Lesson 3: How does speed affect whether you will avoid a collision?

Previous Lesson *We analyzed videos of two drivers encountering a sudden obstacle: one who is undistracted and one who is distracted.*

This Lesson

Investigation

2 days

Photo courtesy of photos-public-domain.com

We use mathematical models to generate data about how speed affects reaction distance based on average reaction times for distracted versus undistracted drivers. We use what we have figured out from video data and mathematical modeling to identify design features that can decrease reaction distances to prevent collisions in the event of a sudden obstacle. The speed we are going definitely makes a difference in whether we are going to hit the obstacle. But by braking in time, we can bring that speed down quite a bit. We are wondering how speed at the moment of a collision affects the outcome of the collision, assuming that it cannot be avoided.

Next Lesson *We will use a speed versus time graph to predict how the initial speed, braking force, and mass of a moving vehicle affect stopping time. We will collect data to test our predictions and graph it in CODAP. We will use curve fits to identify patterns indicating a mathematical relationship. To further test this relationship, we will use a simulation to gather additional data.*

BUILDING TOWARD NGSS

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

What students will do

3.A Use a mathematical model (distance = speed * time) to generate data about how speed affects reaction distance based on average reaction times for distracted versus undistracted drivers. (SEP: 5.2; CCC: 3.5; DCI: ETS1.A.2)

3.B Use student-generated evidence from video data and mathematical modeling to make a claim about the problem of distracted driving. Identify design solutions that could have the effect of decreasing reaction distances to prevent a collision in the event of a sudden obstacle, and identify a range of constraints associated with each solution. (SEP: 6.5; CCC: 2.3; DCI: ETS1.A.2, ETS1.B.1)

What students will figure out

- We can plot the speed at which a vehicle travels over time to learn more about how it is moving, including how its speed is changing.

- If you are going faster before the collision, your reaction time will not change but your reaction distance will, because distance = speed * time.
- There are engineering solutions that can affect reaction distance, such as speed limits and phones that turn off notifications while driving.

Lesson 3 • Learning Plan Snapshot

Part	Duration		Summary	Slide	Materials
1	5 min		**NAVIGATE BY LOOKING BACK AT EXIT TICKETS** Use the exit tickets to motivate a look at speed.	A-B	exit ticket from Lesson 2
2	15 min		**GRAPH SPEED VERSUS TIME** Elicit help from students to draw a graph of speed versus time for both drivers. Students make predictions about how a higher speed would affect the graphs we made.	C	science notebook with "Position vs Time" graph from Lesson 2, colored pencils (assorted), chart paper, chart paper markers (three colors)
3	15 min		**INVESTIGATING SPEED VERSUS REACTION DISTANCE** Use the *Calculating Reaction Distances* handout to investigate the impact of speed on reaction distance and reaction time.	D	*Calculating Reaction Distances*, colored pencils (optional), 12" ruler
4	10 min		**DEBRIEF AND ASSIGN THE SPEED LIMITS HOME LEARNING** Debrief the investigation and consider speed limits as a design solution. Assign home learning.	E-G	*Calculating Reaction Distances*, *Speed Home Learning*
					End of day 1
5	10 min		**NAVIGATION AND RETURN TO HOME LEARNING** Debrief the home learning and navigate back to speed limits as an engineering design solution.	H	*Speed Home Learning*, *Calculating Reaction Distances*
6	10 min		**INTRODUCE THE ENGINEERING PROGRESS TRACKER** Introduce the *Engineering Progress Tracker* and fill in just the first row.	I	*Engineering Progress Tracker*
7	20 min		**ENGINEERING FASTER REACTION TIMES** Read about several design solutions individually and add them to the *Engineering Progress Tracker* in partners.	J	*Engineering Progress Tracker*, *Engineering Faster Reaction Times*
8	5 min		**NAVIGATE AND ASSIGN THE EXIT TICKET** Navigate by posing a question about braking as an exit ticket.	K	
					End of day 2

Lesson 3 • Materials List

	per student	per group	per class
Lesson materials	• science notebook • science notebook with “Position vs Time” graph from Lesson 2 • colored pencils (assorted) • *Calculating Reaction Distances* • colored pencils (optional) • *Speed Home Learning* • *Engineering Progress Tracker* • *Engineering Faster Reaction Times*	• 12” ruler	• exit ticket from Lesson 2 • chart paper • chart paper markers (three colors)

Materials preparation (45 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.

