Lesson Overview

In this multiday lesson, students create their apparatus—circuit, spacecraft, and test hardware box. Teams use available materials to build the design they believe best addresses criteria, constraints, and tradeoffs. Students need to justify all design decisions using data science ideas developed on Days 1 through 3. Students also need to justify their purchases and use of time during the design phase.

Connecting to the Next Generation Science Standards

On Days 5 through 7, students demonstrate understanding of the performance expectations and three dimensions developed throughout the entire module. These lessons serve as a performance assessment in which all of the performance expectations and dimensions are addressed in the final presentation. Revisit the performance expectations, disciplinary core ideas, science and engineering practices, and crosscutting concepts referenced in this module’s front matter. In addition, students dive more deeply into the engineering design performance expectations, which are interwoven throughout the module.

Basic Teacher Preparation

In these three important lessons, students begin to build the three components for the design challenge. If possible, build a design solution prior to Days 5 through 7 to gain first-hand experience constructing the testing apparatus and capsule.

Refer to the Soft Landing Student Handbook ahead of time so you can address any questions students might have. All documents for this lesson can be found on pages 2–7, 17, and 18 in the Soft Landing Student Handbook. The documents used in this lesson are:

- Student Reflections and New Questions (pages 2 and 3)
- Soft Landing Design Problem (pages 4–6)
- KLEWS Chart (page 7)
- Student Time Tracker (page 17)
- Expense Report Form (page 18)

The Suggested Teacher Resources at the end of Day 7 contains information to help teachers convey key concepts and instructions to students as they build the various components. Read through all of this information ahead of time. Additionally, review and print student handouts before class time.
### Required Preparation

- Gather or purchase the required materials for the lesson

  Refer to the [Materials List](#) that follows

- Review suggested teacher preparation resources

  Refer to the [Suggested Teacher Resources](#) at the end of Day 7

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### Materials List

All materials listed for Day 4 should also be available on Days 5 through 7.
Lesson 5: Work It!

Introduction (5 minutes)

Refer students to the growing KLEWS Chart they have been updating for the past four lessons, and give them some time to review the information in addition to the design challenge.

Class discussion questions:

- What information from your KLEWS Chart will you use today as you design your apparatus?
- What information might you still need?

Design Work: Build Time (40 minutes)

During the next three sessions, students create their apparatus—the circuit, spacecraft, and test hardware box. Students use their blueprints to guide them while they build.

Show students the materials available to select from and work with. Refer students to the Student Time Tracker and the Expense Report Form (pages 17 and 18 in the Soft Landing Student Handbook), and explain that each team must keep track of time, tasks, and materials being used. Further, students must justify their time and purchases.

Any revisions to the design should be clearly documented on the blueprint and justified using science ideas and data developed during Days 1 through 3 or during prototype testing. Be sure that when students mark revisions, they do not erase original design decisions. If desired, instruct students to use a different color pencil or create a second set of blueprints to help keep track of versions.

Monitor the materials station closely. When students “purchase” (select) materials, they must bring their Expense Report Form with sufficient justifications for purchases. This form must be signed by the teacher each time a material is “purchased.” Walk around and monitor students while they work, ask probing questions, and provide support as needed.

NGSS Key Moment

The design and build phase of this unit helps students deepen their understanding of both the Physical Science and the Engineering Design Performance Expectations.

Helpful Tips

- To ensure students are on task, project a digital clock onto the board to help keep students aware of the time constraints.
- Make sure students understand that everyone needs to work together for this project to work.
- Make sure students know the materials they should have, need to share, and need to purchase.
Student Reflection (5 minutes)

Refer students to the growing KLEWS Chart, and ask them to add to any of the columns. Allow time for students to share “shout outs” for work done by team members.

Have students write a reflection in their science notebooks or on Day 5 of the Student Reflections and New Questions Table (page 2 in the Soft Landing Student Handbook). Possible questions to address include:

- What was challenging about today?
- What are you going to do tonight to ensure that your team is on track to be done by Day 7?

Homework

Have students continue to modify their blueprints. Students bring this information back to the next class session to help guide them during the next stage in the Soft Landing Unit.
Lesson 6: Work It!

