FLEET MIDDLE SCHOOL CURRICULUM

Easily adaptable lesson plans and resources for teaching forces and motion using a video game’s physics simulator.

Contact us:
fleet@navalengineers.org
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FLEET software was creation by Navatek and FLEET curricula development by ASNE
Introduction: **FLEET Middle School Unit**

The unit starts with lessons that introduce concepts through hands-on science (झ) and YouTube videos (झ). Students work on these concepts in groups. This group work often requires sketching designs or notetaking which can be done electronically or by paper and pencil (झ). Students apply these lessons in the FLEET simulator (झ). And, you can decide whether to create prizes for the FLEET Final (झ).

Many lessons have hands-on activities where students work with “boats” in water (झ). We suggest having several types of recyclables handy along with scissors and tape. The boats will need to float in enough water that they can move freely. A science classroom with sinks is great. Containers filled with water before class also work well. See fleetengineering.org for pictures of student-created boats.

Currently, all lessons are adaptable from 45 minutes (झ) to 1 hour, 30 minutes (झ). Lessons describe one possible flow for a 45-minute lesson, and a second possible flow for a class lasting 90-minutes class. Note that everything is suggested; you can change this pacing, add some supplemental ELA resources, use your own classroom processes (e.g., science notebooks) to make these lessons work for your students.

Each lesson has:

- Introductory information including alignments, topics, overview and source material
- Two possible paces for using these materials
- Student Learning Objectives
- Materials needed using the icons shown above
- Step-by-step lesson plan with additional resources listed at the end
<table>
<thead>
<tr>
<th>Lesson Plan Overviews</th>
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<tbody>
<tr>
<td><strong>1</strong>&lt;br&gt;What's our process?</td>
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<td><strong>Optional:</strong></td>
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<td><strong>2</strong>&lt;br&gt;How can we work on a boat?</td>
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<td><strong>3</strong>&lt;br&gt;Reverse engineering ships</td>
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<td><strong>Optional:</strong></td>
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<td>Lesson Plan Overviews</td>
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| **4**  
**Sink that boat!**  
**Time**  
[tramonto] to [tramonto]  
Students will discover a wide array of boat design challenges by investigating and sharing ways to sink a boat.  
| Understanding/Analyzing how mass and motion are related in ships (MS-PS2-2),  
Using Engineering Design Process (MS-ETS1-1, 1-2, 1-3, 1-4)  
Optional:  
| FLEET  
STEAM  |
| **5**  
**Steady!! Steady!!**  
**Time**  
[tramonto] to [tramonto]  
Students will design a boat to address one or more of the challenges identified last class and pitch their design in a classroom Shark Tank™.  
| Understanding/Analyzing how mass and motion are related in ships (MS-PS2-2),  
Using Engineering Design Process (MS-ETS1-1, 1-2, 1-3, 1-4)  
Presenting results (CCSS-ELA SL.4, SL.5, SL.6)  
Optional:  
| FLEET  
STEAM  |
| **6**  
**Search and Rescue**  
**Time**  
[tramonto] to [tramonto]  
A day to thoughtfully apply design principles to designing a FLEET vessel for a specific purpose.  
| Using Engineering Design Process (MS-ETS1-1, 1-2, 1-3, 1-4)  
Presenting results (CCSS-ELA SL.4, SL.5, SL.6)  
Optional:  
| FLEET  
STEAM  |
| **7**  
A day to test out all the ships, boats, and helicopters in the game. A low-stress application of the engineering  
| Using Engineering Design Process (MS-ETS1-1, 1-2, 1-3, 1-4)  
| FLEET  
STEAM  |
<table>
<thead>
<tr>
<th>Lesson Plan Overviews</th>
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<tr>
<td><strong>FLEET All-Star Break</strong></td>
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<td><strong>Time</strong></td>
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<td><strong>8</strong></td>
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<td><strong>10</strong></td>
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8: Students investigate Newton’s Three Laws using footage from the NFL and the FLEET physics simulator.

9: Students investigate drag and thrust using footage from Olympic swimmers and the FLEET physics simulator.

10: The final day! A final day for competitions and awards. The lesson provides many options or make your own!
What’s our process?

| Middle School | Standard(s): MS-ETS1-2, 1-3, 1-4, CCS-ELA.SL.1,2,4  
(Exclusive: CCS-ELA.II.1,2,4) | Topic: Engineering Design Process | Developed by: ASNE with videos from NASA and Massachusetts DOE |

**Overview:** A 5-minute warm-up activity has students talking about designing a process. Then, the class will discuss and create the engineering design process for this Club. You could use the optional materials in this plan (NASA videos, an educational diagram) or have a straightforward discussion to accomplish this goal. Students will then use this process to figure out how to work on the bottom of a ship.

**Sample Lesson Flow:**
- Warm-up (5 min), discuss warm-up (5 min), learn/discuss engineering process (20 min), create an engineering process (10 min), exit discussion (5 min).
- Warm-up (5 min), discuss warm-up (10 min), learn/discuss engineering process (20 min), create an engineering process (20 min), create art to document process (30 min), exit discussion (5 min).

**Note for schools with design processes:**
A growing number of schools use engineering/design processes that are established. This lesson is about exploring/creating a process, which is not useful for your class. You can skip to Step #16 and ask students to discuss/document difficult aspects of the process or you can simply proceed to the next lesson.

**Prior Student Knowledge Required:**
- None, but there is an option for literacy-focused schools to assign a reading activity the night before: Massachusetts Engineering Design process and associated literacy questions.

**Student Learning Objective:**
- Understand the cyclical nature of the engineering design model.
- Create/Adopt an engineering design model that works for your group.
- Design an engineering solution to a complex, real-world problem.

**Materials:**
- Technology to play YouTube video
- Place for students to record thoughts (notebook/pencil, chalkboard/chalk, poster/art supplies, etc.)
- Permanent place to record your engineering design process (poster, webpage, PowerPoint slide, etc.)
- Access to FLEET Forums to store and share your engineering design plan.
- (Optional, Prior Knowledge) Print Massachusetts Engineering Design process and associated literacy questions.
- (Optional, Step #16) Poster, video, diagram, etc. to document the engineering design process.

**LESSON PLAN – (5-E Model)**

**Engage**

1. Start with a 5-minute Think-Pair-Share:

   ![How would you engineer a solution to this problem? 💭

   What would be your process?

Choose one of the big engineering challenges below to spark student’s imagination. You can choose one below or highlight a problem that is local or timely (there is a slide online and a handout on the last page of this lesson that lists these challenges):

- **a.** The U.S. government paid $13 billion for the most recent aircraft carrier, the *USS Gerald Ford*. Describe your plan to create an aircraft carrier that could earn you $13 billion!

- **b.** Sometimes ships have to go across the Arctic Ocean through the ice. They use ice breakers like the Coast Guard Cutter *Healy*. Create a plan to build a new and improved icebreaker that can travel across the Arctic Ocean.
c. A local marine biologist wants to explore dolphins that usually swim a couple miles off the coast. She wants to have a glass-bottom boat so that she can watch the dolphins swim and interact. Create a plan that will convince her that you can build the perfect glass-bottom boat for dolphin watching (You may choose to play this glass-bottom boat video on mute while students work: https://www.youtube.com/watch?v=XKAUIzoT3WM).

d. There were no bridges over the Mississippi River until 1856 (literary resource). Using tools and materials available in the 1850s, create a plan to build the first bridge across the Mississippi River.

e. Imagine NASA will pay someone $25 million to create a machine to gather rocks on Mars. Create a plan that shows how you would get the job done.

f. **NOTE:** There is a slide with this information that you could show to students on the computer screen(s) as they enter.

2. These problems are case studies. The goal is to engage students in an engineering process and these experiences will be the heart of the final conversation (Step #15). Circulate the room and remind them they are designing the process to solve the problem, they are not directly solving the problem yet.

3. Ask for a few people share their experience after 5 minutes:

   ```
   What were some important parts of the process to solve this engineering problem?
   ```

**Explore**

4. Now that everyone has considered designing a process. The conversation will now focus on,

   **How will your group design solutions to problems this year?**

   If your students worry about being incorrect, you could start with a process as outlined in the next nine steps. **Or,** you could skip the videos and let students research and brainstorm in small groups.

5. NASA released a series of videos that use 6 simple words to describe a basic engineering design process:

   a. **Ask** questions
   b. **Imagine** solutions
   c. **Plan** possible designs
   d. **Create** models
   e. **Experiment** and try out the model
   f. **Improve** the model by revising it

6. There are six videos below; one for each engineering design process. After each video, ask if students have any questions and then ask them the discussion questions provided (possible answers in parentheses).

   a. **Note:** If you think these videos will not entertain your students, consider using the optional literary activity about the engineering design process. There is an optional worksheet with guiding questions as well.

7. **Ask**

   ![Link](https://youtu.be/Oy1DrYTFwil) (Length: 1:51)

   a. Class Discussion Questions:
What’s our process?

i. What engineering question is asked in this video? (how to build a rocket, and lots of sub questions)

ii. What does “ask” mean to an engineer? (clarifying the problem)

iii. What is a “limitation” in finding a solution? (things we want to use but don’t have infinite amount of)

8. Imagine

Link: https://youtu.be/laPUvKFP-GY (Length: 1:59)

a. Class Discussion Questions:
   i. What is the “spirit of imagining”? (having a wide range of possible solutions)
   ii. What does it mean that ideas are “synergistic”? (they work together)
   iii. What does it mean that ideas “build on each other”? (you may hear someone’s idea and add something to it to make it better)
   iv. What does it mean that “there are no bad ideas”? (we need to come up with many different ideas that are wildly different)

9. Planning

Link: https://youtu.be/bYxO3iXfu-Y (Length: 2:18)

a. Class Discussion Questions:
   i. Why do we plan? (because time and other resources are limited; to make sure teams work together well)
   ii. How does the video suggest you plan? (sketching)
   iii. Do you agree sketching is the best way for you and your group to plan? (no correct response here)
   iv. What do you change during the experiment phase? (one variable)
   v. What is a test of a sketch? What makes it a “good” sketch? (You can draw something from it)

10. Creating

Link: https://youtu.be/VzVJbgucZw8 (Length: 0:49)

a. Class Discussion Questions:
   i. What is a limitation that you need to work in? (a certain amount of time)
   ii. What should you use from the Planning phase? (sketch)

11. Experiment

Link: https://youtu.be/ICXlhe66pfs (Length: 1:26)

a. Class Discussion Question:
   i. What does experimenting involve? (changing one variable)
   ii. What do you use to compare experiments? (data, measurements)

12. Improve

Link: https://youtu.be/Kt1oVv2D_ns (Length: 1:22)

a. Class Discussion Questions:
What’s our process?

i. What are questions that you should ask after the experiment? (What didn’t work? What could work better?)