Make copies of the handouts for this lesson:

- *Engineering Progress Tracker* (1 per student)
- *Calculating Reaction Distances* (1 per student)
- *Speed Home Learning* (1 per student)
- *Engineering Faster Reaction Times* (1 per student)

Three-hole-punch all images and handouts so they can be added to students’ science notebooks.

In this lesson students use their *Engineering Progress Tracker* for the first time. Make sure they have a section in their notebook ready to put this handout where they can return to it over the course of the unit.

Lesson 3 • Where We Are Going and NOT Going

Where We Are Going

Lessons 2 and 3 of this unit are the only lessons in the course that will focus on kinematics. This lesson focuses on some of the basic kinematic conventions and high school-level computational thinking that students will need in future lessons in order to figure out how force, momentum, and time are related. Students will consider how the speed of a vehicle affects the possibility of getting into a collision. In Lessons 4-7, they will begin to apply their ideas about speed, distance, and time to think about the forces in a collision. Kinematics are not emphasized in the NGSS, which is why much of the physics ideas in this lesson are not well aligned to high school physical science disciplinary core ideas (DCIs). Instead, the major standards-aligned ideas in this lesson are concerned with engineering and identifying a major challenge with ramifications in communities, an important element of the DCI ETS1.A.

This lesson builds on Lesson 2 to coherently build ideas related to the following DCIs:

- **ETS1.A.2 Defining and Delimiting Engineering Problems:** Humanity faces major global challenges today, ~~such as the need for supplies of clean water and food or for energy sources that minimize pollution,~~ which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)
- **ETS1.B.1 Developing Possible Solutions:** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)

In Lesson 2, students identified a major challenge--that distracted driving is dangerous. In this lesson, they learn about a set of design solutions aimed at preventing distracted driving and consider the constraints that society sets on these solutions. The *Engineering Progress Tracker* provides a tool to evaluate trade-offs related to these constraints. Students will consider, using algebraic techniques, how the speed of a vehicle affects the possibility of getting into a collision. They quantify criteria and constraints in the OpenSciEd High School Chemistry course and 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 coherently build ideas related to the following crosscutting concept (CCC):

- **Scale, Proportion, and Quantity:** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

and following science and engineering practices (SEP):

- **Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

In this lesson, students are engaging with simple algebraic relationships (distance = speed * time) and speed versus time graphs to explain reaction distance. In the next couple lessons, the relationships become more complex. In Lesson 4, use speed versus time graphs to predict how variables will affect braking time. Then they develop $F = (m * \Delta speed)/\Delta t$ within the braking lab to make sense of how stopping time is affected by changing other variables by using curve fitting. In lesson 5, the equation is simplified to $F = m * a$, and students are asked to use these algebraic relationships in the Electronic Exit Ticket assessment. In lesson 6, students use multiple types of mathematical representations to make sense of momentum conservation, which is then assessed within the transfer task in Lesson 7. Graphs continue to be an important analysis tool throughout the unit, although not always tied to specific assessment moments. During this lesson, pay special attention to how students are using mathematical representations, especially graphs and equations, as well as how comfortable they are with algebra. Students may or may not have strong prior knowledge on concepts such as slope, scales, and solving for an unknown. Consider consulting with your students' math teacher to better understand what skills students have covered in math classes and what common vocabulary may help students transfer skills between courses.

Students will co-develop a definition for the following vocabulary: *reaction distance.* Be prepared for them to add this phrase to their Personal Glossary. Students may also want to add some new terms they learned from the reading, including *collision avoidance system.* **Do not** ask students to define or keep track of any words until after your class has developed a shared understanding of their meaning.

