distance} / \text{time}</math> to find one quantity given the other two quantities.</li> <li>• Solve a multistep problem.</li> <li>• Use a ruler.</li> </ul>  |
| <b>DC 1: A STORM IS APPROACHING!</b> | <p>A severe thunderstorm is heading toward the island and will be arriving in just a few hours. Students must build a shelter to protect them from the rain and strong winds. There is a limited supply of materials on the island. Students will work in teams to design and build a scale model of a shelter that can withstand strong winds, is water resistant, and provides a minimum of 1 cubic meter of personal space for each member of the team.</p>  | <ul style="list-style-type: none"> <li>• Identify similar three-dimensional objects.</li> <li>• Identify corresponding dimensions of similar objects.</li> <li>• Use a ruler to measure three-dimensional objects.</li> <li>• Calculate surface area and volume of rectangular prisms.</li> <li>• Analyze a table of values for patterns.</li> <li>• Generalize patterns using symbols.</li> <li>• Use a scale to calculate the amount of materials available for building a scale model.</li> <li>• Apply the engineering design process to solve a problem.</li> </ul>   |
| <b>DC 2: WE NEED WATER!</b>          | <p>The average person cannot survive for more than one week without fresh water. Ocean salt water surrounds the island, and there is no supply of fresh water on the island. Students will have to rely on rainwater for survival. In this activity, students discover an irregularly shaped piece of plane siding. Students will use this piece of siding to create a rainwater collector. The challenge is to create a collector design with a large volume as well as functionality. Students will investigate the relationship among height, radius, surface area, and volume of a cylinder to help them with their design.</p> | <ul style="list-style-type: none"> <li>• Find the area of an irregular two-dimensional shape using strategies for finding the areas of triangles, rectangles, and parallelograms.</li> <li>• Use a ruler to measure three-dimensional objects (cylinders and rectangular prisms).</li> <li>• Calculate the surface area and volume of three-dimensional objects.</li> <li>• Analyze a table of values for patterns.</li> <li>• Make and test conjectures about the relationship between surface area and volume, and dimensions and volume.</li> <li>• Produce and analyze line graphs that represent the relationship between two variables.</li> <li>• Apply the engineering design process to solve a problem.</li> </ul> |

# COMMON CORE AND ITEEA STANDARDS CORRELATIONS

The following tables show how each design challenge addresses Common Core State Mathematics Standards and International Technology and Engineering Standards. In the Common Core column, double asterisks (\*\*) denote standards that are not expressly addressed by the design challenges, but that can be addressed by using optional suggestions included in the instructional text for that design challenge. References to the specific pages are included.

| <b>Common Core State Standards for Mathematics (Grades 6–8)<sup>1</sup></b> |   |
|---|---|
| <b>WHERE ARE WE?</b>  | <p><b>Mathematical Practices</b></p> <p>2. Reason abstractly and quantitatively.<br/> <i>**See Optional CCSS Enhancement(s) on page 14.</i></p> <p>3. Construct viable arguments and critique the reasoning of others.</p> <p>6. Attend to precision.</p> <p><b>Standards</b></p> <p><b>6.RP.1.</b> Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.</p> <p><b>6.RP.3.</b> Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables** of equivalent ratios, ... or equations.**<br/> <i>**See Optional CCSS Enhancement(s) on page 14.</i></p> <p>a. Make tables of equivalent ratios relating quantities with whole-number measurements, find missing values in the tables.... Use tables to compare ratios.**<br/> <i>**See Optional CCSS Enhancement(s) on page 14.</i></p> <p>b. Solve unit rate problems including those involving ... constant speed.</p> <p>d. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.</p> |
|   | <p><b>6.NS.1.</b> Interpret and compute quotients of fractions, and solve word problems involving division of fractions by fractions....</p> <p><b>7.G.1.</b> Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas** from a scale drawing....<br/> <i>**See Optional CCSS Enhancement(s) on page 14.</i></p>  |

<sup>1</sup>Common Core State Standards. Copyright 2010. National Governor’s Association Center for Best Practices and Council of Chief State School Officers. All rights reserved.