13. Now discuss the entire engineering design process. How does this process match the plans created in the student case studies? Are there steps in NASA’s design process that a group skipped? Is there a group that designed a plan that does not fit into the NASA model?

14. Tell your class: Now it is time to decide our club’s engineering process. Someone will need to lead the conversation and write down the ideas. The notetaker could be you or a student.

Tell the class the time allotted for this activity (20-30 minutes is recommended). The activity is to decide on our engineering process.

a. If conversation becomes a disagreement between “two sides”, remind them that most engineers work in teams and cooperate closely together. If there is still disagreement after 5 more minutes, suggest the class tests out two competing models.

b. If your students quickly choose to adopt the NASA process, ask them to create a definition for each step. Then, ask them how the “Ask” step is different the second time through the engineering process (the goal here is to emphasize the cyclical nature of the process.)

15. Your class has now decided on its own engineering design process to use for the investigations. This could be one of three results:

a. Adopted the NASA model as the process for your group going forward.

b. Modified the NASA model so that it incorporates any new ideas from the group.

c. Created a new model using the students’ language that encapsulates the ideas of being creative, testing and iteratively improving designs.

Evaluate

16. (Optional) Tell students that they know need to make something that will best explain their process to strangers. This could be a series of posters, pictures that form a cartoon, a video, etc.

Think about the important parts of the process or the parts that are difficult to understand. Let’s create art that will help show these ideas. We will use your creations throughout our work engineering solutions to FLEET.

Additional Resources

A. If you want another closing activity, or want to give a hint, play this amazing time lapse video of a real drydock being flooded and the ship returning to sea.
  https://www.youtube.com/watch?v=dw8kvPN0oK0

B. Throughout your teaching, please use the FLEET Forum called “FLEET Discussion” as a place to share what works and what you had trouble with (http://www.navalengineers.org/Membership/Forum). Also, feel free to use that space to list your ideas as a safe space to try out ideas amongst other educators thinking about the same issues.

C. NASA has an educator-facing overview video of this process: https://youtu.be/c0wh4GxoL28

D. If you are interested in a survey of different engineering design principles, see this article published by NASA and Texas researchers: https://www.asme.org/public/conferences/8/papers/4130/view

E. At times the U.S. has built floating drydocks that uses some of the same principles. There is a great article on drydocks with pictures at: http://www.msc.navy.mil/sealift/2005/August/drydock.htm
5 Minutes! Think-Pair-Share

Describe a **plan** you would use to accomplish **one** of these tasks:

A. The U.S. government paid $13 billion for the most recent aircraft carrier, the *USS Gerald Ford*. Describe your plan to create an aircraft carrier that could earn you $13 billion!

B. Sometimes ships have to go across the Arctic Ocean through the ice. They use ice breakers like the Coast Guard Cutter *Healy*. Create a plan to build a new and improved icebreaker that can travel across the Arctic Ocean.

C. A local marine biologist wants to explore dolphins that usually swim a couple miles off the coast. She wants to have a glass-bottom boat so that she can watch the dolphins swim and interact. Create a plan that will convince her that you can build the perfect glass-bottom boat for dolphin watching (You may choose to play this glass-bottom boat video on mute while you work: [https://www.youtube.com/watch?v=XKAUlzoT3WM)](https://www.youtube.com/watch?v=XKAUlzoT3WM)).

D. Imagine NASA will pay someone $25 million to create a machine to gather rocks on Mars. Create a plan that shows you would get the job done.

E. There were no bridges over the Mississippi River until 1856 ([literary resource](#)). Using tools and materials available in the 1850s, create a plan to build the first bridge across the Mississippi River.
How can we work on a boat?

| Middle School | Standard(s): MS-PS-2; MS-ETS-1-1, 1-2, 1-3, 1-4; | Topic: How to work on a boat | Developed by: ASNE | Image by U.S. Navy |

**Overview:** Students will think outside the box on ways to work on a ship. They will discover how a dry dock works and see the dry dock area in **FLEET**.

**Sample Lesson Flow:**
- Engineer a way to work on the bottom of a boat (15 min), present solutions (10 min), introduction to **FLEET** (5 min), use worksheet to explore **FLEET** (15 min)
- Engineer a way to work on the bottom of a boat (20 min), present/discuss solutions (15 min), engineer a drydock that can support the students’ boat (20 min), present/discuss solutions (15 min), transition to **FLEET** (5 min), use worksheet to explore **FLEET** (15 min)

**NOTE:** This lesson combines an engineering challenge with a **FLEET** overview. If this is too much to cover, students with internet access could explore **FLEET** independently at home and bring back the worksheet next class.

**Prior Student Knowledge from Lesson 1:**
- In the first lesson, students will decide on an engineering design process in Lesson 1. This lesson will be the first application of the student-created engineering design process.

**Student Learning Objective:**
A. Become familiar with elements of the engineering process by engaging in a hands-on engineering activity.
B. Discover the purpose of a dry dock and key elements.

**Materials:**
- “Boats” for this lesson would ideally be plastic bottles with lids of different sizes (20 oz, 2L soda bottles, ½ gallon, gallon milk jugs; peanut butter containers; etc.). Be sure to wash all containers so there are no allergens that affect your students.
- A sink per group of students (a science lab, cafeteria, etc.) with drain stopper would be great.
- If a sink is not available, a small container of water is acceptable.
- Computers with **FLEET** installed.
- Handouts of “**USS Detroit and FLEET**” or the ability to show the picture on a screen.

**LESSON PLAN – (This uses the 5-E Model)**

**Engage**
1. Group students as they come into the room. Then, start the class by holding up a “boat” (the boat could be a coffee cup, a plastic cup, recyclable bottle, etc.). Explain the activity:

   **This cup represents an aircraft carrier. We need to work on the bottom of it but it’s in water now. You will use our engineering design process to design a solution so that we can work on the bottom of this aircraft carrier.**

**Explore**
2. There are a few initial problems your student groups will confront about the vocabulary and the challenge:
a. Probable vocabulary questions:
   i. What is an aircraft carrier? (a huge ship that carries planes; over 1,000 feet long)
   ii. What is a hull? (the main structure of the boat, including the exterior sides that touch the water)
   iii. What is the waterline? (a line that goes around the boat showing where the surface of the water is)
   iv. NOTE: You may choose to allow students to turn on their phones and use other nearby resources to research the question. OR, encourage students to create a sketch showing the definition of unknown words. These sketches could start a Word Wall specific to the club.

b. Probable challenge questions
   i. Can they pick it up? (It’s possible, but it introduces another challenge: The aircraft carrier weighs about 224,000,000 pounds and the average crane can lift 30 tons. (measurements are purposefully given in different units here, you may decide to use Scientific Notation or other units).
   ii. Can we use cranes? (It’s possible, but you will need to be more specific. See weight information above and note that the aircraft carrier USS Gerald Ford is about 1,106 feet long and 78 meters wide. (again, units are purposefully different, so students will engage in mathematics).
   iii. Can people just scuba down to work on it? (Scuba equipment could be used for small jobs, but the group should consider how much tools and steel a scuba diver could handle.)

3. Possible engineering solutions
   a. Using cranes to lift the boat. Although not cost effective or realistic, this is one solution. Groups that quickly reach this decision could be asked to find a more cost-effective solution. (Cost is a common design concern in life and in FLEET).
   b. Creating a device that lifts the boat out of the water. (This has been done historically. For example, floating dry docks used levers to lift ships.) Groups reaching this decision quickly could be asked to refine their design and consider whether the full weight of the aircraft carrier could be lifted using their design.
   c. Pulling the drain in the sink is an ideal solution—these groups have discovered the dry dock. Groups that quickly reach this solution should consider weighs that the sink could be drained in real life.
      i. Most dry docks rely on pumps to actively remove the water. Like most sinks the dry docks are designed.
      ii. Tides could be used in some harbors to control the amount of water in the dry dock, but usually this is not sufficient to completely drain the dry dock.

4. Many groups will struggle to get to this solution because it is out-of-the-box thinking. That’s ok today. You are working with engineering topics like this so that your students move away from textbook learning and toward real-world problem solving. You may even find that students that are not strong solving problems with one answer will excel dealing with problems that have multiple possible solutions.

5. (Optional) If there is time, let students fully design a drydock that can accommodate the boat you gave them. Students will need access to some supplies like glues, wooden/plastic supports, etc. (Optional) Fully design a drydock using the given materials so that your boat rests securely. If you have time, design how the water will re-enter the drydock so that
your boat can safely return to the ocean.

i. Possible answers that mimic real-life solutions:

1. The bottom of the sink needs something to hold the ship. Dry docks use structures that center and support the ship.
2. The water should re-enter the dry dock from the bottom (rather than from the faucet above). By slowly filling the dry dock with water, ships can be carefully returned to the sea.

b. (Optional) Use the real-life dimensions of the USS Gerald Ford to create a diagram that shows the necessary structures and machines to create a dry dock for an aircraft carrier.

Explain

6. Remember to give a five-minute warning before the groups share.
7. (Optional) If you have time, Ask the groups to create a diagram or use the chalkboard/projector to best explain their solution.

Elaborate

8. Groups will share their solutions one at a time. Teams will present solutions to reduce anxiety that individuals may have about speaking in front of groups. Set the stage by saying:

   We will listen quietly and ask questions at the end. We want to be sure we understand each proposed solution. At the end, we will combine the best ideas to create our best solution to this problem.

9. As groups present, encourage other students to ask for elaborations if they do not understand aspects of the solution.