Where We Are NOT Going

Students will not consider the forces in a collision in this lesson and will be thinking only about time, distance, and speed. They will not be using vectors in this lesson and will be thinking about speed rather than velocity until Lesson 4. In this lesson, students "invent" speed versus time graphs in order to understand how initial speed can affect the possibility of a collision. Avoid presenting these graphs in a decontextualized way or as "something we use in physics." Instead, use student questions to motivate looking at how speed changes over time before a possible vehicle collision, so it becomes clear why these representations are useful.

LEARNING PLAN for LESSON 3

1 · NAVIGATE BY LOOKING BACK AT EXIT TICKETS

5 min

MATERIALS: science notebook, exit ticket from Lesson 2

Use the exit tickets to motivate a look at speed. Say, *Many of you mentioned in your exit tickets that we need to know how fast they were going because this will affect how quickly a driver can slow down.* Alternatively, before class you can choose a student who talked about speed in their exit ticket and ask them to share their response during class.

Then ask, *Who else thinks that the speed that the driver is going before the obstacle appears will make a difference?* Ask for a show of hands.

Present **slide A**. Use the prompt on the slide to get students thinking about how speed will affect both distance and time as shown in the table below.

Suggested prompt	Sample student response
How would the speed that the driver is going affect the position of the car, and time it takes to stop?	We think it will take longer (time) to slow down if they are going faster. This should also tell us how far they will travel in the time it takes them to slow down (distance).

Motivate a speed versus time plot. Present **slide B**. Say, *Let's take a closer look at the speed of the car in the videos we watched last lesson. How did we calculate the speed of the car? Look back in your notebook to remind yourself.*

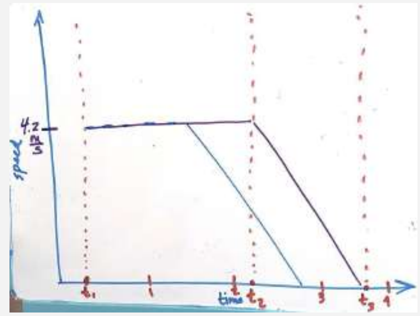
Give students a moment, then say, *We calculated this speed using the slope of the position graph.* Use your hands to mime the shape of the graph to remind them of what you mean by slope. Ask, *What could we do to keep track of how this speed changes over time?*

Listen for students to suggest a plot. If they do, ask, *What could a plot of speed over time tell us about distracted driving?* Accept all ideas. If they do not suggest a plot, say, *Could we do the same thing we did for position, but with speed? What could that tell us?*

2 · GRAPH SPEED VERSUS TIME

15 min

MATERIALS: science notebook with "Position vs Time" graph from Lesson 2, colored pencils (assorted), chart paper, chart paper markers (three colors)



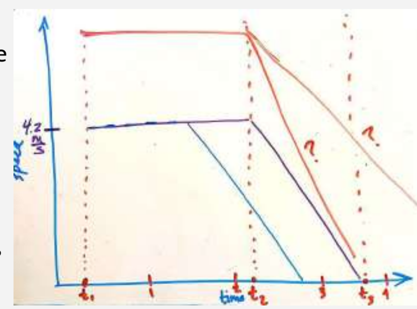
Draw a graph of speed versus time. Present **slide C**. Have a fresh piece of chart paper ready for graphing at the front of the room. Title it “Speed vs. Time.” First sketch the axes (time on the x-axis, and speed on the y-axis). Have students look back at the “Position vs Time” graphs in their notebooks for both drivers. Then ask volunteers to come up and mark the important time points from the video of the undistracted driver (clip #1) on the x-axis, and draw dotted lines up from these points. Label them *t1, t2,* etc, as in the “Position vs. Time” graphs from lesson 2.

Then have students work in small groups to sketch a speed versus time graph in their notebooks, labeling them “Speed versus Time”. Give groups 10 minutes to sketch their ideas.

Bring the class back together and ask, *What speed was the car going between t1 and t2? Did this speed change?* Have a volunteer come up to the “Speed vs. Time” chart and show what their group drew by drawing the line. Students should use the speeds that they recorded in their notebooks in Lesson 2 to show that the car was going between 3-4 m/s before hitting the brakes.

