Carolina **STEM Challenge®**

Geothermal

TEACHER'S MANUAL AND STUDENT GUIDE

CAROLINA STEM CHALLENGE®

Carolina STEM Challenge®

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Photocopy the Student Guide as needed for use in your classroom.

Carolina STEM Challenge® Geothermal

What is a Carolina STEM Challenge® Kit?

This line of investigations challenges students to comprehend, apply, analyze, synthesize, and evaluate scientific concepts and engineering design practices. Students are presented with a question that prompts them to think about the science involved in some practical application, process, or technology. Students research the relevant scientific principles and concepts, and then construct a prototype device or system that serves as the basis for further testing and study. After students are familiar with the apparatus and the ways in which it demonstrates the core ideas being studied, they are presented with a design challenge that requires them to modify their prototype in order to meet one or more specific criteria. They must analyze the problem, identify available resources and constraints, brainstorm solutions, and alter the features of their prototype—applying and building upon the knowledge, skills, and insights they have gained.

Overview

This kit highlights the use of geothermal exchange as a renewable energy source. Students learn about heat transfer and specific heat as well as geothermal exchange systems that work through application of these concepts. During the Prototype activity, students learn how a siphon is created and demonstrate heat transfer in a simple heat exchange model. Next, they develop a more elaborate design that mimics a closed-loop geothermal exchange system based on their research reading and work during the Prototype activity. Finally, student teams compete to engineer the most effective design model for heat transfer between the ground and a structure like a home or building. They demonstrate their knowledge by answering questions and interpreting results at the end of the activity.

Design Challenge Scoring Rubrics and a Grading Rubric are provided, facilitating assessment of each team's results. Team presentations allow students the opportunity to think critically about their experience, communicate scientifically, and demonstrate their learning in creative ways. Assessment questions, STEM-based extension activities, and additional resources are also included. This kit is designed for a class of 32 students working in eight teams of four.

Correlation to the Next Generation Science Standards*

The activities in this kit address the following dimensions of the Next Generation Science Standards:

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS3.B: Conservation of Energy and Energy Transfer** • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Planning and Carrying Out Investigations** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

To view additional national and local standards met by this kit, visit **www.carolina.com/correlations**.

*"Next Generation Science Standards" is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.
Source: NGSS Lead States, 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Performance Objectives

Students' performance objectives are to

- develop an understanding of how the earth's heat and other heat sources can be used as renewable energy resources.
- apply knowledge about heat transfer and geothermal energy to design a model of a closed-loop geothermal heating/cooling system.
- quantify the effectiveness of a model of a closed-loop geothermal heating/cooling system.

Time Requirements

Teacher Preparation*	60 minutes
Research	30 minutes
Prototype	30 minutes
Design Challenge**	120 minutes
Assessment	30 minutes
Presentations**	60 minutes

*An overnight period is also required so that the gel used in the activity can hydrate. See the Preparation instructions for the Design Challenge activities.

**The time required to complete this portion of the lab may vary. Establish a time limit that fits your classroom scheduling needs.

Applied Science Concepts

This kit provides opportunities for students to apply the following concepts as they work to design a solution to a problem:

- heat, heat transfer, and specific heat capacity
- renewable versus nonrenewable energy sources
- open- and closed-loop heating and cooling geothermal exchange systems

Safety

Download Safety Data Sheets (SDS) at **carolina.com/sds** or scan this code:

Use this kit only in accordance with established laboratory safety practices, including wearing appropriate personal protective equipment (PPE). Ensure that students understand and adhere to these practices. Know and follow all federal, state, and local regulations as well as school district guidelines for the disposal of laboratory wastes. Students should not eat, drink, or chew gum in the lab and should wash their hands after entering and before exiting the lab. Thoroughly wash hands after coming in contact with the acrylamide/potassium acrylate copolymer. Handling the gel does dry the skin. Avoid contact with the gel as much as possible. Wearing non-latex disposable gloves is recommended. Any water spills that occur during the activities should be cleaned up immediately. When working with hot water, be extremely careful to avoid burns, spilling water, and knocking over the beakers, which are made of glass.

Digital Resources

Your kit includes a digital Teacher's Manual with hyperlinks to the following resources. Additional resources may be available. To use these resources, log on to the website below and enter your access code. See the Digital Resource Instruction Card for more information.

http://www.carolinascienceonline.com

Digital resources included with this kit:

RESOURCE	DESCRIPTION
Student Guide Copy Master	Student Guide PDF for printing
Fill-in Answer Sheets	A PDF that can be printed out or assigned digitally, with spaces for students to record their data and answers
Editable Assessment Questions	The assessment questions as a Microsoft® Word document
Whiteboard Resources	Color graphics for use with whiteboards

Materials

Included in the kit:

- ☐ air line tubing, 8 packs, each 25 feet long
- ☐ air line tubing, 8 lengths, each 18 inches long
- ☐ acrylamide/potassium acrylate copolymer crystals, 100 g
- ☐ plastic tanks, 16
- ☐ twist-ties, 160
- ☐ disposable pipets, 8
- ☐ assorted food colors, 4
- ☐ Digital Resource Instruction Card
- ☐ Teacher's Manual and Student Guide

Needed, but not supplied:

- ☐ scoop for students to use to transfer gel from buckets to their own setups
- ☐ laboratory thermometers, 16
- ☐ glass beakers or measuring cups (500–1000 mL), 16
- ☐ scissors, 8 pairs
- ☐ 5-gallon buckets, 2
- ☐ risers of various sizes for adjusting beaker heights, 2 or 3 different height blocks per station*
- ☐ adhesive tape
- ☐ non-latex, disposable gloves
- ☐ tap water, 25 L
- ☐ warm water for the Prototype activity, 5 L
- ☐ hot and cold water, according to students' request for the Design Challenge
- ☐ hot plate(s) for heating up water and maintaining water temperature
- ☐ ice to adjust the temperatures of cold and warm water

*e.g., wood or foam blocks, inverted containers, or standard yoga blocks (made of durable foam, these 10- × 6- × 4-inch blocks can be rotated and used at each of these three heights)

Optional (not supplied):

- ☐ extra thermometers or probeware
- ☐ timing devices (for measuring flow rate)
- ☐ graduated beakers (for measuring flow rate)

Notebooking

Have students compile all their work into a single notebook. Notebooking provides students a complete and tangible record of their project. Students can use their notebooks to organize their notes, document their processes, complete their assignments, review their lessons, and prepare for assessments. Notebooking Tips throughout this Teacher's Manual provide specific instructions on how to help your students achieve success through Notebooking.

Teaching the Engineering Cycle

In every Carolina STEM Challenge® activity, students practice the engineering cycle in order to meet certain performance criteria.

Research – Students are presented with an engineering **problem** or technical challenge, highlighting and identifying science concepts and skills relevant to potential **solutions**.

Prototype – Students demonstrate or construct a **prototype** device or system that will serve as the basis for further testing and study. A prototype is a preliminary model that is used to develop subsequent models of a device or system.

Design Challenge – Students brainstorm ways to modify their prototype to meet the given challenge. Then, they implement and **test** their designs, making modifications and **improvements** on the basis of their observations and data. Design Challenge Scoring Rubrics are provided for judging the success of each group's design and for comparing the designs of different teams.

Assessment – Students reflect on what they learned and present their findings to the class. A Grading Rubric is provided for evaluating each team's performance on the assigned tasks.