10. After each group presents, ask them to describe two things that were key to the process they used to solve the problem.
   a. These answers are your first opportunity to connect student work to the engineering design process you are using.
   b. You can also ask groups about the data they collected to determine their solution was sufficient. (This data could be as simple as “after our process there was 0 gallons of water left around the boat”).

11. Presentation wrap up: Either you can synthesize the great ideas across the groups OR you will lead a class discussion with the goal of pulling together the great ideas across the groups.

12. (Optional) If you have time, consider discussing other aspects of the groups’ presentations:
   a. Presentation: Discuss how different groups communicated their information well.
   b. Engineering: Discuss how different groups used the engineering process with a particular highlight on all data collected.
   c. Scientifically: Discuss how students used data to test hypotheses, and highlight any scientific terminology used.

Evaluate

13. Gather the class around a screen that can show you interacting with FLEET. The first cut screen (shown below) shows the dry dock workspace.

14. Lead a discussion about the key features of the dry dock. Compare and contrast the images in this video to their designs.
15. **(Optional)** Show a couple elements of the game play so that students can participate next lesson.
Specifically, the buttons in the upper left and lower right corners.

a. Buttons in the upper left corner

<table>
<thead>
<tr>
<th>Button</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>+</td>
<td>Gives you access to parts of the ship you have not used yet.</td>
</tr>
<tr>
<td>-</td>
<td>Gives you access to the parts on your current ship.</td>
</tr>
<tr>
<td>Hold</td>
<td>A place to hold on to pieces that you are thinking about using soon.</td>
</tr>
<tr>
<td>-</td>
<td>Use this button to change your view of the ship. (You can also right click and move around the interface.</td>
</tr>
</tbody>
</table>

b. Buttons in the lower right corner

<table>
<thead>
<tr>
<th>Button</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Load a default ship that meets basic mission requirements.</td>
</tr>
<tr>
<td>-</td>
<td>Load one of your saved ships.</td>
</tr>
<tr>
<td>Save</td>
<td>Save your ship. Be sure to hit this button before closing out of FLEET.</td>
</tr>
<tr>
<td>Test</td>
<td>Test or use your ship. You will need to meet all mission requirements first.</td>
</tr>
<tr>
<td>Shuffle</td>
<td>Completely delete this ship and start over. Some lessons will require you to do this. Students may want to keep a record of their ships and data so they can quickly recreate ships from previous lessons.</td>
</tr>
</tbody>
</table>
16. (Optional) You could show this amazing time lapse video of a real dry dock being flooded and the ship returning to sea.

https://www.youtube.com/watch?v=dw8kvPN0oK0

Explain (FLEET)

17. Students will need to log into FLEET. Tell students that FLEET has been installed on machines and you will hand out log-in information shortly. It’s best to have students work in pairs or small groups so they can all use the mouse and work together so they do not get stuck.

18. Tell students to click the FLEET icon on their desktop:

19. They will type the user name and password you provided. If you logged in previously, the Username field will already be populated.

20. While you make sure everyone is logged in, you can also adjust or mute the game play volume.

21. Hand out the “USS Detroit and FLEET” worksheet or display it prominently so students can use it to guide their exploration. Students should hit the Green “+” button has all the possible additions for the boat.

   a. Delete an object: click on it, then hit the red trashcan that appears. (Students may have to adjust the view to see the object.)

   b. NOTE: There is a complete User Guide at www.fleetengineering.org that describes every button on every screen. You may want to download or share this document.

22. To adjust the view hit the Eye button (눈) or right click and move the mouse.

23. Use the list of terms below to help students use the proper names for things that they see.

   i. Dry dock: a narrow basin or vessel that can be flooded to allow a load to be floated in, then drained to allow that load to come to rest on a dry platform.

   ii. Hull: The bottom, sides and deck of a ship

   iii. Deck: The top of the hull

   iv. Cargo: Materials and other things carried on a ship

   v. The structure of a ship: The parts of a ship
vi. **Propulsion**: the engine, what makes the ships go

vii. **Comms** (or **Communications**): The electronics that survey the area and communicate with shore-based mission control.

viii. **Waterline**: where the hull of a ship meets the surface of the water.

ix. **Superstructure**: Something built on top of another structure; parts of a ship above the main deck.

x. **Rudders**: Controls the stability and direction of the boat. Underwater behind the prop.

xi. **Ballast**: heavy material, such as gravel, sand, iron, lead, or water placed low in a vessel to improve its stability

b. **(Optional)** Ask students to pick a word from the list below and create artwork that shows the definition. Post these definitions in a vocabulary word wall.

24. **(Optional)** If you want a motivating award, tell the student(s) that have the sheet filled out the most with nothing incorrect will get to compete in a **FLEET** race at the end. Then, let students drive a boat you created using the Quick Play mode and Speed Test.

25. Give students a five-minute warning to complete as much of the sheet as possible. You can decide whether they should delete their boat by hitting the red trashcan button above the Green Play button. If they do not delete, the boat will be there the next time **FLEET** opens.

**Evaluate**

26. Summarize today’s work: **Today, you talked about plans for million-dollar engineering projects, agreed to an engineering design process, and solved an engineering process. Wow!** Ask students to discuss:

   ![How does the engineering design process *feel* now that you have used it?](image)

   (e.g., Did they ask lots of questions? Did they test out each other’s ideas to see if they would reach the goal? Did they create a plan and then go back and improve it?)

27. This final conversation will help students become metacognitively aware when they are addressing engineering design principles in the future.

**Additional Resources**

<table>
<thead>
<tr>
<th>A. Discovery has a five-minute video about the dry dock for Building Maersk’s largest container ship. The simulations are nice, the video discusses the concept of ballast, and the narrator describes the role of the pumps and supports very well: [<a href="https://youtu.be/RUfGCngF9D%5D%7Bt=5m1s%7D">https://youtu.be/RUfGCngF9D]{t=5m1s}</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>B. At times the U.S. has built floating dry docks that uses some of the same principles. There is a great description of dry docks with pictures at: <a href="http://www.msc.navy.mil/sealift/2005/August/drydock.htm">http://www.msc.navy.mil/sealift/2005/August/drydock.htm</a></td>
</tr>
<tr>
<td>C. There is a national park on Anacapa Island, and its volcanic history is fascinating. Here are some links that further explain Anacapa Island and the other California Channel Islands. (The location of the dry dock is Anacapa Island.)</td>
</tr>
<tr>
<td>c. Geology of California’s Channel Islands: <a href="https://www.nps.gov/chis/learn/nature/geologicformations.htm">https://www.nps.gov/chis/learn/nature/geologicformations.htm</a></td>
</tr>
<tr>
<td>D. ELA Connection: Scott O’Dell’s book <em>Island of the Blue Dolphins</em> was inspired by a woman stranded on the Channel Islands in the 1800s. The book is far removed from engineering, but ties into the historical development of the American west coast.</td>
</tr>
</tbody>
</table>
Reverse Engineering Ships

<table>
<thead>
<tr>
<th>Middle School</th>
<th>Standard(s): MS-ETS-1-2, CCS-IT1, CCS-IT2, MS-PS-2-2,</th>
<th>Topic: Reverse Engineer a Boat</th>
<th>Developed by: ASNE With materials from NASA and the US Copyright Office</th>
</tr>
</thead>
</table>

**Overview:** Students will examine hull designs and videos of working boats to figure out how they move, turn, and keep crew members safe. First, students will learn about the process of reverse engineering and then they use the process to investigate different parts of the boat.

**Sample Lesson Flow**

1. Discuss hull design in groups (10 min), share out those discussions (10 min), discuss videos of ships in groups (10 min), share out the unique aspects with the group (10 min), exit slips (5 min).
2. Warm-up (10 min), discuss hull design in groups (15 min), share out those discussions (15 min), discuss videos of ships in groups (15 min), share out the unique aspects with the group (15 min), discuss tug boat video together (5 min), examine tug boat in groups (10 min), exit slips (5 min).

**Prior Student Knowledge Required:**

- None

**Student Learning Objective:**

- Understand the process of reverse engineering.
- Learn the parts of a boat that will be used in FLEET (e.g., hull, rudder, propeller, hull, deck, etc.).

**Materials:**

- Handouts or internet access to the U.S. Copyright PDFs
- Technology to play videos that show different ships moving/working.
- Technology to play YouTube video about Reverse Engineering

**Lesson Plan – (This uses the 5-E Model)**

**Engage – Reading option**

1. **(Optional)** Students will read how Dr. Schwartz and vision researchers are reverse engineering an eye to solve big problems facing the world. This text is leveled for middle school students and has supports that help student build vocabulary and reading skills. (Reading handout)
2. **(Optional)** Students will read the text, answer the questions independently then go over the answers in small groups or as a full class. (Questions handout)
3. **(Optional)** Lead a class discussion based on the reading. What problem are vision researchers addressing? How is reverse engineering helping them address this problem?

**Overview**

This lesson is about reverse engineering. You can introduce this activity using the reading described in Steps #1-#3 or the video in Step #4. Or, you can jump right into discussing the new hull designs (Step #5).
Engage – Video option

4. (Optional) Students will watch 15 minutes of video describing Boston Engineering’s design of a robotic tuna: https://youtu.be/JdvS-vTe3cO?t=2m40s
   a. The omitted part in the video describes Boston Engineering as an organization. If you want to emphasize career paths available, you may choose to play the first 3 minutes of the video now or at another time.

   What problem are engineers at Boston Engineering addressing? How is reverse engineering helping them to address this problem?

5. (Optional) Apply your engineering process to the steps described by Bob Trieber. You will find that the problem came last in the video. That in itself is worthy of discussion because many scientists work toward developing something even though they are not sure about the applications of their developments. For example, the microwave and lasers are examples of scientific discovery that had no initial uses but became very important later.

Explore

6. Give groups either links to the hull designs below or print out handouts so each group has a different ship listed below.
   People are still inventing new types of ships. I am going to hand you recent copyrights for hull designs. You will answer three questions: 1) What is unique? 2) What is the problem the hull tries to solve? 3) How does the hull solve that problem?