Ask, *What speed was the car going between t2 and t3?* Listen for ideas about how the speed was changing. Say, *We have some ideas about how the speed was changing, but we all agree that it was going this speed at t2 when the brake lights went on* (point to where the drawn line intersects with the t2 dashed line) *and had changed to zero by the time we get to t3, which was when the car stopped.* Have another volunteer come up and draw a line to connect these points. If students are thinking that the speed might change in a variable way (and they draw something nonlinear), ask them to voice their reasoning but do not shut them down. You can use multiple colors to illustrate different ideas.

Repeat for the distracted driver. Ask, *What about our distracted driver?* Repeat this process for the distracted driver in another color. Give students time to make changes to the graph they made in their notebook if necessary using another color of pencil.



Say, *So let’s see what this can tell us about how speed matters. What would happen if this initial speed had been higher? Would the reaction time change?* Sketch a straight, horizontal line above the first line between t1 and t2.

Accept all ideas here, but make sure to highlight that we aren’t sure. Some students may say that no, the reaction time would not change. Some may suggest that the field of vision changes when you are speeding, or another mechanism by which a higher initial speed might affect reaction time. Say, *It sounds like we aren’t sure about this, but we can’t think of anything that would affect reaction time in a big way, so I think we can assume the same reaction times, even if the driver is speeding.*

Ask, *So what would this line look like assuming the reaction time is not affected by initial speed?* Point at the space to the right of the line you just drew.

Listen for students to say that either the car would take way longer to stop if we mimic the braking line from before, or they would have to slow down way faster (a much steeper line between t2 and t3) for both distracted and undistracted drivers. Accept all ideas right now. Then ask, *Does it matter if the driver is distracted?* Again, accept all ideas.

Sketch predictions. Give students a minute to sketch their predictions and a minute to share their ideas with their group or a partner. Then ask for a volunteer to share out. Ask the class if they drew something similar or different and elicit a couple of ideas. Once there is some consensus, sketch these predictions on the “Speed vs. Time” chart in another color. Add question marks to show that we aren’t sure. Make sure that students have labeled their graphs “Speed vs Time Graphs” so that they can find them again for Lesson 4.

3 · INVESTIGATING SPEED VERSUS REACTION DISTANCE

15 min

MATERIALS: *Calculating Reaction Distances*, colored pencils (optional), 12” ruler

Investigate speed versus reaction distance in pairs. Present **slide D**. Say, *We had some ideas about how our initial speed, meaning the speed we are going before an obstacle appears, might affect our probability of collision. Let’s investigate this further and find out exactly how much of a difference initial speed makes.* Distribute *Calculating Reaction Distances*. If they are not already in groups, break students into pairs or groups of three to complete the handout. They may want to use multiple colors as suggested in the handout.

ADDITIONAL GUIDANCE Take a moment to review the term *reaction distance* and reiterate why we care. Remind students that reaction distance is the part of the overall distance it takes to stop that is due to how quickly we react. So by reducing reaction distance, we are reducing the overall stopping distance. Remind them that the other part of stopping distance is the *braking distance*.

The handout provides the information that the average reaction time is 0.75 seconds and assumes that a distracted driver will have a reaction time twice that long (1.5 seconds). Point out to students that this is based on the information from the *Distracted Driving Research* we read for Lesson 2. Then move around the classroom and support students as they do the math ✱ and the graphing; they will see that reaction distance increases with speed and distracted driving doubles that. ✱

ADDITIONAL GUIDANCE In the *Calculating Reaction Distances* handout, speed is converted from m/s to mph before the data are graphed. The purpose of this conversion is to aid students in conceptually understanding how distracted driving impacts reaction distance, given that most speedometers on vehicles have the unit of mph. If it is more important for you that your students use metric units, feel free to keep data in m/s. However, if students graph in m/s it may be difficult for them to make connections to their real-world understanding.

