



The Friends of Flight 93 National Memorial is the official 501(C)3 non-profit that represents Flight 93 National Memorial in partnership with the National Park Service. The suggested STEM lesson plan below was developed by the Learning Center Coordinator. The Friends' website provides a wealth of information about the events on 9/11, the Story of Flight 93, and Flight 93 National Memorial. We encourage you to explore the website for further education resources.

Friends of Flight 93 National Memorial website: <https://www.flight93friends.org/>

## **A Towering Lesson in Engineering Design – *grades 6-8***

### **Purpose:**

- Students will engineer a tower that is 93 inches tall and comprised of 40 parts.
- Students will be able to experience the engineering process using math, technology, and engineering skills.
- Students will examine various ways to create a structure to specifications in a limited time period.
- Students will learn about the actions of the 40 passengers and crew members of Flight 93.

### **Goals:**

- Students will demonstrate how to engineer a design.
- Students will experience first-hand an engineering simulation of contrasting a tower, complete with chimes.
- Students will compare and contrast towers between teams.
- Students will write a short essay to express what their monument symbolizes.
- Students will understand the events of September 11, 2001.

## Objectives:

By the end of this lesson, students will be able to:

1. Explain the engineering process
2. Write a description of the steps they used, the choices they made, etc., to either work on and/or complete their tower.
3. Construct a model complete with symbolic chimes

## Next Gen Science Standards:

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

## Pennsylvania State Standards:

- 3.4.10.C2. Analyze a prototype and/or create a working model to test a design concept by making actual observations and necessary adjustments.
- 3.4.12.C2. Apply the concept that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
- 3.4.12.D2. Verify that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
- 3.4.10.E4. Evaluate the purpose and effectiveness of information and communication systems.
- 3.4.10.E7. Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.

## Background:

### Tower of Voices Project Description

#### Overview

The Tower of Voices (TOV) serves as both a visual and audible reminder of the heroism of the 40 passengers and crew members of United Flight 93 on September 11, 2001. In 2018, Flight 93 National Memorial hosted a dedication event to commemorate the final phase of construction and complete the permanent memorial.

The TOV is conceived as a monumental, 93-foot-tall musical instrument holding 40 wind chimes, representing the 40 passengers and crew members. It is intended to be a landmark feature near the memorial entrance, visible from U.S. Route 30/Lincoln Highway. The Tower of Voices will provide a living memorial in sound to remember the 40 Heroes through their ongoing voices.

The three components of the memorial are separated to maintain the integrity and peace of the crash site, now sacred ground. With the Tower of Voices located at the entrance of the memorial, the chimes can be heard as a visitor enters or exits the park.

The TOV project was constructed from 2017-2018 with a dedication of the project on September 9, 2018. Funding for the design and construction of the project was provided through private donations to the National Park Foundation and the Friends of Flight 93 National Memorial. The 40 chimes are anticipated to be installed in 2020.

#### Surrounding Landscape

The Tower of Voices is located on an oval concrete plaza that is built on top of an earth mound to create an area more prominent on the landscape. The plaza includes two curved, concrete benches facing the opening of the tower.

The TOV is surrounded by concentric rings of white pine trees and deciduous plants. The concentric plantings may be interpreted as resonating “sound waves” from the tower, alluding to the auditory qualities of the chimes housed within. A direct paved path leads to the tower from the parking lot. A longer, meandering crushed stone path leads through the trees and allows visitors an alternative approach to the Tower of Voices. All other landscaped areas of the project will be planted with a native wildflower mix similar to other landscaped areas of the memorial.