   Explain that people are still inventing new solutions for new boat problems.

| Copyright documentation for a 295-foot catamaran hull | https://www.copyright.gov/vessels/regs/dvh0530.pdf |
| Copyright documentation for a sailboat hull            | https://www.copyright.gov/vessels/regs/dvh0527.pdf |
| Copyright documentation for a fishing boat hull and top| https://www.copyright.gov/vessels/regs/dvh0513.pdf |
| Copyright documentation for a 310 foot oil supply hull with bulbous end | https://www.copyright.gov/vessels/regs/dvh0509.pdf |
| Copyright documentation for a kayak                    | https://www.copyright.gov/vessels/regs/dvh0529.pdf |
| Copyright documentation for a houseboat hull           | https://www.copyright.gov/vessels/regs/dvh0508.pdf |

   a. If you want more designs, they are listed at: https://www.copyright.gov/vessels/list/

7. (Optional) Explain that the U.S. Copyright Office and the U.S. Patent and Trademark Office certify new inventions so that inventors make money from their work and others cannot steal their ideas.

Explain

8. Students should work in groups. They will present answers to these three questions (you could have them share orally, draw something on a poster, use a PowerPoint slide, etc.):
   a. What is unique about the design?
   b. What problem is the design addressing?
   c. How does the design address that problem?

Elaborate

9. Now we will reverse engineering whole ships using YouTube videos to see different parts of ships.
Ships are designed over years, so you and your students will not be able to reverse engineer everything in minutes or hours, but the goal is to use the reverse engineering process to consider components of the ship, like:

a. **Propulsion:** Makes the ship move  
b. **Cabins:** Where people live on the ship  
c. **Gallery:** Where people eat on the ship

10. You can use the same design questions from looking at the hulls:

a. **What is unique about each part of the ship?**  
b. **What problems are parts of the ship solving?** (there are many!)  
c. **How does the design of that ship part solve that problem?**  
d. **NOTE:** If these three questions are too big, start with “How does the boat move? What does the boat move? How?”

<table>
<thead>
<tr>
<th>Sea trials of aircraft carrier <strong>USS Gerald Ford</strong></th>
<th><a href="https://www.youtube.com/watch?v=s_AmTOak0mc">https://www.youtube.com/watch?v=s_AmTOak0mc</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fastest US Navy ship: Boeing Pegasus-Class (first 5 minutes needed)</td>
<td><a href="https://www.youtube.com/watch?v=zQ2sSRBMPqs">https://www.youtube.com/watch?v=zQ2sSRBMPqs</a></td>
</tr>
<tr>
<td>Car carrying <strong>Faust</strong> by Smithsonian Channel</td>
<td><a href="https://www.youtube.com/watch?v=TNY4Gd6YlAE">https://www.youtube.com/watch?v=TNY4Gd6YlAE</a></td>
</tr>
<tr>
<td>Tug boat at a dry dock on Staten Island, NY</td>
<td><a href="https://www.youtube.com/watch?v=2HoNFv6A1TA">https://www.youtube.com/watch?v=2HoNFv6A1TA</a></td>
</tr>
<tr>
<td>Cruise ship <strong>MS Paul Gauguin</strong> (first 3 minutes, 30 seconds)</td>
<td><a href="https://www.youtube.com/watch?v=tiZgYvaTC-c">https://www.youtube.com/watch?v=tiZgYvaTC-c</a></td>
</tr>
<tr>
<td>Historic British warships in the mid 1700s</td>
<td><a href="https://youtu.be/O71kEiM2GOQ?t=35m41s">https://youtu.be/O71kEiM2GOQ?t=35m41s</a></td>
</tr>
<tr>
<td>Sea Trials of the <strong>USS Milwaukee</strong></td>
<td><a href="https://www.youtube.com/watch?v=bc6aDt3e6ek">https://www.youtube.com/watch?v=bc6aDt3e6ek</a></td>
</tr>
</tbody>
</table>

11. After a good amount of exploration, students can share the answers about the parts of the ships as before (orally, on posters, on PowerPoint, etc.).  

**Optional extension activity:**

12. **(Optional)** Show students this video [https://www.youtube.com/watch?v=2HoNFv6A1TA](https://www.youtube.com/watch?v=2HoNFv6A1TA) and lead a class discussion using the questions below. You may want to play the video on loop (if it isn’t overly distracting to the students) so that they can continue to look and learn in order to answer your questions.  

a. Why is the hull shaped like this?  
b. Why is the superstructure so tall?  
c. What are the shapes of the propellers? Why?  
d. Which direction will the ship move when the propellers rotate clockwise?  
e. Why do you think there are two propellers?  
f. What are behind the propellers? What is the purpose of this structure?  
g. What does the rod going from the hull to the propeller do?

13. **(Optional)** Students could then work in groups to answer similar questions about this video:
a. What makes this propeller unit rotate?
b. During the test, how fast does the propeller move? What does the speed of the propeller influence?
c. Where is the propeller located?
d. How quickly does the propeller slow down in this video?
e. How quickly does the propeller speed up in this video?

14. (Optional) Then you could lead a conversation comparing the Melville and Tug boat design:

a. How does this propeller differ from the tug boat propeller?
b. What is one benefit of the tug boat design?
c. What is one benefit of the Melville’s rotating ship propeller?
d. What are the 10-12 things at the center of the propeller? Why are they needed?

Evaluate

15. Synthesize the discussions by asking students to compare and contrast the hulls they investigated on an exit slip.

On a slip of paper write the purpose of a hull that was shared by all the hulls we discussed today. Mark this “Same”. Then, describe a purpose of a hull that was unique to one of the designs. Mark this “Different”.

Additional Resources

A. ABB advertises a propulsion system in this video: https://www.youtube.com/watch?v=dv4C_LdoDaE.

You could add this video and these discussion questions, time permitting:

a. What are the two types of propellers described by the pilot?
b. What are the shape of the propellers? Why?
c. What do the propellers do?
d. How do the propellers move?
e. What are the waves behind the ships at 3:00 of the video?
f. What are the size of the propellers? Why do you think this size is appropriate for these ships?
g. Look at the ship moving at 4:00 in the video. Draw the ship and the direction of the propeller at this moment?

B. There is a very in-depth discussion of hull design types by the Inland Sea Education Association at:
https://www.youtube.com/watch?v=Ip5FDBkgdj0.
Sink that Boat!

<table>
<thead>
<tr>
<th>Middle School</th>
<th>Standard(s): MS-PS2-2, MS-ETS-1-2, CCSS-ELA SL.2, SL.4, SL.6</th>
<th>Topic: Overcoming buoyancy force</th>
<th>Developed by: ASNE</th>
</tr>
</thead>
</table>

**Overview:** Students will try to sink objects representing boats and determine problems that can affect ships. By sinking boats students should begin to see some of the problems that boat designs could have. You can also ask probing questions about why things are happening to get at key scientific concepts like mass, the center of mass, buoyancy force, density.

**Sample Lesson Flow**
- Introductory engagement (3 min), investigating sinking methods in groups (15 min), discussing the sinking methods discovered (10 min), explore ship height and weight distribution in FLEET (15 min), exit slips (2 min)
- Introductory engagement (3 min), investigating sinking methods in groups (15 min), discussing the sinking methods discovered (15 min), investigating sinking methods in groups (15 min), discussing the sinking methods discovered (10 min), explore ship height and weight distribution in FLEET (15 min), discuss findings (5 min), create/diagram/test tinfoil boats (10 min), ensure notes are complete for next class (2 min)

**Prior Student Knowledge Required:**
- Continue implementing your engineering design process.

**Student Learning Objective:**
- Experiment with buoyancy, stability, and centers of mass.

**Materials:**
- “Boats” anything that can be in the water will be fine. Cans, containers, jugs, bottles, Frisbees, boxes, sandwich bags, have all worked well in previous investigations. If possible, have at least 3 per group so they can explore different shapes and densities.
- Students need to record sinking methods so that they can refer to them during the next lesson.
- Containers or sinks with at least 4-6 inches of water.
- One piece of tinfoil per person or group for closing activity.
- String or cord to pull boats.
- Computers with FLEET for students to investigate ship height and weight distribution.
- Tinfoil and test sink for students to build one boat that will definitely float and one that will definitely sink.
- Create two sketches and two descriptions of tinfoil boats.
- Students can draw their tinfoil boat designs with descriptions of what makes them float/sink.

**LESSON PLAN – (This uses the 5-E Model)**

**Engage**
1. Today’s work is all about sinking boats. By sinking boats students should begin to see some of the problems that boat designs could have. You can also ask probing questions about why things are happening to get at key scientific concepts like mass, the center of mass, buoyancy force, and density.

**Explore**
2. Actively reinforce your engineering process by briefly discussing each step of the process before you begin.
3. Ask students to take organized notes so that their notes next class (the next lesson is engineering a solution to one or more of the challenges that can sink boats).
4. Put the class into groups to investigate the challenge:
   - Today we are going to sink a boat in as many different ways as possible. By finding all
the ways that boats can fail, we are able to identify engineering challenges. We will use your notes next class, so be sure to organize your notes well.

5. Let students imagine possibilities, sketch their idea, plan the study, and begin trying out the different ways to sink their boat. You can have these discussions as a class or students can discuss in their small groups.
   a. What data should we write down?
      i. Students will need to clearly describe each Sinking Method. But, what else would be useful? ("How hard it was to sink this way", "How much of the boat sinks", etc.) Students are starting to take ownership of what data they collect and how they use data starting with this lesson.
   b. Any other types of data we could collect?
      i. Students may take short cell-phone videos to document the research if you are fine with cell phone use. Students could use scales to weigh their boats, thermometers to measure whether water temperature is a challenge for boats, etc.
   c. NOTE: If your students hesitate for more than 1-2 minutes, you can show one of the Sinking Methods listed below to help them brainstorm.

What are the all the ways you can find to sink your ship?

6. Encourage students to use initial trials to spur new ideas about how to sink the ship.

7. Give students a five-minute warning and tell them that they will present their data to the class.

Explain

8. There are a couple of ways to organize this discussion:
   a. Ask groups to share 2 or 3 ways they found to sink the boat. OR,
   b. Use Scattegories™ rules and ask each group to share 1 new way to sink the boat. Go around the room until there are no unique solutions left. OR,
   c. If students recorded videos of each sinking method, you could use this video library to group into videos of the same problem.
   d. Record the answers so everyone can refer to them.