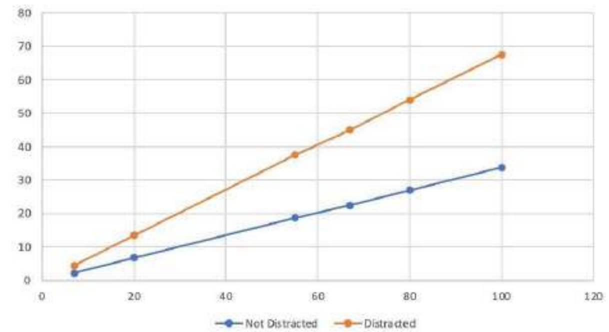
✱ ATTENDING TO EQUITY

Supporting emergent multilingual learners: Provide additional guidance via small group check-ins or with the whole class to help students co-construct an understanding of the data we are graphing. Revisit the diagrams generated in Lesson 2 for how the reaction distance differs between undistracted versus distracted driving. Review the key take-away from Lesson 2 by asking, *Why are we plotting the reaction distance versus the time? Why is the reaction distance greater when drivers are distracted?* Additionally, acknowledge that the term *reaction* is polysemous. When investigating vehicle collisions, reaction distance is the interval (or the total distance a moving vehicle travels) between the appearance of an obstacle and the brake lights turning on.

ASSESSMENT OPPORTUNITY

What to look for/listen for in the moment: Move around the classroom while students are working. You can also collect students' handouts at the end of class to give more-focused feedback. Look for students to do the following:

- Correctly apply the equation most of the time--flag solutions that don't make sense. (SEP: 5.2)
- Draw somewhat straight lines in the graphs as in the example below. (SEP: 5.2)



- Describe how in both scenarios, reaction distance goes up with speed and thus increases the probability of a collision in the event of an obstacle. (CCC: 3.5; DCI: ETS1.A.2)
- Describe how in the distracted driver scenario, the reaction distance goes up faster with speed, making it even more likely that there will be a collision in the event of an obstacle. (CCC: 3.5; DCI: ETS1.A.2)

What to do: Flag incorrect solutions and graphing errors but focus feedback on questions 4 and 5 on the handout. If any students are having trouble making connections, ask them to first point to patterns they see in the graph and use a highlighter to mark where these patterns are happening. Then ask them to caption the graph, explaining what might be happening to produce those patterns. This is the I^2 (Identify and Interpret) strategy for scaffolding the analysis of data displays.

Building toward: 3.A Use a mathematical model (distance = speed * time) to generate data about how speed affects reaction distance based on average reaction times for distracted versus undistracted drivers. (SEP: 5.2; CCC: 3.5; DCI: ETS1.A.2)

✱ ATTENDING TO EQUITY

Universal Design for Learning: Students can use a calculator to do these calculations. Allowing alternatives for using tools such as a calculator can remove barriers for students in *expressing* their understanding by keeping the focus on the learning goal. Use of such tools can help provide a match between a student's abilities and the demands of the task. You might also consider allowing students to use a digital graphing tool such as a graphing calculator, or spreadsheet software such as desmos.com, to create their graphs.

ALTERNATE ACTIVITY	**Extension**: If you wish to spend more time making sense of braking and reaction time and motion graphs, the collision avoidance restricted view of the vehicle collisions simulation (https://www.nhtsa.gov/sites/nhtsa.gov/files/nhtsa-ppt-schoolbus.pdf) can be used to let students investigate relationships by adjusting the distance, speed, reaction time, braking force, and road conditions. This view of the simulation only shows data for the vehicle in order to be appropriate for use at this point in the unit. The simulation creates graphs of distance from the barrier and vehicle velocity that can be connected to the graphs students have made and analyzed. Note that the term velocity is not introduced formally until Lesson 6.

4 · DEBRIEF AND ASSIGN THE SPEED LIMITS HOME LEARNING

10 min

MATERIALS: *Calculating Reaction Distances*, *Speed Home Learning*

Debrief the investigation. Present **slide E**. Use the prompt as shown in the table below to start the discussion. Use the additional prompts below, or something similar, to push students for evidence.

