Lesson 15: How can we use physics and engineering ideas to make decisions that will make driving safer for everyone?

Previous Lesson *We identified driving-related problems we care about, then considered the scope of these problems and related physics models to narrow down to a single problem per group. We considered cause and effect to prioritize criteria, then got peer feedback on how to model this system. We then identified reasonable approximations and developed our proposal in a format we chose.*

This Lesson

Putting Pieces Together

1 day

James Vaughan, CC BY-NC-SA 2.0

We take an end-of-unit assessment. We revisit the DQB and determine what questions we can now answer. We reflect on and document the most important things learned in our unit.

Next Lesson *There is no next lesson.*

BUILDING TOWARD NGSS | **What students will do**

HS-ETS1-3, HS-PS2-2, HS-PS2-3, HS-PS2-1

15.A Apply scientific ideas, principles, and evidence that we developed over the course of the unit related to changes in the motion of macroscopic objects to answer questions on our DQB about how the safety features we had questions about may have been designed to mitigate risk. (SEP: 6.3; CCC: 2.3; DCI: PS2.A.1, PS2.A.2)

Transfer Task PE: HS-PS2-3 Apply scientific and engineering ideas to ~~design,~~ evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. (SEP: 6.3; CCC: 2.3; DCI: PS2.A.3, ETS1.C.1, ETS1.A.1)

What students will figure out

- We can use our science and engineering ideas to evaluate the merits of two solutions and make recommendations for improvements.
- We can use our science and engineering ideas to answer unanswered questions on our Driving Question Board.

Lesson 15 • Learning Plan Snapshot

Part	Duration		Summary	Slide	Materials
1	10 min		**WATCH DESIGN VIDEOS** Provide a student content advisory. Watch https://youtu.be/LlyEIaRw010?feature=shared and https://www.youtube.com/watch?v=hw5v0M3q8G8&list=PLSLDxqPb5NQmc9aOPrh0SjG_BRiZsVdWA&index=10 together as a class and share noticings and wonderings.	A-E	*Pedestrian Solutions*, *Safety Scoop Transcript* (optional), *Pedestrian Catcher Transcript* (optional), https://youtu.be/LlyEIaRw010?feature=shared, https://www.youtube.com/watch?v=hw5v0M3q8G8&list=PLSLDxqPb5NQmc9aOPrh0SjG_BRiZsVdWA&index=10
2	25 min		**COMPLETE ASSESSMENT** Complete *Pedestrian Solutions* individually.	F	*Pedestrian Solutions*, *Safety Scoop Transcript* (optional), *Pedestrian Catcher Transcript* (optional)
3	8 min		**REVISIT DRIVING QUESTION BOARD** Revisit the Driving Question Board to determine what questions can now be answered.	G	pencil, copy paper (optional), Driving Question Board
4	2 min		**MINDFULNESS AND REFLECTION** Engage in mindfulness and share take-aways from the unit. Celebrate the completion of the unit!	H	*Student Mindfulness Resource*

End of day 1

Lesson 15 • Materials List

	per student	per group	per class
Lesson materials	• *Pedestrian Solutions* • *Safety Scoop Transcript* (optional) • *Pedestrian Catcher Transcript* (optional) • pencil • copy paper (optional) • *Student Mindfulness Resource*		• https://youtu.be/LlyEIaRw010?feature=shared • https://www.youtube.com/watch?v=hw5v0M3q8G8&list=PLSLDxqPb5NQmc9aOPrh0SjG_BRiZsVdWA&index=10 • Driving Question Board

Materials preparation (15 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Test videos
Test the following videos to be used for the assessment:

- https://youtu.be/LlyEIaRw010?feature=shared
- https://www.youtube.com/watch?v=hw5v0M3q8G8&list=PLSLDxqPb5NQmc9aOPrh0SjG_BRiZsVdWA&index=10

Lesson 15 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students will engage in a transfer task specifically designed to address the following performance expectation:

HS-PS2-3 Apply science and engineering ideas to ~~design,~~ evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [Clarification Statement: Examples of evaluation and refinement could include determining the success of a device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]

This transfer task was designed to give students a chance to evaluate design solutions using the tools they have been applying over the past several lessons. Over the last several lessons, students have gradually gained independence with the evaluation of arguments and designs with the use of the argumentation tool.