9. After you have a good list of ways to sink the boat, work together to sort the issues into two groups:
   a. Could be Completely Solved: Students could make a design that would never have this problem (e.g., a cardboard boat may get wet and let water seep in, but a different boat material would make this problem go away).
   b. Could be Partially Solved: Students could make it harder to sink a boat this way, but it is always possible (e.g., a wide boat could be sunk by pushing on the side, but if the boat had more weight in the middle, especially if that weight was under water, then it would be harder to tip a boat over and sink it.
   c. You may have an Unsure category too. That is fine to come back to later.

10. If possible, take a couple pictures and/or videos of successful sinkings. Share links to those pictures or videos on the FLEET Forum (http://www.navalengineers.org/Membership/Forum) under “FLEET Exchange.”

Some Sinking Methods
- Wave fills up boat from the side
- Something pushes boat down
- The boat tips over
- Boat has a hole below the water line
- Boat moves forward into a big wave
- Many, many more!!

What are the all the ways you can find to sink your ship?

- Wave fills up boat from the side
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- Boat moves forward into a big wave
- Many, many more!!
11. Tie the conversation together by giving some scientific terms to the issues that the students see:
   a. **Mass**: the amount of matter in an object (similar to weight in the eyes of students)
   b. **Center of Mass**: The point in an object where there is the same amount of mass in every direction.
      i. *Sinking Methods* reflected: pushing on the side of the boat, pushing on the top of the boat.
   c. **Buoyancy Force**: The force from the water that makes the boat float
      i. *Sinking Methods* reflected: pushing straight down on the boat will overcome the buoyancy force, pulling down from underneath
   d. **Hull and material**: What the bottom of the boat is made from
      i. *Sinking Methods* reflected: Poking holes in the material, tearing the material or crumpling the material
   e. **Weather concerns**: Issues related to changes in weather.
      i. *Sinking Methods* reflected: Students may create “big waves” or simulate” heavy rain” which fill up the

12. (Optional) Give each group a piece of string and some tape. Ask them to investigate whether a boat in motion behaves the same as the boat sitting still.

   (Optional) What are the you can sink your ship while it is moving?

Are the same ways to sink the boat still relevant?
   a. In addition to the variables the students are collecting ask students to record one variable for you: the height of the tape above the water.
   b. Students will find that the force from the string can sink the boat or make it flip over (capsize). This force is particularly destructive if it is above the center of mass.

13. (Optional) Use FLEET to experiment how ship height and weight distribution can affect ships. You can adjust the ship height by adding a radar tower. You can adjust the weight distribution easily by adjusting the water in the ballast tanks. Then, hit “Play” to use the Stability Test to see if the ship is stable or too unsafe for sailors to use.

   (Optional) How does ship height and weight distribution affect the stability of your ship? What does stability tell us about whether the ship will sink or float?
a. **Radar Towers:** Add a radar tower to this ship by going to the “Advanced” menu, click “Comms”, then select the “Dish Radar” or the “Doppler Radar”. Place the radar on the ship. Then, click directly on the radar tower to Edit the component. Experiment with “Height” by clicking on the bar to increase/decrease its length.

   ![Radar Tower Image]

   i. Students can use a variety of heights, then test their ship using the Stability Test by hitting the play button ( ). (Ships will have to meet the basic requirements; consider using the default ship if this causes your students issue.)

b. **Ballast Tanks:** The default ship already has a ballast tank. You can access it by clicking the Ship icon in the upper left. In the Structure menu, you can see “Ballast Tanks”. Click on the “Water Tank” button. These are the tanks currently on your ship. Click the water button in the Edit component window.

   ![Ballast Tank Image]

   i. Students can adjust the water level in each tank strategically to “sink” the ship in the Stability Test.

**Evaluate**

14. **(Optional)** Give students a piece of tinfoil to make two boats.

   **(Optional) Use one sheet of tinfoil to create one “boat” you know will float. Write a sentence describing your thinking. Then, use your tinfoil to create another boat you know that will sink immediately. Write another sentence describing your thinking.**

15. **(Optional)** Ask students to write a sentence that describes why they made each “boat” that way.

16. **(Optional)** Have students create a poster or write in a notebook with these sentences then have them sketch their boat from a couple different views.

17. **(Optional)** Then, let them test the boat.

18. **(Optional)** You or the student should hold on to the sentence for future reference. You could put the sentence and a picture of each boat with both sentences on a PowerPoint slide. Or, students could simply sketch their boat and keep the sketch and their sentence in their engineering notebook.

**Additional Resources**

A. Here is a short video by the *Washington Post* about common ways boats sink: [https://www.youtube.com/watch?v=j0XBMuQDY1M](https://www.youtube.com/watch?v=j0XBMuQDY1M)

B. If you would like to use the closing activity as a full-class activity. We have a lesson plan for that too! You can find it at: [http://www.navalengineers.org/STEM-FLEET/For-Educators/FLEET-Centered-Curriculum-for-HS-Students](http://www.navalengineers.org/STEM-FLEET/For-Educators/FLEET-Centered-Curriculum-for-HS-Students)
## Overview
Students will engineer a boat to pitch in a Shark Tank™-like class discussion. Knowledge gained through these experiments and explorations will be used in FLEET to succeed and purposefully fail Stability Test and explore the Speed and Maneuverability Tests, time permitting.

### Sample Lesson Flow
- **Introductory engagement** (3 min), work in groups to design a boat (15 min), pitch/discuss boat designs (20 min), pass **FLEET** Stability Test (5 min), exit question (2 min).
- **Introductory engagement** (3 min), work in groups to design a boat (25 min), pitch/discuss boat designs (30 min), pass & fail **FLEET** Stability Test (10 min), explore Speed & Maneuverability Tests (20 min), exit question (2 min).

### Prior Student Knowledge Required:
- **Engineering Design Process**

### Student Learning Objective:
- Understand the importance of ballast.
- Experimentally explore how the center of mass and hydrostatic chart are influenced by the distribution of mass.

### Materials:
- “Boats” for this lesson would ideally be plastic bottles with lids of different sizes (20 oz, 2L soda bottles, ½ gallon, gallon milk jugs; peanut butter containers; etc.). Be sure to wash all containers so there are no allergens that affect your students.
- Container of water or sinks that are stopped and filled with enough water to “sink” the “boats.”
- Materials for students to share solutions in a “Shark Tank” show.
- Computers with **FLEET** for students to build a stable ship.
- (Optional, Step #4) Technology to show a YouTube clip.
- (Optional, Step #12 & 13) Computers with **FLEET** for students to build unstable ships and test the Speed and Maneuverability Tests

### LESSON PLAN – (This uses the 5-E Model)

#### Engage
1. Last lesson, your students sank boats. If they were able to tape a piece of string and drag a boat across the water, then they saw the importance of forces that act horizontally on boats. Introduce this lesson, by calling back to these experiences.

   **Last time we sank boats. Today we are going to use that experience and that data to design boats that address these problems.**

2. Today’s design challenge is to make a good boat. Your groups could make their most stable design, or they could focus on designing a boat that directly addresses one of the *sinking methods* from last class (e.g., a circular boat design would be hardest to tip over).

#### Explore
3. Your students should immediately be thinking about implementing the engineering design process to address today’s problem:

   There are two ways to do this lesson:

   1. Allow students to design the *best boat* possible. This tactic is best if you have a short class period for this topic.
   2. Allow groups to choose *one boat-design challenge* from last class. This focus on one challenge is more scientific and could allow you to take multiple class periods.
a. How can we make a ship that does not tip over easily?
b. Remember cost and ability to replicate are important traits for the engineering solution.
c. Students will need investigate the design and present data in a “pitch” that describes why their design solution is best.

You will share your solution to a group of engineers (this class). We will be interested in funding the most promising solution, so be sure to give us data and justification for your design. This will be a Shark Tank for engineers. And, engineers love data!

4. (Optional) If your students could benefit from more scaffolding, you could show this Coast Guard video which exemplifies some of the forces they will be studying in this lesson:
   a. https://www.youtube.com/watch?v=jXF-TjOjD5k (suggest playing on mute)
   b. Note that you are not asking to design a boat that will flip back over (self-righting), but they can use this video to think about the forces the engineers used to make a boat that is so steady.

5. Let students engage in the full engineering design process while working in groups. Ask probing questions of the groups to ensure that they are acting like engineers:
   a. How will you test your design?
   b. What data will you collect to compare tests?
   c. What variables are you manipulating?
   d. NOTE: measuring the force applied to the ship will be difficult and probably beyond the scope of what you can expect in one day. If measuring force exactly is important to you, have students tie or tape string to the side of their ship then attach weights to the other end of the string. The string will need to be long enough that it goes over the side of the water container and/or table so it can freely hang.

6. Students may initially explore obvious features of their boat (like which side of the container is the bottom). But, within 5 minutes they should be building and improving designs. If you need to jumpstart this design conversation, consider one of these solutions:
   a. Show ballast water. One advanced ship design feature is putting water near the bottom of the hull to add stability. Filling the container with water may come naturally to students that have played a lot of FLEET because they have seen the ballast tanks.
   b. Move around. Sometimes students simply need to stand up and move around with their ship to build energy. This need is particularly seen in after-school programs.
   c. Quick class discussion. Bring the class together and discuss what are the best ways to steady a ship that they have discovered.
   d. YouTube research. The video in Step #3a shows a Coast Guard ship that is designed to return to balance even if it is upside down. This behavior is called self-righting. Students could play this clip and pause it to study how engineers built a boat that takes advantage of buoyancy force.

Explain

7. Have students present their data and final designs as a pitch about why the class should support their design.
   a. You could congratulate everyone on pitching their designs or give superlatives to the groups (most engaging, best visual aid, best use of data, etc.).

Elaborate

8. Encourage the group to ask questions after each pitch so the group can elaborate on their engineering process and the data they gathered. Ask questions to ensure the data supports students’ claims.

Explore
9. Reorganize students so they are in front of computers with FLEET. Before letting them loose on the two FLEET Challenges, lead a discussion about the center of mass.