Suggested prompt	Sample student response
What did the data say about the impact of speed on reaction distance given a fixed reaction time?	Higher speeds mean longer reaction distances for both undistracted and distracted drivers.
What evidence can you point to in your graphs to support this claim?	As the speed goes up on the x-axis, the reaction distances go up too, for both lines. It looks linear.
Was this the same for both distracted and undistracted drivers?	Yes. But when a driver is distracted, their reaction distance will be twice as long as it would have been because their reaction time is twice as long.
What evidence can you point to in your graphs to support this claim?	As the speed goes up for the distracted driver, the reaction distance gets even bigger because everything was doubled. The slope of the distracted line is higher.

Present **slide F**. Say, *Wow, speed clearly makes a difference. What can we do to limit people's speeds?* Listen for students to suggest imposing speed limits, adding speed bumps, or giving tickets. Accept all ideas.

✱ ATTENDING TO EQUITY

Universal Design for Learning: This home learning is used to broaden students' thinking to everyday phenomena and leverage the science experiences they have outside of school to augment the learning that happens in the classroom. Framing families and communities as legitimate sources of knowledge can serve multiple purposes. It can (1) help students feel that they belong in the science classroom by situating their family and community knowledge as productive for science, (2) engage their families in conversations about what is happening in the classroom, and (3) help students make connections between the science classroom and their everyday lives, supporting their *engagement*.

Assign home learning. ✱ Present **slide G**. Distribute the *Speed Home Learning* handout. Explain that students will ask a family, friend, or community member these questions:

1. *What are the speed limits in different parts of our community?*
2. *Have they changed? How? Why do you think they were changed?*
3. *Should they be changed? Why or why not? If so, how?*

Instruct students to keep track of what they learn on the bottom of the handout to guide our discussion next time. You will not need to collect the handout.

End of day 1

5 · NAVIGATION AND RETURN TO HOME LEARNING

10 min

MATERIALS: science notebook, *Speed Home Learning*, *Calculating Reaction Distances*

Debrief the home learning and return to speed limits as an engineering design solution. Have students pull out their home learning notes. Present **slide H**. Move through the prompts as a class. Encourage students to refer to *Calculating Reaction Distances* in their notebook to support their claims related to the third question, as suggested in the fourth prompt in the table below.

Suggested prompt	Sample student response
What did you learn from talking to friends, caregivers, and community members about speed limits in our community?	(Responses will vary. Listen for students to reference specific stretches of road in your community.)
What can we do to limit people's speeds?	We can set speed limits, add speed bumps, put up signs, give out more tickets, or increase fines.
How would limiting speeds make driving more safe?	It would mean that people could stop faster and avoid a collision.
What did we figure out in our investigation of speed that would support that claim?	As the speed goes up on the x-axis, the reaction distances went up too, for both the distracted driver and the undistracted driver.

> That means the car will move farther in the same amount of reaction time.

Ask students to hold on to their home learning handout for use in a later lesson (Lesson 12).

6 · INTRODUCE THE ENGINEERING PROGRESS TRACKER

10 min

MATERIALS: *Engineering Progress Tracker*


Name
Date
Engineering Progress Tracker

Introduce the new tracker. Say, *Let's keep track of these ideas about how to make driving safer by limiting speeds.* Present **slide I**. Distribute the *Engineering Progress Tracker* and lead a quick discussion to help the class fill in the first row as shown below, using the ideas that emerged in the home learning debrief. The example includes speed limits, but you may choose speed bumps, speed cameras, or anything else the class comes up with.

Consider constraints by filling in the last column. Point out that many solutions come with *constraints*. If this word is new for students, write it at the front of the room and have them add it to their Personal Glossary. Explain that a constraint might be something as simple as a solution being too expensive, or it might be much more complex. As we fill in the tracker's last column, we need to think about the constraints on the design solution and whether that constraint might not affect everyone equally.

