Steady!! Steady!!!

<table>
<thead>
<tr>
<th>High School</th>
<th>Standard(s): NGSS.HS-PS2-1; CCSS-ELA SL.4, SL.5, SL.6</th>
<th>Topic: Ballast and the center of mass</th>
<th>Developed by: ASNE With materials from Coast Guard and Washington Post via YouTube</th>
</tr>
</thead>
</table>

**Overview:** Students will explore stability using the engineering process in order to pitch the most stable boat design in a Shark Tank-like class discussion. Students will then use this new knowledge and 360° tour of a ship to gain familiarity with the FLEET video game.

**Sample Lesson Flow:**
- Engineer a stable boat design (15 min), present solutions (10 min), transition to FLEET (5 min), use worksheet to explore FLEET* (15 min)
- Engineer a stable boat design (30 min), present/discuss solutions (30 min), transition to FLEET (5 min), use worksheet to explore FLEET (25 min)

* Students with internet access could explore FLEET independently at home if you want to use this time for more hands-on engineering.

**Prior Student Knowledge Required:**
- None.

**Student Learning Objective:**
- Understand the importance of ballast.
- Gain familiarity using FLEET interface.

**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.
  - If you decide to use tin foil, then students will focus on hull design, rather than stability
  - Glass bottles could also work but shatter.
- Container of water OR a sink that is stopped and filled with enough water to “sink” the “boats.”
- Computers set up with FLEET.
- Paper and pen/pencil for notetaking during engineering process and creating presentation
- Handouts of “USS Detroit and FLEET” or the ability to show the picture on a screen.
- Materials for Shark Tank™-like presentations
  
*Optional, Step #3 Technology to show a YouTube clip.*

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

**Engage**

1. Today’s design challenge is to make a boat that is steady when being moved from side to side. Your students should immediately be thinking about implementing the engineering design process to address today’s problem:
   - **How can we make a ship that does not tip over easily?**
     a. Mention that cost and ability to replicate the design are important traits for engineering solutions.
     b. Students will need investigate the design using the engineering design process from last class.
     c. Then, each group will present data supporting their solution in a “pitch” that describes why their design solution is best.
     d. *(Optional)* If you have a suitable boat in your FLEET account, show the Stability Test that
simulates a wave crossing your boat to test its stability. This simulation will show the real-world applicability of this work.

2. Tell your students they will design a solution, appoint one or more presenters, and outline the presentation.

   You will share your solution to a group of engineers (the 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.

   a. Be clear about the time expectation; you may want each group to appoint a program manager that ensures they finish the project on time.

   b. NOTE: These lessons are full of language designed to help students see themselves as future engineers. This language is intended to build their skills, beliefs, and attitudes toward STEAM.

3. (Optional) If you would like to play a video while your students work, you could show this Coast Guard video which exemplifies some of the forces they will be studying in this lesson:

   ![YouTube video player](https://www.youtube.com/watch?v=jXF-TjOjD5k) (suggest playing on mute)

   a. Note that you are not asking students 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.

4. 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.

5. Initially students will explore obvious features like which side of the container is the bottom and whether to use the lid. The next-level variable will be putting some water in the container so that it still floats, but the waterline moves up the vessel. Filling the container with water may come naturally to students that have played a lot of *FLEET* because they have seen the Ballast Tanks category.

   a. (Optional) If the students are stuck, ask them to take a break (possibly engage in something aerobic to stimulate their minds in a different direction. Bring the class together and discuss what are the best ways to steady a ship that they have discovered. If no one mentions filling the container with some water, then show this clip (or replicate it as a demonstration):

      ![YouTube video player](https://www.youtube.com/watch?v=aR0b4QRhfU0)

   i. This video explores density. The diet Coke can is less dense than water, while the Coke can is more dense than water. Ask: Could either of these designs influence your designs in a way that will make your ship harder to tip over?

