Lessons 21–26
Reducing the Impact of Storm Surge

Prepare

In previous lessons, students developed an understanding of the weather hazards related to different types of severe weather. In Lessons 21–24, students apply that knowledge to solve a problem in an engineering challenge. Students use the engineering design process to design a seawall based on established criteria and constraints to reduce the impact of flooding caused by storm surge. In Lesson 25, student groups present their solutions to their peers. Finally, in Lesson 26, students explore how modern-day coastal cities implement a variety of solutions to reduce the impact of weather hazards related to hurricanes. Students also consider how these modern solutions might prevent another disaster like the 1900 Galveston hurricane.

Application of Concepts

Task

Engineering Challenge

Phenomenon Question

How can people design better solutions to reduce the impact of weather hazards?

Student Learning

Knowledge Statement

People can use the engineering design process to design solutions to protect themselves from weather hazards.

Objectives

- Lessons 21–25: Apply the engineering design process to design a structure that reduces the impact of flooding caused by storm surge.
- Lesson 26: Explore modern solutions that reduce the impact of weather hazards related to hurricanes.

Texas Essential Knowledge and Skills Addressed

3.2A **Plan and implement descriptive investigations, including asking and answering questions,** making inferences, and selecting and using equipment or technology needed, **to solve a specific problem in the natural world.** (Addressed)

3.2D **Analyze and interpret** patterns in **data to construct reasonable explanations based on evidence from investigations.** (Addressed)

3.2F **Communicate valid conclusions supported by data in writing, by drawing pictures, and through verbal discussion.** (Addressed)

3.3B **Represent the natural world using models** such as volcanoes or the Sun, Earth, and Moon system and identify their limitations, including size, properties, and materials. (Addressed)

3.9C **Describe environmental changes such as floods and droughts** where some organisms thrive and others perish or move to new locations. (Addressed)

English Language Proficiency Standards Addressed

1C Use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary.

4A Learn relationships between sounds and letters of the English language and decode (sound out) words using a combination of skills such as recognizing sound-letter relationships and identifying cognates, affixes, roots, and base words.

4G Demonstrate comprehension of increasingly complex English by participating in shared reading, retelling or summarizing material, responding to questions, and taking notes commensurate with content area and grade level needs.

5F Narrate, describe, and explain with increasing specificity and detail to fulfill content area writing needs as more English is acquired.

Materials

		Lesson 21	Lesson 22	Lesson 23	Lesson 24	Lesson 25	Lesson 26
Student	Science Logbook (Lesson 21 Activity Guide)	●	●	●	●		
	Science Logbook (Lesson 22 Activity Guide)		●	●	●	●	
	Engineering Challenge (1 per group): 16.9-ounce plastic bottle filled with water, 1 pound of modeling clay, clear plastic bin (13.5″ × 8″ × 4.5″ or larger) with hole (Lesson 21 Resource D), foil ramp			●	●	●	
	Science Logbook (Lesson 24 Activity Guide)				●	●	
Teacher	Engineering Design Process (Lesson 21 Resource A)	●					
	Marvelous Mattie: How Margaret E. Knight Became an Inventor by Emily Arnold McCully (2006)	●					
	Blank Engineering Design Process Chart (Lesson 21 Resource B)	●					
	Engineering Challenge Scenario (Lesson 21 Resource C)	●	●				
	Seawall Photographs (Lesson 22 Resource)		●				
	Galveston Seawall Photograph (Lesson 26 Resource A)						●
	"Katrina Strikes" (Lake 2012) (Lesson 26 Resource B)						●
	Anchor chart					●	
	Anchor model					●	●
	Driving question board						●
Preparation	Prepare a set of engineering challenge materials for students to observe (see Lesson 21 Resource D).	●					
	Prepare a set of engineering challenge materials for each group (see Lesson 21 Resource D).			●			

Lesson 22

Objective: Apply the engineering design process to design a structure that reduces the impact of flooding caused by storm surge.