The assessment is also directly related to the following connections to Engineering, Technology, and Applications of Science:
Influence of Science, Engineering, and Technology on Society and the Natural World: New technologies can have deep impacts on society and the environment, including some that were not anticipated. ~~Analysis of costs and benefits is a critical aspect of decisions about technology.~~ (HS-ETS-1-3)

While students consider the effects of each design on society and environment, along with possible unintended consequences, they do not directly consider cost as a constraint. This aspect of the Nature of Science is more directly addressed in *OpenSciEd Unit P.1: How can we design more reliable systems to meet our communities' energy needs? (Electricity Unit)*.

This lesson is designed to specifically assess the following disciplinary core ideas:

- **PS2.A.3: Forces and Motion** If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-3)
- **PS2.A.2**: **Forces and Motion** Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)
- **ETS1.C.1: Optimizing the Design Solution** ~~Criteria may need to be broken down into simpler ones that can be approached systematically~~, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (HS-PS2-3)
- **ETS1.A.1: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, ~~and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them~~. (secondary to HS-PS2-3)
- **PS2.A.1: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)

This unit is not covering the first half of ETS1.C, as this occurs in *Electricity Unit*. The quantification of criteria and constraints in the second half of ETS1.A.1 also occurs in *Electricity Unit*.

In addition to this, students will revisit the Driving Question Board, specifically those questions about safety features.

Where We Are NOT Going

In the transfer task, students will not be designing a new device to minimize force on a person in a collision. Instead, they will be qualitatively evaluating two devices to determine which device has the most merit and how that device can be refined to minimize force on both the person and the vehicle.

At the end of this lesson, not all questions from the Driving Question Board may be answered. This is OK. Appendix G of the NGSS makes this clear:

- Not all questions can be answered by science.
- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.

Highlight these ideas at the end of class to reassure students if not all the questions were answered. Remind students that some questions may be out of the scope of answering in the context of the classroom, or they may be too complex to be answered using science ideas alone. Other questions may need more information to be answered–that could be gained in future units–or be out of the scope of our high school grade band. See the end of this *Teacher Guide* for suggestions on what to do with these questions that can be answered within the scope of the classroom.

LEARNING PLAN for LESSON 15

1 · WATCH DESIGN VIDEOS

10 min

MATERIALS: *Pedestrian Solutions*, *Safety Scoop Transcript* (optional), *Pedestrian Catcher Transcript* (optional), https://youtu.be/LlyEIaRw010?feature=shared, https://www.youtube.com/watch?v=hw5v0M3q8G8&list=PLSLDxqPb5NQmc9aOPrh0SjG_BRiZsVdWA&index=10

Share the **"Student Content Advisory" information.** Present **slide A**. Explain that we will be taking an assessment about solutions designed to keep pedestrians safe and that we will watch videos of these designs in action. Nobody will be injured in the videos. Remind students about *Student Mindfulness Resource* as a resource and ask them to raise their hand quietly if they need anything during the assessment.

Introduce the two design solutions. Display **slide B**. Explain that first students will get an opportunity to watch each design as a class, and after each video students will be given a moment to record noticings and wonderings and then to discuss briefly with the class.

Watch a video of the first design. Display **slide C**. Explain that the first design is called the Safety Scoop. Others also call this design the Car Catcher. If students would benefit from a transcript, distribute *Safety Scoop Transcript* now. Play https://youtu.be/LlyEIaRw010?feature=shared. Remind students to record in their notebook any notes they have about the Safety Scoop design.

Watch a video of the second design. Display **slide D**. Explain that the second design is called the Pedestrian Catcher and the class will watch only the part of the video that shows off this device. Distribute *Pedestrian Catcher Transcript* to students who would benefit. Play https://www.youtube.com/watch?v=hw5v0M3q8G8&list=PLSLDxqPb5NQmc9aOPrh0SjG_BRiZsVdWA&index=10, beginning at 1:19 and ending at 1:57. ✱

Project **slide E**. Ask students to briefly share their noticings and wonderings. This is an opportunity for students to feel more confident about what was in the video by listening to the things their peers saw and were curious about.