Introduction (5 minutes)

Refer students to the growing **KLEWS Chart** they have been updating and give them some time to review the information in addition to the design challenge.

Class discussion questions:
- What information from your **KLEWS Chart** will you use today as you design your apparatus?
- What information might you still need?

Design Work: Build Time (40 minutes)

For Day 6, repeat the activity sequence from Day 5. Continue to remind students to justify their use of time and purchasing decisions.

Remind students that any revisions to the design should be clearly documented on the blueprint and justified using science ideas and data developed during Days 1 through 3 or during prototype testing. Be sure that when students mark revisions, they do not erase original design decisions.

Once students have settled on a final design for the drop tower and capsule, students should create a final draft blueprint. The final blueprint should accurately represent the build and should include justifications for all design decisions. Justifications should be based in science ideas and data collected throughout the module, and they should include an explanation of the physical laws at play. Final blueprints should be created on large chart paper.

Student Reflection (5 minutes)

Refer students to the growing **KLEWS Chart**, and ask them to add to any of the columns. Allow time for students to share “shout outs” for work done by team members.

Have students write a reflection in their science notebooks or on Day 6 of the **Student Reflections and New Questions Table** (page 3 in the **Soft Landing Student Handbook**). Possible questions to address include:
- What was challenging about today?
- What are you going to do tonight to ensure that your team is on track to be done by Day 7?

Homework

Have students continue to modify their blueprints. Students bring this information to the next class session to help guide them during the next stage in the Soft Landing Unit.
Design Work: Repeat Lessons 5 and 6 (40 minutes)

For Day 7, repeat the activity sequence from Lesson 6.

Lesson Close (10 minutes)

Ask students, *What do engineers learn from failure?* Have students record their ideas and share their answers.

During the lesson’s close, be sure to touch on the following ideas with students:

- Engineering teams rarely stick to their original designs completely. This is good, because a lot can be learned from ideas that do not work as expected during implementation or building.
- Sometimes, the original design needs to be updated because they work differently than expected, customer requirements have changed, or some other external force occurs (such as, you cannot get a specific part or material used in the design).

Knowing what they know now, ask students to think about what they would do differently if they had to start the design process over again. Some questions to ask:

- *Would you change your budget?*
- *Would you make your design simpler?*
- *Would you think more about how the different parts would join together?*

Tell students that there is an old saying that you should build something once to see how to build it, and then throw it away and build it again. This method is not practical, but it does point out the value of having an engineer or engineering team that is familiar with the kind of problem they need to solve.

Some students in class might have tried to build a design that was not possible to achieve. Point out that during projects, engineers often spend a lot of time figuring out why something doesn’t work, because that information can be very valuable when they try again later. In fact, some engineers are *failure analysts* who specialize in figuring out why things fail.

Assessment

Several opportunities for formative assessment exist in this lesson:

- Use the KLEWS Chart to gather data to determine student progress.
• Use the **Student Time Tracker** logs to monitor student progress and justifications for time spent.
• Use the **Expense Report** to monitor student justifications for purchases.
• When students purchase materials at the store, students should continue to justify purchases. Use student responses to gage understanding of core ideas.
• Blueprint revisions, specifically justifications and revisions to justifications for design decisions, can be used to monitor progress on all identified disciplinary core ideas, science and engineering practices, and crosscutting concepts. Blueprint justifications should be used as a primary source of student progress in this module.

Use the identified assessment opportunities to monitor student progress on disciplinary core ideas, science and engineering practices, and crosscutting concepts. Provide appropriate supports or extensions when necessary. Reference **Appendix B** for suggestions for meeting the needs of all learners.

### Community Connections

If any practicing engineers are willing to be guests or volunteers in the classroom during the build phase, their expertise and assistance can be invaluable. Furthermore, any assistance from the community in this phase would decrease the load on the teacher and allow more time for discovery and instruction.