## INTRODUCTION

**OBJECTIVE:** Students will read and understand the problem presented for the first design challenge.

**CLASS** Read or ask a student to read aloud the introduction.

### ASK THE CLASS:

- Have you ever been caught outside in the rain or other bad weather without shelter or an umbrella?
- Why is it important for people to have shelter?

Explain that the challenge in this activity is to design and build a model of a shelter on the island where they have been stranded.



### INTERESTING INFO

What to do and not do in a lightning storm:

- a. Don't take refuge under a tree.
- b. Don't huddle with others.
- c. Don't sit on the ground.
- d. Don't try to "read" the sky.
- e. Do help a lightning victim. (It is safe.)

**TRY IT!** You can calculate the distance (in kilometers) of a storm by counting the number of seconds starting from when you first see lightning until when you hear thunder, and then dividing the number of seconds by three.

A dramatic, high-contrast photograph of dark, heavy storm clouds filling the sky. The clouds are textured and layered, with some light breaking through near the horizon.

# Design Challenge 1

A Storm  
Is Approaching!

## **INTRODUCTION**

Dark clouds are heading your way, and the wind is beginning to pick up. There is a loud crack of thunder coming from the distance.

It looks like severe weather will be here in just a few hours. How will you protect yourself during the storm?

## 1. DEFINE THE PROBLEM: A STORM IS APPROACHING!

**OBJECTIVE:** Students will read and understand the criteria and constraints of the design challenge.

**CLASS** Together, read Define the Problem. Make sure that students understand the engineering criteria and constraints.

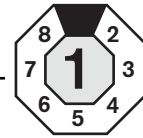


### INTERESTING INFO

Engineers must always carefully plan their experiments and follow a structured design plan. The explosion of the Chernobyl nuclear power plant is an example of the importance of planning. In 1986, engineers were testing one of the turbines in the power plant. They did not have a structured plan for the experiment and ignored many safety precautions. The results were catastrophic because they did not follow the engineering criteria and design steps. The power plant had a meltdown and exploded. There were 31 casualties from the explosion. The surrounding area is currently an uninhabited nuclear wasteland.

Name \_\_\_\_\_

STUDENT PAGE



DEFINE

## 1. DEFINE THE PROBLEM: A STORM IS APPROACHING!

The thunderstorm is quickly approaching, so you and your teammates will need to think fast. You need to design and construct a shelter that can withstand strong winds, keep out the rain, and hold all of your team members.

| ENGINEERING CRITERIA |  |
|----------------------|--|
| STURDY               | Given three heavy gusts of wind, the shelter must not move, tip over, or be damaged in any way.      |
| WATER RESISTANT      | Given three squirts of water to simulate rain, the inside of the shelter must remain completely dry. |
| SPACIOUS             | Each member of your team must have at least 1 cubic meter (m <sup>3</sup> ) of space.                |

| ENGINEERING CONSTRAINTS  |  |
|--|--|
| ACTUAL MATERIALS ON THE ISLAND   | MATERIALS FOR BUILDING THE SHELTER MODEL |
| logs<br>(20 logs per team; 3 meters long each)                                       | craft sticks (12 cm long)                |
| strip of plane siding that washed ashore<br>(1 piece 2.5 meters × 4 meters per team) | aluminum foil                            |
| tarp from the rescue raft<br>(1 piece 3 meters × 5 meters per team)                  | wax paper                                |
| rope that washed ashore<br>(6 meters of rope per team)                               | string                                   |
| mud<br>(1 bucket filled with 1 cubic meter (m <sup>3</sup> ) of mud per team)        | clay                                     |



**SPEED = DISTANCE/TIME ACTIVITY**

1. 50 km
2. 6.67 km/hr
3. 1/3 hour or 20 minutes

**PAGES 8-9****USING A SCALE ACTIVITY**

1. 1.5 cm
2. 30 cm × 100 cm
3. 12 cm × 12 cm × 12 cm = 1728 cm<sup>3</sup> (equivalent to 1.728 liters)

**PAGE 15****WHERE ARE WE?**

Step 1: 850 km/h × 9.5 hours = 8,075 km

Step 4: 15 km/h × 24 hours = 360 km