Agenda

Launch (3 minutes)

Learn (40 minutes)

- Ask about an Engineering Problem (10 minutes)
- Imagine a Design Solution (15 minutes)
- Plan a Design Solution (15 minutes)

Land (2 minutes)

Launch 3 minutes

On the first day of the engineering challenge, review the Phenomenon Question **How can people design better solutions to reduce the impact of weather hazards?** Ask students to recap key ideas from the previous lesson about how storm surge may damage homes and other property in a coastal community. Tell students that they will follow in the footsteps of Margaret E. Knight as they imagine, plan, and create a design solution that reduces the impact of flooding caused by storm surge.

Learn 40 minutes

Ask about an Engineering Problem 10 minutes

Display the photograph of a flooded coastal community (Lesson 21 Resource C) and ask students to imagine the following engineering challenge scenario.

▶ **You live in a coastal community that is likely to experience hurricanes. Many people build their homes on or near the coast like the homes in the photograph. Members of the community decide that a seawall is the best solution to protect these homes from potential flooding caused by storm surge during a hurricane. They want your help to design the seawall.**

Explain that a **seawall** is a structure built along a coast to block ocean water from reaching land. Then have students summarize the problem and record it in the Ask section of their Science Logbooks (Lesson 22 Activity Guide).

Sample problem summary:

- *Flooding caused by storm surge can damage homes near the coast.*

Tell students that engineers must also determine the criteria and constraints of the solution in the Ask stage. Explain that criteria describe the requirements for the design solution—what is necessary for the design to be successful. Then explain that constraints describe the limitations of the design solutions—under what conditions the problem must be solved. Some common engineering constraints are time, cost, and materials.

English Language Development

The terms *criteria* and *constraints* are used repeatedly in the engineering challenge. Introduce these terms explicitly. Sharing the Spanish cognate for *criteria* (*criterios*) may be useful.

Remind students that they will design a seawall as a solution to the problem of flooding caused by storm surge. Then discuss the criteria and constraints that students' seawall designs must meet. Have students record the criteria and constraints in the Ask section of their Science Logbooks (Lesson 22 Activity Guide).

To help students determine the criteria for their seawall designs, ask the following questions:

▸ What is an acceptable amount of flooding in the coastal community?

- *There should not be any flooding. Any flooding could damage the homes in the community.*

▸ How will you know if flooding is happening? What might you see?

- *Water will get into the homes in the community.*
- *Ocean water will get to the other side of the seawall and into the community.*

▸ How will you know if your seawall is successful? What might you notice?

- *The seawall will block the water from getting into the community.*
- *Water will not get past the seawall.*

To help students determine the constraints for their seawall designs, ask the following question:

▸ When designing your seawall, what constraints should you consider?

- *We will not be able to test our seawall in a real community, but we can build and test it in a plastic bin.*
- *We can only use materials from the classroom.*

Sample criteria and constraints:

Criteria	Constraints
▪ *The seawall must block all water from reaching the community.*	▪ *The seawall must fit inside a plastic bin.* ▪ *The seawall must be made with classroom materials provided by our teacher.*

Differentiation

As students discuss and record the criteria and constraints, consider providing sentence frames to support English learners and striving writers.

- The community must _______.
- The solution must _______ (5F).

Ask students to return to the engineering design process visual in their Science Logbooks (Lesson 21 Activity Guide). Direct students' attention to the Ask stage and explain that defining the problem and identifying the criteria and constraints of the solution are both important parts of this stage. Have students draw two circles near the Ask stage and write the following phrases, one phrase in each circle:

- Define the problem
- Identify criteria and constraints

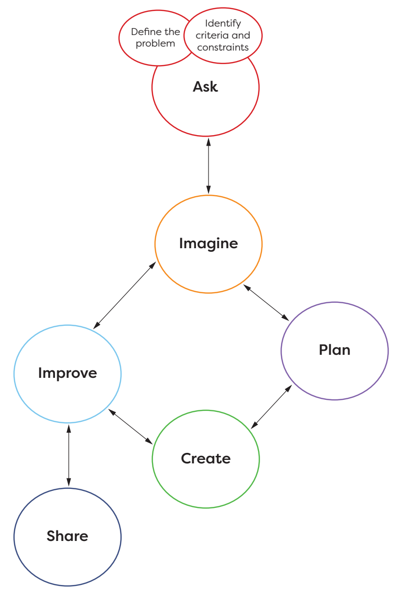
Imagine a Design Solution 15 minutes

Review class expectations for group work and assign student groups for the engineering challenge. Then draw students' attention to the Imagine stage of the engineering design process. Explain that in this stage, engineers typically research the problem and study past designs. Then engineers brainstorm new designs or consider modifications to past designs to better meet the criteria and constraints and select the best design solution. Tell students they will work in their groups to research, brainstorm, and develop their own designs.