Mass is that amount of matter in something. You have been organizing mass to make boats sink and float for a while now. How did your group distribute mass in your design?

a. (Mass is the amount of matter in an object. In boats, the mass is usually distributed equally across the center of mass.)

b. (Students can work directly with this concept by creating 2-dimensional sketches of the boat and folding it in half. Sketches looking down at the boat will generally be perfectly symmetrical.)

c. (Sketches from the side will not be symmetrical. You will want to talk about where students think the center of mass is. For stable boats, the center of mass is below the waterline. This means the center of mass is below the water’s surface. When the center of mass is low the water’s force is stronger on the ship and can help stabilize the ship.)

d. (Unstable boats have a high center of mass. A high center of mass means that waves can easily push the boat without an opposing force stabilizing the boat.)

e. (Students can investigate this ship geometry by carefully tracking the data in the hydrostatic chart.)

How do you plan to distribute mass so your boat is as stable as possible?

10. (Optional) If your students did not use ballast tanks in the previous lesson, show students how to adjust the ballast in the containers. Ask them to consider why the ballast tanks are symmetrical on either side of the boat.

Elaborate

11. Have students log into FLEET and use their newfound knowledge to complete the Stability Test. (Hit the green play button as soon as the ship is ready).

FLEET Challenge #1: Use your knowledge to pass the Stability Test.

a. Note: If you run out of time, it’s fine to hold this off to the next class. To access the Stability Test you must meet all the mission requirements so students may have to add components to their ships.

b. Ask the students to record the Ship Properties and Hydrostatic Chart data (if these data displays are not active, click the ship button in the upper left corner, and they will reappear).

c. Save this boat before moving to the next challenge.

12. (Optional) If students have time, encourage them to explore thoughtfully how the concept of ballast can be used to fail the Stability Test.

(Optional) FLEET Challenge #2: Use your knowledge to fail the Stability Test purposefully.

a. Ask the students to record the Ship Properties and Hydrostatic Chart data (if these data displays are not active, click the ship button in the upper left corner, and they will reappear).
13. **(Optional)** If students have time, allow them to try the Speed Test and Maneuverability Test using the same ship from Challenge #1 using the Open button.

**(Optional)** **FLEET Challenge #3:** What design choices in your Stable Boat design makes your boat fast? What design choices are slowing you down?

a. Keep these notes for future use. Building a fast, maneuverable ship will be critical for the Search & Rescue mission.

**Evaluate**

14. Have students compare the data and experiences from using FLEET as a naval physics simulator. You can facilitate their analyses with questions like:
   a. What designs were successful?
   b. **(Optional)** What was different about the successful and unsuccessful tests?

15. **Exit question:**

   Now that we have sunk ships and failed Stability Tests. Can you learn from mistakes? How?

**Additional Resources**

A. As a closing activity, you could show this video of a ship with its propeller out of the water. Let students identify the problem in the video and describe how they would solve this problem.

   https://www.youtube.com/watch?v=Hx5oefHKZSU

B. This NBC/NSF five-minute video describes the center of mass for NFL lineman and is a good corollary for why the rescue ships spin around on large waves (the ships are experiencing torque):

   https://science360.gov/obj/video/9112c778-48e4-4b75-a09b-2f2d2404da12/science-nfl-football-torque

C. Another self-righting ship video with a slow-motion replay (slow motion at 1:40):

   https://www.youtube.com/watch?v=eCoYeAgui6E

D. This 15-minute lesson from Harvard fully explores why the Coast Guard cutter is able to self-right so quickly:

   https://sciencedemonstrations.fas.harvard.edu/presentations/stability-flotation

E. Need help understanding the Center of Gravity vs. Center of Buoyancy? See:

## Search and Rescue Mission

<table>
<thead>
<tr>
<th>Middle School</th>
<th>Standard(s): MS-PS2-2; MS-ETS-1-1 through MS-ETS1-4; CCSS.SL.1, CCSS.SL.4</th>
<th>Topic: Designing a search and rescue mission</th>
<th>Developed by: ASNE</th>
</tr>
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### Overview:
Students will design a solution to an engineering problem in groups and share those results. Then, students will interact with the same engineering problem through FLEET.

### Sample Lesson Flow:
- **Engage:** Design a solution to an engineering problem (15 min), share results (10 min), attempt FLEET search and rescue mission (15 min), closing discussion about using data in FLEET (5 min)
- **Explore:** Design a solution to an engineering problem (25 min), share results (15 min), attempt FLEET search and rescue mission (45 min), closing discussion about using data in FLEET (5 min)

### Prior Student Knowledge Required:
- Engineering Design Process

### Student Learning Objective:
- Design a ship that will be able to rescue shipwrecked sailors.

### Materials:
- Computers set up with FLEET
- Technology to play YouTube video

### LESSON PLAN – (This uses the 5-E Model)

#### Engage
1. Start with students in groups and remind them of your engineering design process. Today’s engineering process is:
   - **Design a ship that can quickly save shipwrecked sailors that are miles away from harbor. You will pitch your design to the Coast Guard in a one-minute presentation.**
     a. Tell students that they will pitch their ideas to the Coast Guard in a one-minute presentation. The Coast Guard will want to know what variables students considered and how students plan to test their design.
     b. **(Optional)** If you already have many students that have engaged with the Search and Rescue mission, you may want to tweak the initial engineering task by asking the groups to design a system that will allow the Coast Guard to know when a ship is wrecked within America’s territorial waters (12 nautical miles from shore).
     c. **(Optional)** You could also use this NOAA video in your wrap up discussion:
       - https://www.youtube.com/watch?v=xNQt4QlvV64

2. Previous design challenges involved using water. This challenge involves considering all the problems caused by a Search & Rescue mission and adding or honing to the theoretical design students make. Even though their design is theoretical, encourage students to describe how to test their design.

#### Explore
3. Students should be able to work on these problems with minimal educator input. If you would like to guide the discussions, you could ask questions like:
   a. What data will you collect to evaluate your design?
   b. Are you thinking about forces and acceleration in your designs? How will you use this knowledge to improve your design?
   c. I like your design. What can you do to make it even better?
   d. What would you do to test your design?
**Explain & Elaborate**

4. Have students share their process and ask each group a follow-up question about how they addressed a step in your design process.

5. *(Optional)* If you want to choose a winner, score the teams’ presentations on how the presentations reflected each step of your engineering process.

**Explore**

6. Hopefully a group suggested testing using a simulator as well as in real-life. Simulators are a common way engineering groups of all types save resources while testing their designs. Now your engineers will test and re-test designs in the simulator, **FLEET**.

   **FLEET Challenge: Today’s challenge is to complete the Search & Rescue mission with the highest score.**

7. Have students log into **FLEET** and create a ship for the **Search and Rescue mission**. Students can read the mission description by clicking the book in the upper right corner and then selecting the “Missions & Achievements” tab. We included that text here so you can have it handy as you walk around. In particular, ask students what the objectives are (these are the engineering design goals, so students must keep them in mind).

   a. **FLEET Text:** Design and build a stable ship that can rescue a group of shipwrecked mariners.

      Make sure you stay under budget, stay close to design displacement, and have all the necessary equipment. Remember, you need to get the men out of the water as quickly as possible. Salvaging their sinking ship is a bonus.

   b. **Objectives**

      i. Find the fishing boat.

      ii. Recover the mariners.

8. Be sure to show students how the color changes as they address each design requirement.

9. These missions could take a very long time (20+ minutes). That is ok. Students are exploring what works and what doesn’t work and using that information for the next test. Once a student has gathered data on their design solution, they may choose to restart the mission without completing it. Today is a day where students may feel like they don’t have enough time to do all the testing they want. An engineer’s biggest problem!

10. After each group completes the mission, ask them to consider how the score is calculated.

    **What does the score show you is important in successful search and rescue missions? How can you use this feedback to improve your design?**

    a. NOTE: If students need an additional challenge, show them how to change the Environment from “Sunny” to “Storm” when they choose the mission. (After they hit the green play button in the drydock and the missions and tests appear, there is a drop-down menu for “Environment” in the lower left.)

11. Save 5 minutes for a wrap-up discussion by asking students:

    **How did you collect and use data? How did you use the engineering design process?**

    **What was your best solution so far?**

    The next class will be the final class and the first half of class will be spent improving and perfecting this design.

**Additional Resources**


B. If you have the ability to play a video on mute while students are working in **FLEET**, we suggest this
GoPro video of a U.S. Coast Guard rescue swimmer. Probably worth muting the clip since the only real noise is the helicopter.  

https://www.youtube.com/watch?v=IPERJ-p4qU

C. Search and Rescue as a job is shown by this report by ABC in Virginia Beach. You can make connections between the practice of these professionals with the testing done by engineers because both give feedback and experience used to create a great final product.

https://www.youtube.com/watch?v=Io_c_GxiwAM
## FLEET All-Star Break

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<tr>
<th>Middle School</th>
<th>Standard(s): MS-PS2-2; MS-ETS-1-1, 1-2, 1-3, 1-4</th>
<th>Topic: Investigating vehicles, exploring FLEET.</th>
<th>Developed by: ASNE</th>
</tr>
</thead>
</table>

**Overview:** Students will engage with FLEET all day by testing out different vehicles and getting familiar with the gameplay.

**Sample Lesson Flow**

1. Warm-up discussion (5 min), FLEET gameplay (30 min), exit discussion (10 min)
2. Warm-up discussion (5 min), FLEET gameplay (75 min), exit discussion (10 min)

**Prior Student Knowledge Required:**
- Engineering design process

**Student Learning Objective:**
- Use the engineering design process to purposefully design successful solutions to earn FLEET awards.

**Materials:**
- Computers set up with FLEET
  - (Optional, Step #3) Top speeds and times could receive awards, recognitions, or simply be part of the engineering process toward setting a nationwide FLEET high score.
  - (Optional, Step #10) Editable top-speed lists for use in future lessons.