## Materials/Preparation

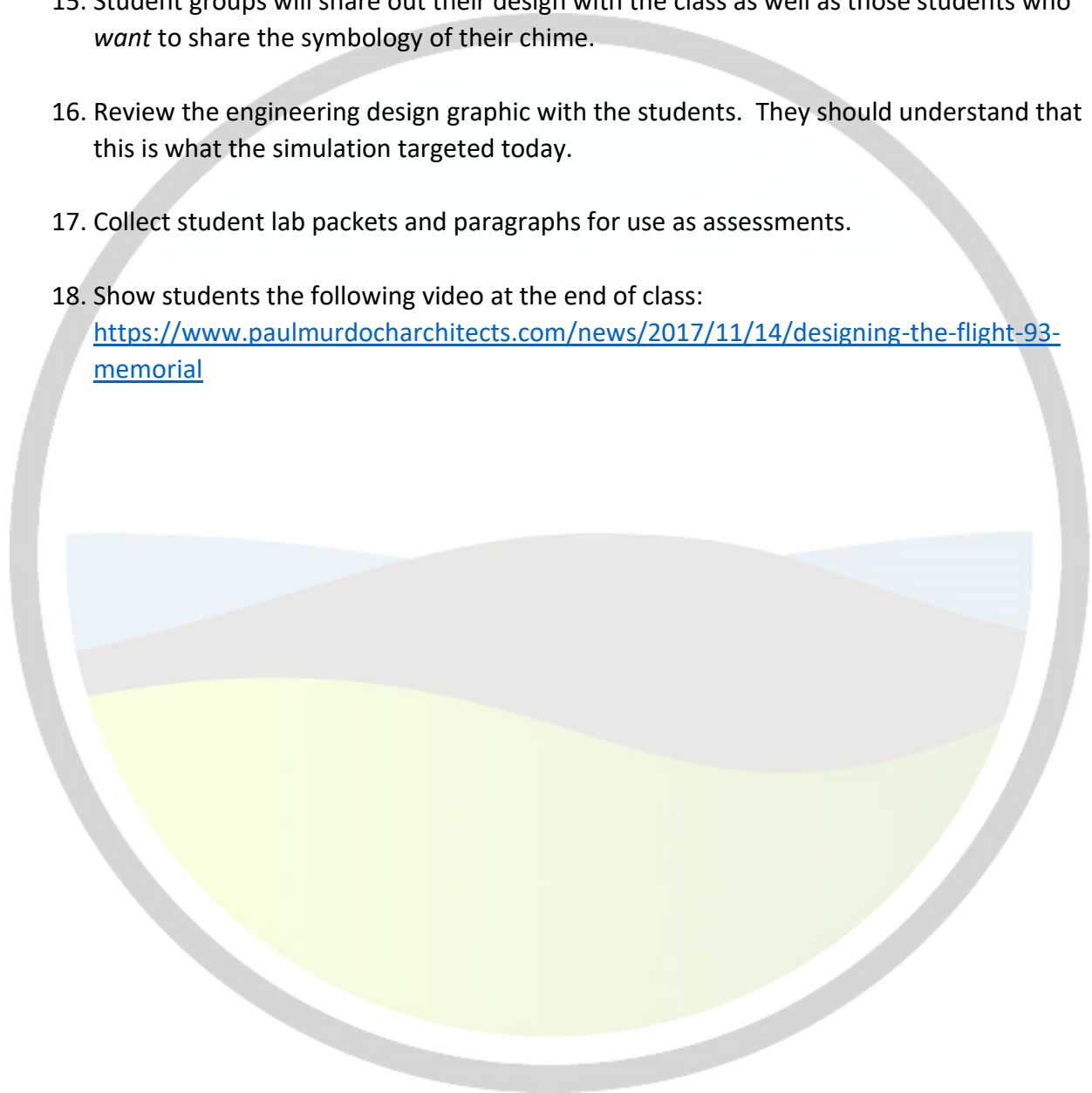
- Various lengths of PVC pipe. Make sure all pipes are the same diameter. (Each team will need 40 pieces)
- Various PVC connectors that coordinate with the pipe size selected.
- Wind chimes (1 per student)
- Notebooks
- Pencil
- Notebook paper
- String/fishing line to hang the chimes
- Rulers
- Yardsticks
- Tape measures
- Computer with internet access (for video display)
- Lab packet (1 copy per student)
  - Do not include engineering graphic page (last page)
- Engineering graphic page (1 per student)
  - Found at end of lab packet

