Eighth Grade Instructional Segment on Newton's Laws
Transportation Troubles: Outcomes of car and truck accidents have inspired many innovations and solutions that make driving safer.

Student Science Performance	
Grade Level: 8th	**Title:** Transportation Troubles: Vehicular Motion
Topic: Force & Motion	

GSE Performance Expectations:

S8P3. Obtain, evaluate, and communicate information about cause and effect relationships between force, mass, and the motion of objects.

a. Analyze and interpret data to identify patterns in the relationships between speed and distance, and velocity and acceleration.
(*Clarification statement:* Students should be able to analyze motion graphs, but students should not be expected to calculate velocity or acceleration.)
b. Construct an explanation using Newton's Laws' of Motion to describe the effects of balanced and unbalanced forces on the motion of an object.
c. Construct an argument from evidence to support the claim that the amount of force needed to accelerate an object is proportional to its mass (inertia).

Lesson Performance Expectations:

- Analyze and interpret data to identify patterns in the relationship between speed and distance and between velocity and acceleration.
- Construct and argue an explanation using Newton's Laws of Motion.

Additional notes on student supports

Materials: Balance scales, Spring scales. weights, paper clips, scissors, toy cars, ramps or tracks, tape, washers or clay, meter sticks or meter tape, obstacles for collision such as empty cereal boxes

Engage	***Phenomenon:***   I have two brothers, a sister, and a big brown Labrador Retriever dog. With all that cargo, my mom drives a big SUV. The other day my mom was passing a big 18-wheeler (truck) when I heard someone honking their horn. When I looked back, it was another driver visibly frustrated at how slow my mom was passing. After that incident I started to notice that when my mom passes other cars, it really *does* seem to take her a long time to get around the car. ***Communicating*** Students talk with their elbow partners or in small groups about shared similar experiences. Students share aloud whole group some of their experiences. *Teacher Notes: Attempt to facilitate whole group discussion so that students have listed/posted at least one experience representative of each of Newton's laws. Listen for students to comment on* ● *experiences with their parents getting frustrated at how slow 18 wheelers travel,* ● *motorcyclists weaving in and out of traffic,* ● *how they've had to hold on to the handle on the roof when their parents take a turn quickly,* ● *how the seat belt will lock on them sometimes when their parents come to a real quick stop, etc.*

	Evaluating Back in partnerships/small groups, students develop initial explanations for both their shared experiences and the SUV story. Students determine any obvious patterns in their initial explanations. ***Communicating*** Students state patterns in their observations as part of whole group discussion. *Teacher Notes: Listen for students to identify patterns such as bigger/heavier cars take longer to speed up and slow down, sports cars can go fast really quickly; when there's an accident, sports cars seem to get really banged up while big trucks seem to slide sideways and don't have much damage, etc.*
Explore	***Obtaining*** Students plan and investigate the potential science behind the observed patterns in their experiences. Student investigations should correlate to the experiences shared. *Teacher Notes: Some learners may need more structure than others. Suggestions for structuring investigations are provided below. Always carefully adjust scaffolds as student(s) show greater aptitude toward independent planning and investigating.* Suggestions for Structuring Investigations *(Obtaining/Evaluating/Communicating)*: **Part 1: Force/Mass/Acceleration**: Students use spring scales and objects of different masses to measure the force required to move various object. As part of evaluation, students consider what properties of the objects contribute to the force required to accelerate the objects. Sample Organizer for Gathering Data (Parts 1 and 2) As part of initial sense making through models/visual representations, students then determine how this idea connects to the reality of getting big trucks versus cars up to certain speeds, but then are also challenged to consider what it might mean for trying to stop, and/or change its direction. **Part 2: Inertia**: Students investigate the motion of objects (i.e. passengers) both with and without restraints (i.e. seat belts). *Teacher Notes: Consider the use of a racetrack or roller coaster track to facilitate this investigation. If time permits consider allowing students to construct/design the track so that the car is released from a high point, moving its way through the track without additional input force. Facilitating the investigation in this way allows for the integration of gravitational potential energy and kinetic energy.* *Teacher Notes: Passengers are represented with washers or clay. Clear tape can represent seatbelts.* Sample Organizer for Gathering Data Part Three: As part of initial sense making through models/visual representations, students