## LESSON PLAN

### Welcome and FLEET time

1. There hasn’t been a full day yet devoted to simply engaging with FLEET. Today is that day.
2. Have students in front of FLEET computers and remind them that when they confront challenges, then they should talk with each other and engage in the engineering design process.
3. Explain that today is the All-Star Break and it’s time to engage in some skills competitions. Today’s challenges are (you could give awards, 🏆, or make this data collection part of the engineering process):
   - a. Top speed in the rescue ship.
   - b. Top speed in the helicopter
   - c. Best time on the Speed Test
   - d. Best time on the Maneuverability Test
   - e. Best time on Rescue Practice
   - f. Ship most under budget
   - g. Most expensive ship
4. These are 6 challenges and you only have limited time, so students should pick 2-3 to try and win.
5. Tell them that they will need to save 20 minutes at the end to discuss how they solved design challenges and to document the data.
6. Warm-up discussion:
   - 🧐 What data should we collect so we can use and study the results later? 🧐
7. Remember you will compete against other schools so you want to work together to understand as much Physics as possible.
   - a. For example, the data could be what’s on the ship, the draft, and the speed or time.
   - b. Or, you could decide to record the displacement, the trim, the amount over/under budget, the high speed, and time completed.
c. Or, any other data that you and your students decide. The key is that everyone must collect the same data.

8. For the “Top Speed” awards you should ask students to replicate their speeds in front of you for confirmation. Replication is a critical part of science and engineering.
   a. If this is simply not possible, ask students to take 2 screen shots of their top speed and save the images on the Desktop. (Most keyboards have a “Print Screen” key in the upper right.

9. Circulate the room to make sure no one is “stuck” on a screen or a challenge.

10. With 20 minutes left, bring everyone together to share the top 3-5 in each category. Centralize the data on to one poster, chalkboard, website, Excel file, etc.
    "As you share your data and high scores, share your process and what you learned."

11. (Optional) Write down the top 3 in each category in a way that is easily displayed and easily edited. Tell students that if they collect all the requisite data and beat one of these scores, then their name will be added to the list over the next few classes. This could become a few week-long FLEET-tathlon to motivate students.

12. In any case, please, please share out a few pictures, and screenshots from your successful All-Star Breaks on the FLEET Forum (http://www.navalengineers.org/Membership/Forum) under “FLEET Awards”

Additional Resources

A. If you want more celebration ideas, be sure to check the FLEET Forum (http://www.navalengineers.org/Membership/Forum). During this initial roll out, feel free to use that space to list your ideas as a safe space to try out ideas amongst other educators thinking about the same issues.
The Force is Strong in Your Ship

Middle School

| Standard(s): MS-PS2-2; MS-ETS1-1, 1-2, 1-3, 1-4, CCSS.SL.1,4,&6 | Topic: Newton’s Three Laws and Archimedes Principle | Developed by: ASNE With materials from TedEd, NSF and NBC |

Overview: Students will learn about Newton’s Three Laws and, if there is time, Archimedes Principle through engaging videos and class discussion (30-45 minutes). Then, students will apply this knowledge to the Search & Rescue Mission in FLEET (20-25 minutes).

Sample Lesson Flow:

- Warm-up (5 min), discuss engineering process (20 min), use engineering process (15 min), exit discussion (5 min)
- Warm-up (5 min), discuss engineering process (25 min), create artifact to document the engineering design process (20 min), use engineering process (40 min), exit discussion (5 min)

Prior Student Knowledge Required:
- Engineering design process

Student Learning Objective:
- Understand Newton’s Three Laws
- Understand Archimedes’ Principle as an extension of current knowledge of forces

Materials:
- Technology to play YouTube videos about forces shown in football
- Computers set up with FLEET (Optional, Step #7) Technology to play YouTube videos about Archimedes Principle.

LESSON PLAN – (This uses the 5-E Model)

Engage

1. Engage students with each of these five-minute long videos. They are produced by NBC with support from the National Science Foundation:

Explore & Explain

2. After you play each video, ask students to explain how the football players showed Newton’s Law.
   - What did you learn about this law of motion?
   - How is it shown in the NFL?

Elaborate

3. Then, ask students to expand this knowledge and think about how FLEET shows each of Newton’s Laws. You can do this after each video or as a second conversation.
   - How do you see this law of motion in FLEET?

Answers include:

- Newton’s First Law: Friction between the ship, air, and water means things are rarely at rest, so there are few examples of things at rest or in constant velocity in FLEET. That said, a wave is a good example of something with minimal forces acting upon it that will continue at the same speed forever (or until it impacts a beach).
- Newton’s Second Law: The ships are always battling waves. One way to overcome the force of...
a wave is to accelerate the boat greatly. Another way is to make the boat heavier through ballast or additional components. Discuss the differences in driving the landing craft and the main ship. The main difference is the mass is so different that they exert different forces in cutting through waves and in creating buoyancy force.

c. Newton’s Third Law: This law is closely tied to the concept of buoyancy because gravity is applying a force on the water and the water is applying an equal force on the ship. Since the water is applying exactly the same amount of force, the boat floats. If the water could not apply a great enough force, then the boat would sink.

Evaluate

4. Have a student play FLEET on a monitor that all students can see. Ask students to call out when they see one of Newton’s Laws being acted out in FLEET.
   a. Unpack this learning event in a conversation afterwards allowing students to more fully describe how they saw Newton’s Laws and correct any misunderstandings.

Explore

5. Move students to machines with FLEET to practice the Search & Rescue Mission again. Charge them with this purpose:

   Think like an engineer would approach a race. How can you use the forces from the waves to improve your speed? Use our design process. Try out different solutions thoughtfully. We will discuss the best race practices you discovered in your process.

Explain

6. Save 5 minutes at the end to bring the class together to share out their findings about mitigating the force of the wave in driving the FLEET ship. Ask students for data to back up their assertions. (Even if they do not have the data this will be a good reminder that engineers always support their findings with data, and people receiving reports from engineers expect to see this data.)

Optional additional material for Archimedes Principle

7. (Optional) If you have time, you can repeat the process with this TedEd video about Archimedes Principle. It more fully explains the forces of buoyancy related to Newton’s Third Law:
   a. First show the video https://www.youtube.com/watch?v=0v86Yk14rf8
   b. Then ask students to describe what is Archimedes Principle.
   c. Then ask students to transfer that knowledge to FLEET and describe how they see Archimedes Principle in their ships.
   d. Then ask students to use FLEET to explore Archimedes Principle by adding/subtracting weight to the ship and seeing how the waterline changes
      i. Students should be using “Ship properties” to record exact weights using “displacement”. Ask students why the displacement and the ship’s weight are equal? (because Archimedes Principle shows this must be true).
      ii. Students should also record the draft of the ship in the “Ship properties”.
   e. Save 5 minutes for a wrap-up discussion of Archimedes Principle. Ask students to share their data. You can share that many ships have a known measurement called “Tonnes per centimeter”. Tonnes per centimeter means the number of tonnes of cargo that has to be added to the ship to increase the draft 1 centimeter. That measurement shows how much the water weighs in such a small cross-section of the ship.

Additional Resources

A. ASNE also has Literacy materials for Newton’s three laws that also assess the Scientific Concepts.
B. Newton’s First Law is a little tricky because constant velocity is not something we can see on Earth. It requires a vacuum like space. This video European Space Organization is geared toward students and presents Newton’s First Law in a way that may be clearer for some students:

https://www.youtube.com/watch?v=Q0Wz5P0JdeU

C. If you want a PowerPoint resource, this Fall-themed presentation from Virginia’s Jefferson Lab:

http://education.jlab.org/jsat/powerpoint/newtons_laws_of_motion.ppt

D. This TedEd video presents Newton’s Three Laws using a bicycle reference:

https://www.youtube.com/watch?v=JGO_zDWmkvk&spfreload=10

E. If you have time for Archimedes Principle, this Smithsonian video shows how a ship can carry 30,000 tons of grain and how it affects the draft of the ship. This video also describes some additional engineering constraints which are always important to highlight:

https://www.youtube.com/watch?v=0v86Yk14rf8

F. If you are looking for more ways for students to creatively engage with Science and Engineering (think STEAM!), you may want to show one of these videos as a way to spur creativity:

a. https://www.youtube.com/watch?v=okCCGxWs_L8 (adaptation of What does a fox say?)

b. https://www.youtube.com/watch?v=kn_UMUASyP (adaptation of Katy Perry’s Roar)

G. Our high school materials also link to this excellent Yale lecture on Newton’s Three Laws:

https://www.youtube.com/watch?v=Ns6GB4Dph9U&list=PLFE3074A4CB751B2B&index=3
### A Speedy Design

<table>
<thead>
<tr>
<th>Middle School</th>
<th>Standard(s): MS-PS2-2; MS-ETS-1-1, 1-2, 1-3, 1-4; CCSS.SL.1,4,&amp;6</th>
<th>Topic: Designing for speed</th>
<th>Developed by: ASNE With materials from NBC and NSF</th>
</tr>
</thead>
</table>

**Overview:** A quick introduction to a discussion of speed in the water (5-10 minutes). But primarily testing in FLEET and trying out different designs for the Speed Test (20-25 minutes). Extended testing in the Search and Rescue mission (15-45 minutes).

**Sample Lesson Flow:**
- 💻: Engage with video (5 min), discuss speed and design as shown in the video (10 min), identify terms in FLEET (5 min), use knowledge to improve FLEET designs (25 min)
- 🎬: Engage with video (5 min), discuss speed and design as shown in the video (15 min), identify terms in FLEET (10 min), use knowledge to improve FLEET designs (60 min), share out one lesson learned (5 min)

**Prior Student Knowledge Required:**
- Engineering Design Process

**Student Learning Objective:**
Understand how to make things move faster in water.

**Materials:**
- Technology to play YouTube video
- Computers set up with FLEET, including one machine that everyone can watch (may need a projector for larger classes)

**LESSON PLAN – (This uses the 5-E Model)**

**Engage**
   - a. Note: Although this video is shot in 2012, students could research Katie Ledecky for a modern-day, young phenom.

   **How does Missy Franklin experience:**
   - frictional drag?
   - pressure drag?
   - wave drag?
   - thrust?

**Explore & Explain**
2. Have a student complete the Maneuverability Test in front of the class and have students call out when they see each of the four terms from above in FLEET.
   - a. Unpack this learning event in a conversation after so students describe what they saw Newton’s Laws and correct any misunderstandings.