Elaborate

6. Have students share their data and final designs. Remind them of the challenge five minutes before you plan to end this group work:

   **Remember you will present your best design as a 1-2-minute-long pitch to our *Shark Tank*™ for engineers. Your pitches should describe why your design is best, the data that shows their design is worthy of investment.**
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.).

b. Display good mathematical data and scientific diagrams permanently on the wall so students can use them as models for future presentations.

Explain
7. Explain to students that groups that put water in the container to stabilize their ship discovered “ballast.” Ballast tanks hold water on the bottoms of ships so that they ride lower in the water which gives them more stability.

   a. If no one, discovered ballast independently take a container and fill partially fill it with water. Compare this data with data the students just presented.

Engage
8. Reorganize students so they are in front of computers with FLEET and distribute the USS Detroit handout.

9. Show students this 360° interactive The Detroit News created this interactive of the USS Detroit (http://content-static.detroitnews.com/projects/uss-detroit/interactive-tour.htm). Explain that the handout will allow them to compare features on the USS Detroit with features available in FLEET.

   a. If you want other models, you could use:

      i. 360° interactive: Google has a 360-degree interactive of the USS Constitution.
      ii. 3D Model: Clara is a site with thousands of 3D models including dozens of boats (https://clara.io/library?query=boat)

10. Tell students they can explore FLEET until there is 5 minutes left. Then, you will ask students to share how many features they have in both lists (they may need more than the 12 blanks listed). 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 in the Practice – Speed option.

FLEET Start-up Directions
11. Students first click the FLEET icon on their desktop:

12. They will log in with the user name and password you provided. (See the last page of this lesson for information copied from

Created by American Society of Naval Engineers through a grant by the Office of Naval Research

Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)
FAQ Section “How do I create multiple accounts for my students?” (for more details on creating student accounts.) If you logged in previously, the Username field will already be populated.

13. While you ensure everyone is logged in, you can also adjust or mute the game play volume.

14. The first screen is the dry dock at Anacapa Island, which your students may have seen in the first lesson.

15. You can refresh students’ memory on the buttons at the top and bottom if necessary using a table like the one below or introduce them to the User Guide. Many students figure out the buttons without aids because FLEET uses the Unity™ platform so the controls match many commonly-played video games.

<table>
<thead>
<tr>
<th>Button</th>
<th>Description</th>
</tr>
</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>

a. Load your ship from the server (usually this happens automatically).

b. Save your ship. Be sure to hit this button before closing out of FLEET.

c. Completely delete your ship and start again. 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.

d. When you meet the mission requirements, hit this button to Practice or go on Missions.

16. Students can hit the “+” button (➕) to see all the possible additions for the boat.

   a. Delete an object: click on it, then hit the red trashcan button (🗑️) that appears. (Students may adjust the view by right clicking on the screen and moving the mouse.)

Evaluate

17. (Optional ⬤) If you have 10 minutes at the end, ask students to choose one of the terms and create a sketch with a definition that describes the purpose of the component. Then, put these drawings on a wall so that students start creating a visual vocabulary wall to consult in future lessons.

Additional Resources

A. As a closing activity, you could show this video: https://www.youtube.com/watch?v=Hx5oefHKZSU 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.

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):

Created by American Society of Naval Engineers through a grant by the Office of Naval Research Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)
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: http://www.engineeringtoolbox.com/centre-gravity-buoyancy-d_1286.html

F. From the FAQ Section on www.fleetengineering.org:

   How do I create multiple accounts for my students?

   Use this form (also on the next page) to list all the accounts you need, and then please email fleet@navalengineers.org. 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”. If this requirement is impossible for you, please email us to discuss your situation.
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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

- Download FLEET: http://www.navalengineers.org/STEM-FLEET/Download-FLEET
- FLEET Forum (FAQs and Technical Support): http://www.navalengineers.org/Membership/Forum/

Created by American Society of Naval Engineers through a grant by the Office of Naval Research Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)