✱ ATTENDING TO EQUITY

Universal Design for Learning: This task was designed to offer multiple *representations* of the designs to students. Information is available about each of the designs in narrated video form with a transcript and also as a reading for each design embedded in the assessment. This provides learners the ability to access information through both auditory and visual representations. In addition, consider using a text reader and pushing out the texts digitally in an editable form to increase access for students.

2 · COMPLETE ASSESSMENT

25 min

MATERIALS: *Pedestrian Solutions*, *Safety Scoop Transcript* (optional), *Pedestrian Catcher Transcript* (optional)

Complete the assessment. Project **slide F** and distribute the assessment. Provide students with time to complete *Pedestrian Solutions*. If students ask to see the videos again, reshow the videos but play them on silent so as to not disturb other students.

ASSESSMENT OPPORTUNITY

What to look/listen for in the moment, and what to do: See [PM.L15.KEY]

This assessment is not building toward a lesson-level performance expectation. It is designed to assess a performance expectation from the NGSS, shown below.

Transfer Task PE: HS-PS2-3 Apply scientific and engineering ideas to ~~design,~~ evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. (SEP: 6.3; CCC: 2.3; DCI: PS2.A.3, ETS1.C.1, ETS1.A.1)

3 · REVISIT DRIVING QUESTION BOARD

8 min

MATERIALS: pencil, copy paper (optional), Driving Question Board

Revisit the DQB. Project **slide G**. Gather students around the Driving Question Board and point out the unanswered questions. Have a conversation with students about which of those we can now answer. As students pick specific questions, ask them what the answer is to the question. Ask a student volunteer to record the answer. They can do this in pencil on the question they have chosen, by taping the sticky to a separate piece of copy paper, or on a class document in a virtual space. Continue this process until all the answerable questions have been addressed.

Most of the questions about basic collision mechanics should have been answered earlier in the unit. At this point of the unit, specifically focus on the questions regarding safety features. Ask students to consider the person and the safety feature and their interactions and how these questions relate to risk mitigation and the requirements set by society.

ASSESSMENT OPPORTUNITY

What to look/listen for in the moment

- Look for students to apply science ideas from the unit related to momentum, forces, and Newton's second law. (SEP: 6.3; DCI: PS2.A.1, PS2.A.2)
- Look for students to explain the purpose of design features such as seat belts and airbags using those science ideas. (SEP: 6.3; CCC: 2.3)

What to do: If students are in disagreement about an answer, ask questions to seek clarification or more information. *Can you tell me more? In what investigation did we figure out that piece of information? Can anyone point to evidence to support ___'s answer? How does this fit in with any societal requirements we have? What does this system do to mitigate risk? What other criteria or constraints do we need to consider with this idea or solution?*

Building toward: 15.A Apply scientific ideas, principles, and evidence that we developed over the course of the unit related to changes in the motion of macroscopic objects to answer questions on our DQB about how the safety features we had questions about may have been designed to mitigate risk. (SEP: 6.3; CCC: 2.3; DCI: PS2.A.1, PS2.A.2)

Determine a strategy for unanswered questions. If there are any questions that are unanswered, consider moving these to a different part of the room to revisit at the end of future units. Some questions that are not answerable now (such as questions about hydrogen cars or efficiency) may be answerable with science ideas from future units. Also consider allowing students to do independent research in order to answer any of these questions and ask students to share their answers in the next class meeting. Remind students that

- not all questions can be answered by science.
- science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.

4 · MINDFULNESS AND REFLECTION

2 min

MATERIALS: *Student Mindfulness Resource*

Engage in mindfulness. Project **slide H**. Ask students to consider the prompt at the top of **slide H** on their own: *How has learning about the physics of vehicle collisions affected the way you feel when you think about vehicle safety?* Remind students that this is a time to check in with themselves and try applying one of the strategies from *Student Mindfulness Resource* and that you are available if they need someone to connect them to additional resources.

Then pose the second prompt: *Has something you learned about during this unit changed the way you will make decisions as a driver, a passenger, a community member, or a pedestrian? If so, how?* If there is time, give students a moment to talk about this prompt in a small group and then share with the whole class.

Celebrate how far we have come. Congratulate students on completing the unit and point to the DQB to show how many questions we have answered together.