Display the photographs of four different seawalls (Lesson 22 Resource). Ask students to discuss in their groups what they notice about each seawall. Have students share their observations with the class. As students share, record their observations near each displayed photograph.

Teacher Note

Guide students toward adding circles like those shown below to the Ask stage (1C).



Seawall photographs with sample student responses:

The seawall is slanted.

The seawall looks more like steps than a wall.

The seawall goes straight up and down.

The seawall is curved.

Use student responses to agree that each seawall has a different shape. Ask students how successful they think each seawall might be at blocking water and preventing flooding.

Sample student responses:

- *I think the straight wall would be best because it is the tallest.*
- *I think it would be hard for water to go over the edge of the curved seawall.*
- *I think steps would help slow water down before it reaches the top of the seawall.*

Explain that groups should now use their knowledge of storm surge and differently shaped seawalls to brainstorm possible seawall designs. Encourage students to be creative with their designs. Students can use the seawalls in the photographs as inspiration, but they should feel free to design any shape they believe will effectively block water from storm surge.

Ask groups to record their thoughts in the Imagine section of their Science Logbooks (Lesson 22 Activity Guide). Then have students revisit the engineering problem, criteria, and constraints before they select a seawall design to build and test.

When students have selected a seawall design, ask them to return to the engineering design process visual in their Science Logbooks (Lesson 21 Activity Guide). Emphasize that conducting research, brainstorming solutions, and selecting a solution are all important parts of the Imagine stage. Have students draw three circles near the Imagine stage and write the following phrases, one phrase in each circle:

- Research
- Brainstorm solutions
- Select a solution

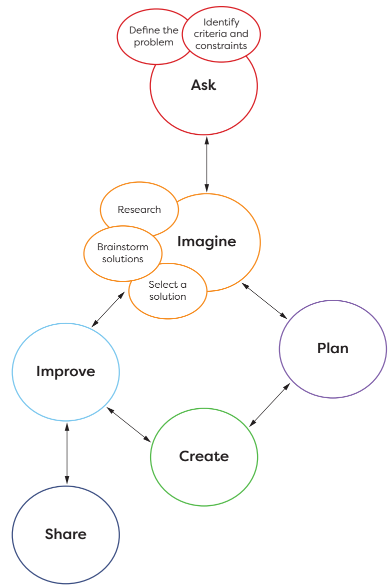
Plan a Design Solution 15 minutes

Tell student groups they are now ready to develop a plan for building and testing their design solutions. Remind students of the materials available for them to use, and direct them to create a diagram of their design in the Plan section of their Science Logbooks (Lesson 22 Activity Guide). Students' diagrams should show both the proposed placement of the seawall in the plastic bin and the shape of the seawall they will build. Students should also indicate what materials they will use for each part.

If needed, prompt students to recognize that they can use modeling clay to build the seawall. Also guide students toward the idea of placing the foil ramp in the hole of the plastic bin, and explain that holding the ramp at an incline while pouring water down it can simulate storm surge. Students should plan to build their seawall near the middle of the plastic bin to leave enough space for water to travel down the ramp and toward the community.

Teacher Note

Guide students toward adding circles like those shown below to the Imagine stage (1C).



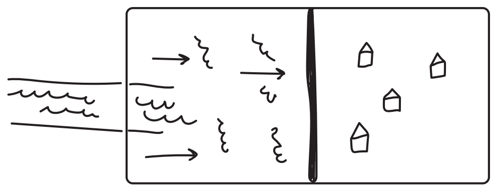
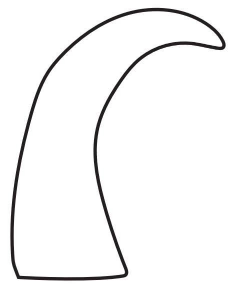
Teacher Note

Students can plan to use pieces of clay or other small objects to represent the community they are trying to protect.