## Procedure:

1. Pose the essential question to students. Give students approximately 3 minutes to copy down the question in their notebooks and to answer independently.
  - a. Essential Question: What is the engineering process?
2. Using 2 minutes, all students to share individual answers with their tablemates. Monitor the conversation by walking about the room, listen and question students as appropriate. Allow students to collaborate on an answer as a table group to share with the class, with each student documenting the group's theory in his/her notebook.
3. Have the large group share out (for further details, see ESL/special education learning strategies section). Allow approximately 30 seconds per table group for one student at each table to share. Other students are to document what they are hearing.
4. Start with the scientific method. Our focus question is, "What is the engineering process?" After the discussion with students, lead them through the scientific method. Identify the problem (the essential questions), form hypotheses, and then follow a procedure to see exactly what the engineering process entails.

5. Each student group will receive the same materials. Each group should be composed of four students and each student should have a notebook to record ideas and the scientific method for the lesson.
6. Show the students the following video from the chief architect of Flight 93 National Memorial. <https://vimeo.com/233527104>
7. Ask students what they noticed about the people carrying the lanterns in the video. (Students may say the people walked slowly, it was night, or that the people were silent.) Tell students that while they are working, they will be silent as well in reverence to Flight 93 National Memorial. Pose the question to students, “How will your team communicate ideas to be able to build the tower?” (They will respond with hand gestures or writing notes.) Inform students that any team that speaks during construction will have a 1-minute penalty during which they must sit and NOT work on their tower.
8. Inform students that today they are going to have a design challenge of their own. Students will be constructing a tower from EXACTLY 40 pieces of PVC pipe and PVC pipe connectors. They can use no more or no less.
9. The tower the team builds must be 93 inches tall. **THEY ARE NOT ALLOWED TO STAND ON ANYTHING TO CONSTRUCT THEIR TOWER.** Ask students how they might be able to build something taller than them without standing on something. (Students should respond with ideas such as it is possible to build it lying down and then stand it up.)
10. Ask students what other large challenge Paul Murdoch had? Show the students the following clip to help them figure out that time constraints are the answer for which you are looking: <http://wtae.com/article/tower-of-voices-wind-chimes-sept-11-flight-93-national-memorial/12213558>
11. Indicate the date on the above video clip is September 2017 and the opening of the Tower of Voices was September 2018.
12. Since Mr. Murdoch had a time limit, students will as well! Teams will have 20 minutes to create a final design, hang wind chimes, and complete the tower.
13. Students will each hang their own chime. Once the student hangs his/her chime, he/she needs to write a paragraph describing what his/her chime symbolizes. Paragraphs should be at least 7 sentences in length. Students should write this paragraph on the worksheet provided.

14. At the end of 20 minutes, some teams will have completed the tower, and some will not. THAT IS FINE! This is part of the engineering process for design. Failure IS an option. After 20 minutes, students may speak. Ask them to complete their paragraphs as well as the engineering design worksheet.
15. Student groups will share out their design with the class as well as those students who *want* to share the symbology of their chime.
16. Review the engineering design graphic with the students. They should understand that this is what the simulation targeted today.
17. Collect student lab packets and paragraphs for use as assessments.
18. Show students the following video at the end of class:  
<https://www.paulmurdocharchitects.com/news/2017/11/14/designing-the-flight-93-memorial>