**Explore**
3. Move students to machines with FLEET to practice the Speed Test again.
   - Charge them with this purpose:
   - **Think like an engineer would approach a race: Make changes strategically, Measure the effect of each change on your speed/time. Try out different solutions strategically. Be ready to describe your solutions and data to your fellow engineers.**
4. Take 5 minutes after the Speed Tests to discuss students’ findings about mitigating the force of the wave in driving the FLEET ship. Ask students for data to back up their assertions.

What is the best way to counteract the force of waves? What data shows you are right? (Even if they do not have the data this will be a good reminder that engineers always support their findings with data, and people receiving reports from engineers expect to see this data.)

Explore, Explain, and Elaborate
5. Move students to the Search & Rescue mission. Remind students of all their shared experiences and lessons learned (e.g., stability tests, Speed Tests they just discussed, experience with helicopter and small ships during the All-Star Break).
   a. Use a similar the Speed Test: Think like an engineer would approach the mission.

   Keep thinking like an engineer on the Search & Rescue mission: Make changes strategically, Collect data on your speed/time. Discuss your solutions strategically. Next class we will try to make the highest score, so use this time wisely to test.

   Encourage groups to work on possible solutions. Next class is the FLEET Finals where students will show their best possible solution.

Evaluate
6. (Optional) Each group can share one lesson learned during their design work today.

Additional Resources
A. Biology connection: This NSF video shows pressure drag in a way that is not obvious in the swimming video or in FLEET interactions: https://science360.gov/obj/video/9f77887e-d1ef-4119-a7ca-c6a903bb770d/efficient-swimmers-ocean-revealed

B. Not only are swimmers and ships fast, but pools can be fast too. This video shows how to make a fast pool. This video is great to discuss the effect of waves on speed: https://science360.gov/obj/video/e1522628-fac0-4301-ac9a-e6b91c28f138/science-summer-olympics-designing-fast-pool
The FLEET Engineering Awards

**Middle School**

**Standard(s):** MS-PS2-2; MS-ETS-1-1, 1-2, 1-3, 1-4

**Topic:** Completing Search and Rescue challenges and celebrating each other.

**Developed by:** ASNE With materials from NOAA

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**Overview:** Students will complete a Search and Rescue mission (10-20 minutes). to begin the Awards and then celebrate their engineering successes (25-70 minutes).

**Sample Lesson Flow**

- Final attempt at high score in FLEET search and rescue mission (20 min), final celebration (25 min).

- Final attempts at high score in FLEET search and rescue mission (45 min), final celebration (45 min).

**Prior Student Knowledge Required:**

- Engineering design process

**Student Learning Objective:**

- Excite students to continue to see themselves as science and engineers.

**Materials:**

- Computers set up with FLEET
- Awards for students’ engineering qualities and successes
- (Optional, Step #2) Technology to play YouTube video
- (Optional, Step #6) paper plates and art supplies to make awards

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**LESSON PLAN – (5-E Model)**

**Welcome and FLEET time**

13. Students know that today is a celebration, and welcome them to the ceremonies.

14. (Optional) If your class responds well to a video introduction, this three-minute clip is a worthwhile reminder of why Search and Rescue is so important and describes some of the scientists that work behind the scenes to make these rescues possible: https://youtu.be/xNQt4QIvV64?t=1m3s

15. Let students compete in the Search and Rescue mission for some time. This mission combines all their knowledge from the videos, activities and tests in the Speed and Maneuverability Tests. You can remind them of these experiences so they can actively draw on that knowledge.

16. Give students a 10-minute warning about when they should wrap up. As students complete a mission in this time window, encourage them to look over the shoulders of students that are still playing.

**Award ceremony**

17. There are many ways to do this (a few are listed below). These materials have two goals: 1) improve students’ knowledge and skills, 2) allow students to see themselves as scientists and engineers. Ensure that your award ceremony addresses Goal #2 in a way that makes sense to your students.

18. Superlatives through STEAM option: 

   a. Create a list of awards, one for each student
   b. Students will create the awards for you. Assign each award to a student that did not win that award. This student has the task of creating an award that shows that idea.
   c. Give students about 10 minutes to create the award they are supposed to design.
   d. Bring the class together, ask each student to come up and describe their thought process in creating the award, then announce who won the award, and then take a picture of the students giving the award to the student.
   e. Some ideas to help you get started on a list of superlatives. These are tied to NASA’s design process, but you should modify the design process as needed:
### List of Some Possible Awards

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<th>Master Engineer of Ask process</th>
<th>Best Unique Thought</th>
</tr>
</thead>
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<td>Master Engineer of Imagine process</td>
<td>Best Engineer – Speed</td>
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<tr>
<td>Master Engineer - Planning process</td>
<td>Best Engineer – Maneuverability</td>
</tr>
<tr>
<td>Master Engineer – Creating</td>
<td>Esteemed Scientist – Best Application of Newton’s First Law</td>
</tr>
<tr>
<td>Master Engineer – Experiment</td>
<td>Most Valuable Contribution of Applying Newton’s Second Law</td>
</tr>
<tr>
<td>Master Engineer - Improve</td>
<td>Most Unique Discovery</td>
</tr>
<tr>
<td>Head Engineer – Process overseer</td>
<td>Most Imaginative Solution</td>
</tr>
<tr>
<td>FLEET Captain</td>
<td>Most Dedicated Problem Solver</td>
</tr>
<tr>
<td>Admiral of FLEET</td>
<td>Eureka! Best Discovery</td>
</tr>
</tbody>
</table>

#### 19. Video game award show! 🎮

a. Unveil the leaderboard that averages the high scores for each mission/weather condition that the students completed. You can award medals for 1st, 2nd and 3rd place or unveil a top 5 or top 10 final standings.

b. It would be great to have top 5s in a few different categories (implementing the engineering process, creating unique solutions to design challenges, etc.) so that students know they had strengths in some of the engineering areas.

#### 20. The Finals

a. If your class is good-natured and competitive, you may choose to have a final competition led by the top 3 or 4 scorers in the Search and Rescue mission. These students will complete in the AUV Recovery mission. Other students may choose to help them modify their ship designs for success. Students not interested in the Finals competition initially could design the awards (sash, crown, trophy, etc.) given to the winner and runner ups.

b. Note: If you had students working in teams throughout this Club, you could modify Step 8a and have a final competition amongst the teams using the AUV Recovery mission.

#### 21. Please post your award ceremony results to the FLEET Forum ([http://www.navalengineers.org/Membership/Forum](http://www.navalengineers.org/Membership/Forum)) under “FLEET Awards”.

### Additional Resources

A. If you want more celebration ideas, be sure to check the FLEET Forum ([http://www.navalengineers.org/Membership/Forum](http://www.navalengineers.org/Membership/Forum)). During this initial roll out, feel free to use that space to list your ideas as a safe space to try out ideas amongst other educators thinking about the same issues.
**FLEET Quick Start**

**FLEET** is a 100% free STEM video game that engages students in the engineering design process through shipbuilding. Everything is free to download at [www.fleetengineering.org](http://www.fleetengineering.org).

This one-page guide goes quickly summarizes the install process. There are more thorough instructions in the **FLEET User Guide**.

1. Download **FLEET** at [http://www.navalengineers.org/STEM-FLEET/Download-FLEET](http://www.navalengineers.org/STEM-FLEET/Download-FLEET). Choose the correct version for your machine, then click “View Cart”. In the next screen, click “Checkout”. To complete checkout, you will need to create an account at navalengineers.org. (Steps #1-#5)
2. Click “Process Order” to complete the process. You will receive an email with a link to the installer. Click the link and the installer will download. (Steps #6-#8)
3. Open the installer and follow the prompts to install FLEET. (Steps #9-#11)
4. Open **FLEET** then create and validate your new account using the registration code “fleetrocks2018” (Steps #12-#19)
   a. You can create your log-in, password, and organization in these screens.
5. Log into **FLEET** using you newly-created account.
6. If you want to quickly explore the game, choose “Quick Play”. Or, you can start a mission in “Mission Headquarters” (Steps #20-22).
7. You will design your ship in the drydock by adding (+) and removing (-) components. Be sure to explore the menus to find all the components, boats, helicopters, etc. (Steps #23-27)
8. You can save ([*]) three different ships and open them later ([*]). (Steps #28-29)
9. Check the logbook ([*]) occasionally to compare your scores to others (p. 22).

**Table 1. Overview of Steering Controls.**

<table>
<thead>
<tr>
<th>Button</th>
<th>Controls</th>
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<tbody>
<tr>
<td>Up ↑</td>
<td>Increases the speed by moving the throttle up.</td>
</tr>
<tr>
<td>Down ↓</td>
<td>Decreases the speed by moving the throttle down. The ship can go backwards!</td>
</tr>
<tr>
<td>Left ←</td>
<td>Steers the boat to the left, or port, when the ship is going forward.</td>
</tr>
<tr>
<td>Right →</td>
<td>Steers the boat to the right, or starboard, when ship boat is going forward.</td>
</tr>
<tr>
<td>Esc</td>
<td>Pulls up a dialogue box allowing you to exit, restart, or return to the mission.</td>
</tr>
<tr>
<td>Mouse right click</td>
<td>Adjusts the view angle (useful for clicking on boats/helicopters to launch them).</td>
</tr>
<tr>
<td>Mouse left click</td>
<td>Click on boats and helicopters to show the launch button. Click the button (on the left side of the screen) to launch and use boats and helicopters.</td>
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</tbody>
</table>

**Quick Contacts**

- For additional technical support, please email navatekstem@gmail.com.
- For curriculum, grants, and event questions, please email fleet@navalengineers.org.
Appendix 2. Creating Multiple FLEET Accounts

Every FLEET account is tied to an email address, so you will need a unique email address for each account. Most schools we work with have students work in teams, so they create accounts for FLEET like “fleet1@school.org” or “school1@gmail.com”.

You can copy-and-paste the table into an email, and send it to fleet@navalengineers.org or you can send us a scan of the completed form to the same address. We will have your accounts ready in one business day.

<table>
<thead>
<tr>
<th>Team Name for Users</th>
<th>OR</th>
<th>User’s first and last name</th>
<th>Email Address</th>
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Remember you will still need to install a version of FLEET on every computer used. In addition, the educators at least should create accounts to access the FLEET Forum.