	then determine how this idea connects to the reality of holding on to handles or getting shoved up against the door when parents take quick turns or seat belts locking up but your body continues to move forward. Sample Organizer: Making Sense of Inertia Handout Part 4: Reciprocal Actions: Students investigate the motion of objects when there is a crash between cars of different masses. Include models of passengers for observational purposes. Sample Organizer for Gathering Data: Reciprocal Actions *Teacher Notes: Collision trials can/should extend beyond that which is provided in the sample organizer. Allow students to investigate additional set ups. Consider using empty cereal boxes as obstacles or barriers and students measuring the distance the barriers move after collision. Then add weight to the cereal boxes and collect data to compare.* As part of initial sense making through models/visual representations, students then determine how this idea connects to the reality of car wrecks that involve cars of same/different masses. Sample Sense-Making Organizer (Evaluating)
Explain	***Obtaining*** Students obtain information that provides scientific explanations for each of the phenomena from the explore phase. *Teacher Notes: Some students will need resources provided.* Suggested Resources: • Khan Academy: One-Dimensional Motion • CK-12: Physical Science • PhET: Forces and Motion Simulation (Attribution: PhET Interactive Simulations, University of Colorado Boulder; https://phet.colorado.edu) ***Evaluating*** Students evaluate information to revise initial models by including captions and/or specific scientific terminology that applies to the situation. *Teacher Notes: Some students would benefit from an organizer that guides a chunking/checking process for accuracy, such as Investigation Organizer.* ***Communicating*** Students peer review and then share/present revised models to include captions and specific terminology. *Teacher Notes: Consider providing students a peer checklist and/or writing rubric.* **Assessment of Student Learning** Students draw diagrams of force and motion scenarios, as well as predict and explain changes in Motion and Force Assessment.

Elaborate	***Phenomenon: Why do I need to wear a helmet?***  ***Communicating*** Students share what they know about different helmets structure and function (e.g. material, correct way to wear, laws, reasons). Students then share what they know about all safety gear associated with various activities (helmets in bike/car racing, safety equipment in sports, spoiler height in car racing, etc.) *Teacher Notes: Facilitate discussion to elicit students' prior knowledge about all safety gear.* ***Obtaining*** Students obtain information about wearing a bicycle helmet, or other safety equipment. There are multiple online sources available. ***Evaluating*** Students plan and investigate the structure and function of helmets, then apply information to design and construct an improvement to _____. *Teacher Notes: Allow students to determine what safety technology they would like to improve. For example, some students may want to improve the material used in seat belts, bumpers on cars, helmet material/design, etc.* ***Communicating*** Students share their new/improved safety technology. Presentation should include a practical reason for the modification/new technology, scientific rationale(s) for the modification, test results of prototype, suggestions for refining model based on test results.
Evaluate	Students will construct an argument and explanation of why their safety design is better than current designs. Have students include all relevant vocabulary on Newton's laws to provide a thoughtful and complete explanation.

SEP, CCC, DCI Featured in Lesson	**Science Essentials**
Science Practices	• Analyzing and interpreting data • Engaging in argument from evidence • Constructing explanations • Obtain, evaluate, and communicate information
Crosscutting Concepts	• Cause and Effect • Patterns
Disciplinary Core Ideas	From *A Framework for K-12 Science Education:* • **PS2.A: Forces and Motion** • **PS2.B: Stability and Instability in Physical Systems** • **PS3.C: Relationship Between Energy and Forces**

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. Provide calculators as needed. 2. Provide graph paper as needed.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. The scenario presented is a good description of what occurs in a vehicle. This may be hard for some students to visualize. The teacher can present this scenario and then show a video that is similar to engage students that did not understand the scenario. Another option would be to draw what is occurring on the board to help students visualize it.
2. The teacher should have guidelines for working in partners or participating in whole group discussion. This will make students feel more comfortable and be more willing to participate.

3. As students throw out ideas it may be beneficial to write the ideas on the board so that students can sort them into the different law categories, later, as review.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. Format options could include drawing, writing or designing a play.
5. The teacher should provide students with an organizer to record their thoughts and observations.

Exploring:

1. Some learners will need more support than others.
2. The teacher should be sure to provide the organizers for gathering data but may also need to provide an organizer for the planning piece of this instructional segment.
3. The teacher should show the sense making material through several avenues. This could occur through articles, videos, other visuals and scenarios.
4. Some students may need additional time to complete the assignments.
5. The teacher can re-frame this into students accidentally bumping into one another in the hallway vs. bumping into an adult or little kid. What happens in each scenario?

Explaining:

1. Struggling students may need assistance with the reading pieces of this lesson. This could be provided by the teacher leading a read aloud, pairing students up to do a partner read, using a text to speech program or using a video instead of the articles.
2. Struggling students may need additional time to revise their model.
3. The teacher can provide a rubric for students to self-assess as they revise their model.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. Format options could include drawing, writing or designing a play.