# A Towering Lesson in Engineering Design

Student Lab Packet



Name \_\_\_\_\_

Date \_\_\_\_\_



Name \_\_\_\_\_

Date \_\_\_\_\_

### A Towering Lesson in Engineering Design

A. List the materials that you used for the lab.

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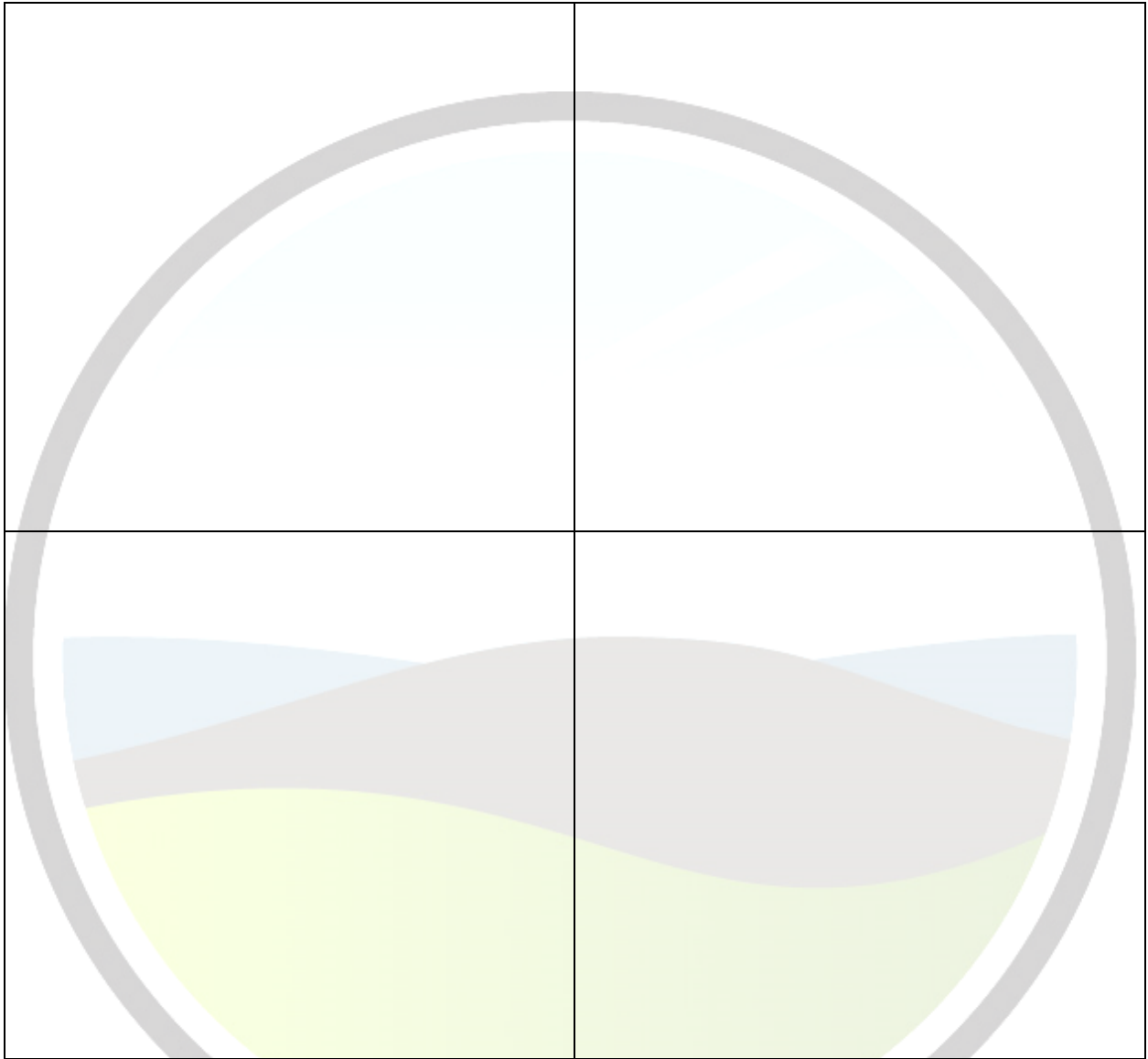
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B. What design challenges did you experience? List how you overcame each challenge.

Challenge Experienced	We solved the challenge by...