### Suggested Teacher Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KLEWS Chart</td>
<td>Ongoing from earlier lessons</td>
</tr>
<tr>
<td>Meeting the Needs of All Learners</td>
<td>Soft Landing Teacher Handbook, Appendix B</td>
</tr>
<tr>
<td>Engineering Failures website</td>
<td>[Web Link]</td>
</tr>
<tr>
<td>Browns Ferry Nuclear Power Plant article</td>
<td>[Web Link]</td>
</tr>
</tbody>
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### Background Information: Required Materials for This Module

Students can build the three components for this design challenge in many ways. As a result, the actual materials you select and use will vary accordingly. The following list contains some specific suggestions for building the apparatus as well as links to additional resources. Keep in mind that these are just a few possible options.

- **Inexpensive 2-gang electrical box**—Available at local hardware stores [Web Link]
  This box has two nails in it. The nails can be removed and used for the homemade electromagnets.
- **Inexpensive single switches**—Available at local hardware stores [Web Link]
  (2 recommended)
This box has two nails in it. The nails can be removed and used for the homemade electromagnets. Consider purchasing one white and one ivory switch (or other alternate color) so students can easily tell which switch is which (although this is not overly important). To ensure safety, have the switches in parallel so that both have to be off to drop the egg.

- **Wire**—Available at local hardware stores [Web Link] (stranded speaker wire recommended)
  Many wire options are available. One possibility is to use zip cord and split it. Old damaged extension cords can also be raided for wire (but this wire is bigger than necessary). You could also use 18- or 24-gauge wire. Regardless, stranded wire (such as the speaker wire identified above) is recommended because solid wire tends to break.

- **Wire nuts**—Available at local hardware stores [Web Link] (stranded speaker wire recommended)
  Wire nuts are used to connect wires. Many options are available. Choose an inexpensive option that fits the selected wire.

- **Battery**—Available at local stores [Web Link]
  Use a 6V lantern battery. The brand does not matter. Alkaline batteries last longer, but regular batteries are cheaper and will last long enough for this module. Alkaline batteries are available at local stores for about $5.00 and are usually located by the flashlights.

- **Electromagnet**—Available online [Web Link]
  If time allows, build the electromagnet. You can use the nails you removed from the electrical boxes and some magnet wire. Magnet wire is hard to strip, but any small (thin) wire will work. Ensure the wire is thin because it needs to be wrapped around the nail.

  You also need a razor and possibly a flame. To do a neat job, get some ¼-inch (or larger) steel nuts and bolts at the local hardware store and matching washers.

  ![Electromagnet example](http://www.purpletrail.com/partytrail/types-of-magnets/)

  **Source:** Purple Trail: Types of Magnets: [http://www.purpletrail.com/partytrail/types-of-magnets/](http://www.purpletrail.com/partytrail/types-of-magnets/)
Nails and salvaged wire can be used effectively, as well. Local electronic stores sometimes have sets of inexpensive magnet wire. Another option is to call someone who rewires motors or electronics; tell them you are a teacher, and ask for scraps.

Several websites contain information about making your own electromagnets.

- Tin can lids
  Use one as an attach plate for the spaceship and another for the electromagnet, or connect the attach plate directly to the electromagnet.

- Drop box
  Use the largest box available. If possible, support the box on two chairs or other fixture to give the box some height. Use box cutters, scissors, and markers to decorate the box. Students might also want to use duct tape to attach the electronics and make the box stronger.

- Capsule
  Many different materials can be used for the capsule. Ensure students have many opportunities to improvise. The simplest capsule would require a tin can lid and an egg in a plastic zip baggie. Hot glue or duct tape the lids to the inside of the Ziploc. Students can also pack the egg in the bag with extra shock-absorbent materials. A capsule could also be made out of an empty tissue box.

- Other items needed
  - Roll of electrical tape
  - Scissors for tape
  - Wire cutters
  - Wire strippers or razor or knife. Wire cutters can also be used for stripping. Place a finger inside the handle of the wire cutters to keep them from closing fully, create a
small gap in the cutter jaws, and pull the wire through it. Some wire cutters also have a wire stripper feature.

- If you use magnet wire, a razor or hobby knife and maybe some emery cloth is needed for stripping as the wire is hard to strip. A flame also works.