Elaborating:

1. The teacher should have some options of helmets that students can choose from such as a bike helmet, horse back riding helmet or motorcycle helmet. This will assist students that do not have life experiences with helmets.
2. The teacher should have guidelines for participating in whole group discussion. This will make students feel more comfortable and be more willing to participate.
3. It may be beneficial to some students to receive a warning that they may be called on.
4. The teacher should increase wait time during class discussion to give students with processing problems time to formulate a response.
5. The teacher should give the students an organizer to record their thoughts, research and procedure.
6. Students may need additional time to construct their design and explanation.

Evaluating:

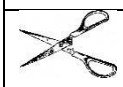
1. Students may need additional time to construct their argument and revise their explanation.
2. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. Format options could include drawing, writing or designing a play.
3. The teacher should provide a rubric for self-assessment.

Return to Instructional Segment

Organizer for Gathering Data

Part 1: Force/Mass/Acceleration: Use spring scales and objects of different masses to measure the force required to move various object. Consider what properties of the objects contribute to the force required to accelerate the objects.

Sample Organizer for Gathering Data:

Object/Mass (**g**) 	Input Force Required to Move Object (**N**) 	Potential Reasons and/or Contributing Properties
 Mass: _____g		
 Mass: _____g		
 Mass: _____g		

Part 2: As part of initial sense making through models/visual representations, determine how this idea connects to the reality of getting big trucks versus cars up to certain speeds, but also consider what it might mean for trying to stop, and/or change its direction.

Sample Sense Making:

Key for Visuals   the object  amount of force acting on the object (***vector***)		How much force would it take to **increase its speed?**	…… **decrease its speed?**	…… **change its direction?**
	18-wheeler: **5000 kg**			
	sports car: **1000 kg**			

Return to Instructional Segment

What Difference Does It Make?

Mass of Passengers w/No Seatbelt: _____

NO SEATBELT	Total Distance Traveled	Total Time Traveled	Observations from Downhill 1	Observations from Downhill 2	Observations from Downhill 3

Mass of Passengers w/ Seatbelt: _____

With SEATBELT	Total Distance Traveled	Total Time Traveled	Observations from Downhill 1	Observations from Downhill 2	Observations from Downhill 3

Return to Instructional Segment

Making Sense of Inertia

		Before	During	After
 the car  passenger  amount of force acting on the objects (***vectors***)	**Taking Quick Turns** and either hold on to handle or get shoved against door			
	Quick stop and seat belt locks but body keeps moving forward			

Return to Instructional Segment

Reciprocal Actions: Organizer for Gathering Data

Mass of Small Car: _____ g Mass of Large Car: _____ g	**Collision Trials** 	**Observations** **On Impact** (Include measurements)	**Observations** **After Impact** (Include measurements)
Moving Objects	Small Mass← collides with moving ←Small Mass		
	Small Mass ← collides with moving ←Large Mass		
Stationary Objects	Small Mass← collides with stationary ←Small Mass		
	Small Mass ← collides with stationary ←Large Mass		

Return to Instructional Segment

Collision Sense Making

Key for Visuals	Description of Trial	**Outcome (Visual Representation)**
 cars  passenger  amount of force acting on the objects (***vectors***)		

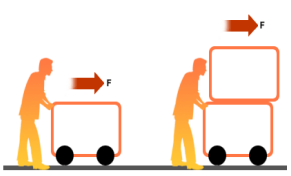
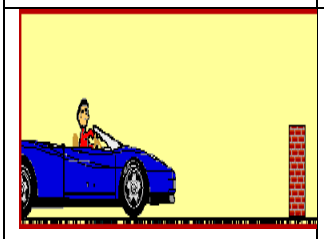
Return to Instructional Segment

Investigation Organizer

Investigation	Visual Representation	Labels that should be applied	Caption
Changing the speed or direction of an 18-wheeler			
Changing the speed or direction of a sports car			
Taking quick turns			
Quickly coming to a stop			
Car Collision:			
Car Collision:			

Return to Instructional Segment

Motion and Force Assessment

	Draw a free body diagram of the forces at work in the situation.	What would happen if…?	Why would this happen?
		…the person flicked the paper?	
		…the swimmer pushes his left arm through the water?	
		…the person doubles the mass being moved?	
		…the driver hits the wall?	

[Return to Instructional Segment]