C. In the boxes below, sketch each design you made and briefly write what worked or didn't work in the box.



D. What is the engineering process? (What steps did you take?)

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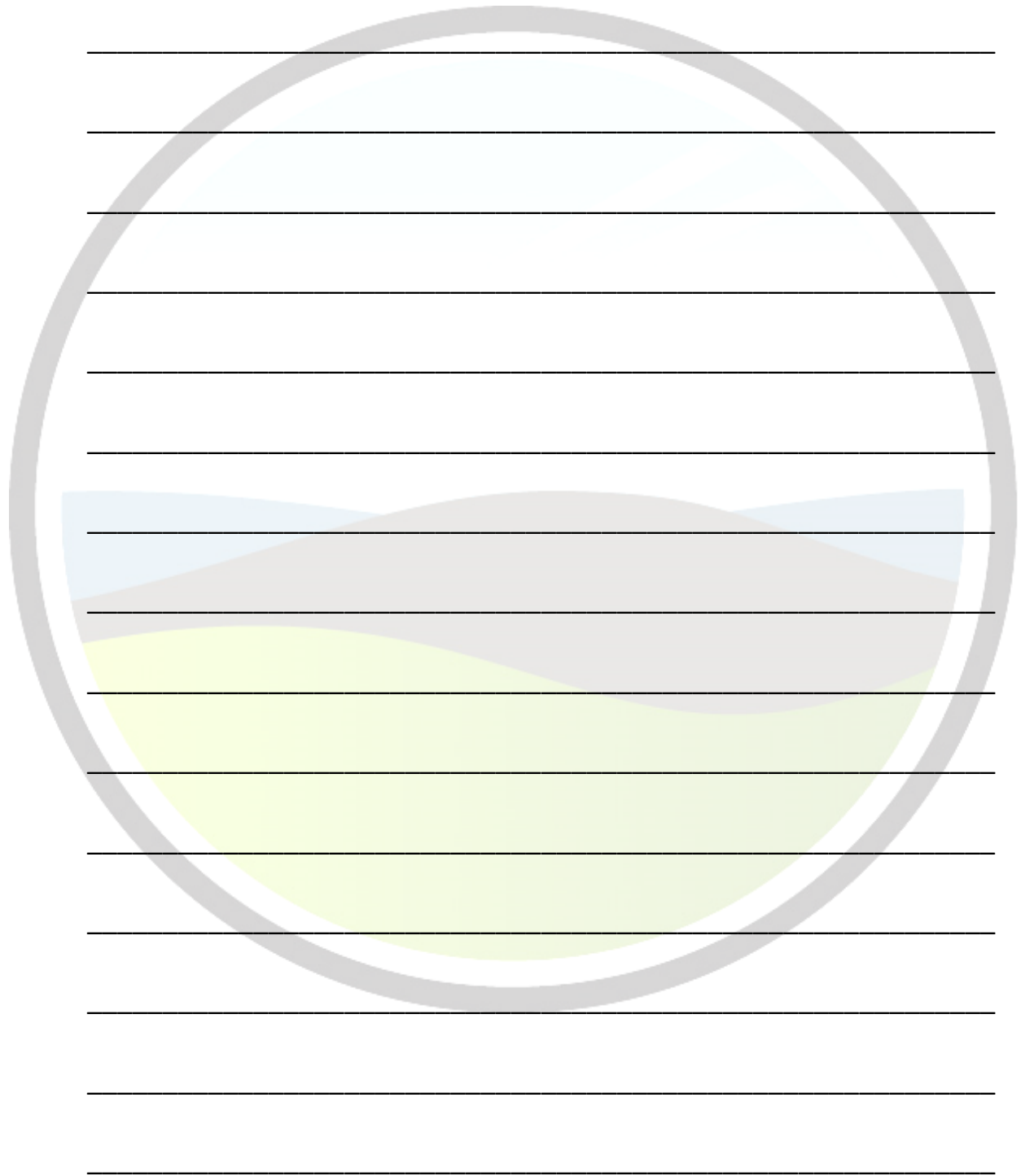
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Name \_\_\_\_\_

Date \_\_\_\_\_

My wind chime symbolizes:



Name \_\_\_\_\_

Date \_\_\_\_\_