Lesson #	What is the design solution?	How do science ideas explain why this solution could keep people safe?	Who does this solution protect? Who does it fail to protect, and why?
3	*Speed limits*	*Driving faster means that your reaction distance will be longer. Speed limits prevent people from driving too fast.*	*This solution protects everyone by making car crashes less likely. But sometimes people don't follow the speed limit, so even if you set it people might not follow it. It is much easier for wealthier people to pay speeding tickets, so a speed limit might not matter as much for them. Also, some people might live in places with different speed limits.*

7 · ENGINEERING FASTER REACTION TIMES

20 min

MATERIALS: *Engineering Progress Tracker*, *Engineering Faster Reaction Times*

Assign the reading. Present **slide J**. Distribute the *Engineering Faster Reaction Times* handout and have students read quietly. ✱ If the reading is overwhelming for some students, consider organizing the class into groups and asking some students to read about one design solution while others read about another. You can then arrange groups combining students who read about different design solutions to work together as they fill in the *Engineering Progress Tracker.*

ALTERNATE ACTIVITY

Give the class a moment to pre-think about these solutions if there is time. To do this, say, *We don't know if speed limits affect reaction time, but they definitely affect reaction distance. Can you think of any design solutions that could increase the amount of reaction time we have?*

Solicit 2-3 ideas. Accept all ideas. You may see ideas about cell phones that sense when you are driving and turn off notifications, heads-up displays that help keep your eyes on the road, hands-free cell phone solutions, or automatic braking.

Continue filling in the tracker in pairs. When students finish reading, they can begin discussing with a partner and filling in additional rows of the *Engineering Progress Tracker*. They do not need to fill in a row for every design solution presented in the reading; rather, encourage them to choose at least two solutions that they find compelling.

ASSESSMENT OPPORTUNITY

What to look for/listen for in the moment: Collect the *Engineering Progress Tracker* at the start of the next class. Examples of what responses in the tracker might look like are in the *L3 EPT Key*. The rows that students will complete as home learning are indicated in grey. Look for students to do the following:

- Complete at least one additional design solution row addressing the problem of distracted driving. (DCI: ETS1.A.2)
- Connect each new design solution to a claim (or claims) that we made during the lesson based on evidence about change over time, such as speed, reaction time, and reaction distance. (SEP: 6.5; CCC: 2.3)
- Highlight in the last column at least one reasonable constraint for each new design solution. (DCI: ETS1.B.1)
- Respectfully consider how the constraint might affect some people, animals, and environments differently than others.

What to do:

- Provide written feedback to help students set expectations for what the tracker entries should look like.

✱ ATTENDING TO EQUITY

In the reading, students learn about design solutions that affect some people more than others because of their race or socioeconomic status. Learning about solutions that feel unfair can be upsetting. Guide students toward the resources provided in Lesson 1 to ground themselves if they are upset. Make space for ideas about what is fair or right as they come up rather than suggesting that they don't belong in science class, and acknowledge that many societal problems can't be solved with physics and engineering.

- In this feedback, encourage students to expand on their ideas by asking questions like *Why?* and *How?*
- Push students to think beyond the driver and passengers of the car. *What about pedestrians? wildlife? Who else might be affected?*

Building toward: 3.B Use student-generated evidence from video data and mathematical modeling to make a claim about the problem of distracted driving, identify design solutions that could have the effect of decreasing reaction distances to prevent a collision in the event of a sudden obstacle, and identify a range of constraints associated with each solution. (SEP: 6.5; CCC: 2.3; DCI: ETS1.A.2, ETS1.B.1)

8 · NAVIGATE AND ASSIGN THE EXIT TICKET

5 min

MATERIALS: science notebook

Navigate by posing a question about braking. Present **slide K**. Say, *We figured out that driving is more dangerous when the car is moving faster because it will travel farther during the time it takes the driver to react. So the driver will brake later, making it harder to avoid an accident. But could the speed also affect what happens after they hit the brakes, changing the braking time and the braking distance?*

Pose the slide's prompt as an exit ticket:

- *How will speed affect the time it takes to stop* ***after*** *the driver hits the brakes?*

Additional Lesson 3 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN MATH	**The Number System** **CCSS.MATH.CONTENT.HS.A-CED.2 Creating Equations:** Create equations that describe numbers or relationships. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. In this lesson, students graph speed versus time in order to understand distracted driving, and apply the equation speed = distance / time.