Teacher Note

Students may generate ideas for unrealistic solutions. Press students to consider practical designs. Use questions such as these to guide them toward realistic solutions: Are these materials available? Could we build this? How would that work?

Sample diagram:

View from Above	Seawall Shape
	

Land

2 minutes

Review with students the stages they have completed in the engineering design process. Ask students to share examples of tasks they completed during each stage.

Sample student responses:

- *During the Ask stage, we defined the problem. We figured out that we need to build a seawall to protect homes in a coastal community from storm surge.*
- *In the Imagine stage, we researched different kinds of seawalls and brainstormed possible solutions.*
- *In the Plan stage, we created a diagram to show how our group will build our seawall.*

Tell students that in the next lesson they will move to the Create stage as they build and test their designs.

Lesson 23

Objective: Apply the engineering design process to design a structure that reduces the impact of flooding caused by storm surge.

Agenda

Launch (2 minutes)

Learn (40 minutes)

- Create a Design Solution (25 minutes)
- Improve a Design Solution (15 minutes)

Land (3 minutes)

Launch 2 minutes

Ask students to get into their engineering groups and discuss where they are in the engineering design process. Remind students that the process is flexible and that they may need to go back to a previous stage as they continue to work.

Learn 40 minutes

Create a Design Solution 25 minutes

Safety Note

The engineering challenge poses a potential hazard. Explain that spilled water could cause slippery surfaces that might lead to falls. To minimize this risk, review with students that spills must always be cleaned up immediately.

Tell students to begin building and testing their prototypes, or the working sample of their designs. Encourage students to refer to the diagrams they created in the Plan stage as they work. As students test their prototypes, they should respond to the questions in the Create section of their Science Logbooks (Lesson 22 Activity Guide).

Sample student responses to questions in the Lesson 22 Activity Guide:

What works well?

- *The seawall blocks almost all the water.*

What needs improvement?

- *Some water still gets past the seawall.*
- *The wall is too tall and keeps falling over.*

Improve a Design Solution 15 minutes

As students finish testing their prototypes, encourage them to brainstorm potential improvements. Have students document their ideas in the Improve section of their Science Logbooks (Lesson 22 Activity Guide).

Once students have documented their ideas, they should clean up the area where they built and tested their prototypes. Support students in safely drying all water spills. Have students keep their seawall designs intact, instructing them to discard any water that remains in the plastic bins.

Teacher Note

In Lesson 25, students will present their designs to the class. Store each group's plastic bin and seawall design in a place that is out of the way. For easy identification, consider labeling each bin with the name of each student in the group or assign each group a number and label the bins with the group numbers.

Keep in mind that the modeling clay will harden if left exposed to open air. Students will not need to redesign their solutions before presenting. However, if groups were unable to finish their design or if they want to demonstrate how their solution works during their presentation, then wrap the bin in plastic wrap or carefully remove the modeling clay and place it into a plastic bag to retain moisture.

Teacher Note

If students need support as they build and test their prototypes, consider sharing the instructions in Lesson 23 Resource.

Extension

For an additional challenge, ask successful groups to retest their seawall designs under different conditions. For example, provide students with more water or ask them to increase the incline of their ramp.

English Language Development

This line of questioning involves the word *improvement*. English learners may benefit from additional scaffolding in the form of sentence frames. Consider using sentence frames such as the ones below to scaffold this conversation.

- We can improve our seawall by _______.
- Our _______ needs improvement.
- _______ isn't working. We can improve it by _______ (5F).

Teacher Note

In this module, the Improve stage is limited to evaluating the success of initial designs and brainstorming potential improvements. Student groups will not make improvements and retest their design solutions. Students will spend more time on the Improve stage of the engineering design process in the engineering challenges for subsequent modules.

Land 3 minutes

Ask student groups to share with the class what improvements they would like to make to their prototypes.

Sample student responses:

- *We would like to improve the shape of our seawall. Water keeps splashing over the wall and getting to the other side.*
- *Our wall is too skinny at the top and falls over. We would make the wall shorter and thicker.*

Remind students that often a prototype must be improved many times before engineers are satisfied with their design. Explain that in the next lesson, students will prepare for the Share stage of the engineering challenge and plan to present their designs to the class. Students should plan to share their ideas for improvement as part of their presentation.

Lesson 24

Objective: Apply the engineering design process to design a structure that reduces the impact of flooding caused by storm surge.

Agenda

Launch (5 minutes)

Learn (35 minutes)

- Prepare to Share a Design Solution (35 minutes)

Land (5 minutes)

Launch 5 minutes

Begin the lesson by asking students to briefly discuss their responses to the questions below.

- Where are you in the engineering design process?
- What has gone well in your group's process?
- What can improve your group's process?

Explain that groups will now have time to plan a presentation for sharing their design solution with the class.

Differentiation

If students need support reflecting on the engineering design process, review the Lesson 21 Activity Guide. Ask students to identify the part of the visual that describes their current tasks. Then ask students to identify the stages they have completed and consider what has gone well and what needs to be improved within those stages.

Learn 35 minutes

Prepare to Share a Design Solution 35 minutes

Explain that scientists and engineers present their work in a variety of ways, including speeches, visual presentations, videos, websites, and published articles. Work with students to determine which methods of presentation will work best considering the time and resources available in the classroom.

Teacher Note

Based on time available, consider having groups create visual aids to use during their presentation. For example, students could create a poster to reference as they present their solution to the class.

Introduce students to the engineering challenge rubric in their Science Logbooks (Lesson 24 Activity Guide) and discuss student questions about the criteria. Give groups time to plan their presentations, create their final diagrams, and record responses in the Share section of their Science Logbooks (Lesson 22 Activity Guide).

Land 5 minutes

Remind students that in the next lesson, groups will present their designs to the class. Ask students to determine how each group member will contribute to the presentation.

Lesson 25

Objective: Apply the engineering design process to design a structure that reduces the impact of flooding caused by storm surge.

Agenda

Launch (5 minutes)

Learn (35 minutes)

- Share a Design Solution (35 minutes)

Land (5 minutes)

Launch 5 minutes

Allow students a few minutes to prepare for their presentations.

Differentiation

Some students may benefit from additional time and support as they prepare for their presentation. If needed, provide students with additional time to rehearse each part of their presentation before sharing with the whole class.

Learn 35 minutes

Share a Design Solution 35 minutes

Gather the class to listen to each group's presentation. Tell students to consider the rubric criteria in their Science Logbooks (Lesson 24 Activity Guide) as they listen.

After each presentation, students should write feedback on sticky notes or half sheets of paper for the group, responding to this prompt:

▸ **Considering the rubric criteria, identify one strength and one idea for improvement for this group's presentation.**

Teacher Note

Groups may elect to demonstrate how their prototype works during their presentation. As needed, support students in setting up their prototype and provide water for students to use during their demonstration.

Each time students respond to the prompt, collect feedback from the class before the next group presents. After all groups have presented, distribute the compiled feedback to each group. Give students time to review the feedback and ask questions before turning it in.

Land 5 minutes

Revisit the Phenomenon Question **How can people design better solutions to reduce the impact of weather hazards?** Discuss students' reflections on the engineering design process. Ask the following questions and reference the anchor chart and anchor model as needed to help guide the discussion.

▶ How did you apply your knowledge of weather hazards to solve the problem?

- *We know that storm surge during a hurricane can cause flooding, so we used that knowledge to design a seawall to protect a coastal community.*

▶ What knowledge of weather hazards was most useful in designing your solution?

- *We know that storm surge causes ocean water to rise and can cause flooding, so we knew we needed to make our seawall as high as possible to keep water from coming over the top.*

▶ What other weather hazards are related to hurricanes? What solutions could engineers design to reduce the impact of those hazards?

- *A hurricane can also have strong winds. Maybe engineers could design stronger roofs to keep them from blowing away.*
- *I know that there can be heavy rainfall during a hurricane, and heavy rainfall can also cause flooding. Maybe engineers could design homes that block water from getting in.*

Build on student responses to emphasize that humans cannot eliminate weather hazards related to severe weather, but they can take steps to reduce the impact of those hazards through engineering and other processes.