Lesson Two: Simulation Driving Day

Grade level: 6-8
Expected length of lesson: 45 minutes

Overview:

The purpose of the lesson is to have students collect data on stopping distance using a combination of variables. Students are assigned their variable combination and are to complete their calculations predicting the stopping distance needed with that variable combination. The variables are: car type (either the BMW or Expedition) and coefficient of friction (COF) (0.85, 0.4, or 0.2). There are six possible car and coefficient of friction combinations: BMW+0.85 Coefficient Of Friction, BMW+0.4 COF, BMW+0.2 COF, Expedition+0.85 COF, Expedition+0.4 COF, and Expedition+0.2 COF. Students drive the simulator for their given variables. The simulation will be set up to match each group's variable combination when they arrive at the simulator. After students run the simulation for their assigned variables they record their results, discuss their results with class members, and partake in journaling as an assessment.

Standards and Benchmarks:

NGSS:

Performance Expectations:

- MS-PS2-2:
  - The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- MS-PS2-1:
  - For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).

Cross-Cutting Concepts:

- MS-PS2-3, MS-PS2-5:
  - Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- MS-PS2-1, MS-PS2-4:
  - Models can be used to represent systems and their interactions such as inputs processes and outputs and energy and matter flows within systems.
- MS-PS2-2:
  - Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Science and Engineering Practices:

- MS-PS2-4:
  - Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

- MS-PS2-2, MS-PS2-4:
  - Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Iowa Core

Science:

- S.6–8.PS.3:
  - Essential Concept and/or Skill: Understand and apply knowledge of motions and forces. The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.

Comprehension and Collaboration:

- SL.8.1:
  - Engage effectively in a range of collaborative discussions (one–on–one, in groups, and teacher–led) with diverse partners on *grade 8 topics, texts, and issues,* building on others' ideas and expressing their own clearly.
- SL.8.2:
  - Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.
- SL.8.3:
  - Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.

Presentation of Knowledge and Ideas:

- SL.8.4:
  - Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well–chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Learning Goals:

Students will understand:

- Motion is dependent on the forces acting on it. In our simulation, the motion of the car is dependent on the amount of friction of the pavement.
- The relationship between friction and stopping distance.
- How a simulation can be used to demonstrate a topic in a novel and real-world way.

Learning Performances:

Students will be able to:

- Properly calculate stopping distance given the variables: car type and coefficient of friction.
- Understand how friction and stopping distance are related by understanding that an increase in friction means a decrease in stopping distance (higher friction (closer to 1.0) means less time required to stop).

Materials:

- Calculations from the previous day
- Their science journals or notebooks to write down observations and discoveries
- The MiniSim Simulator provided by the National Advanced Driving Simulator

Safety:

- Safety guidelines for simulation use from NADS:
- Do not use if you have motion sickness
- Do not use if you have any medical condition that would make your participation unsafe for you (heart condition, etc.)

Students' Ideas:

There are two different aspects that students should know before the day of the simulation. The first idea is the definition of friction and how friction impacts everyday life. If students do not know what friction is they will not understand why there is a difference between pavement conditions. The second idea that students should know is how to do the mathematical calculation needed to figure out stopping distance. If students do not know how to use this calculation they will be unable to predict stopping distance for their given variables. Students will come into this topic with some misconceptions that need to be addressed and will hopefully be corrected during this lesson. The misconceptions that students may have are:

- Friction is caused by surface roughness (there are many times when this is indeed true, but others where a surface may not be as rough but still have more friction, ex: the sticky side of tape is less rough than sandpaper but has more friction)
- An object doesn't stop because of a presence of a force; it stops because of an absence of a force
- Objects at rest have no forces acting on them
- Moving objects come to a stop even when there is no friction
- Friction only occurs between solids
- There are tiny bumps that cause friction (the use of sandpaper)
- Friction always hinders motion; reducing friction is always desired

Critical Thinking Questions:

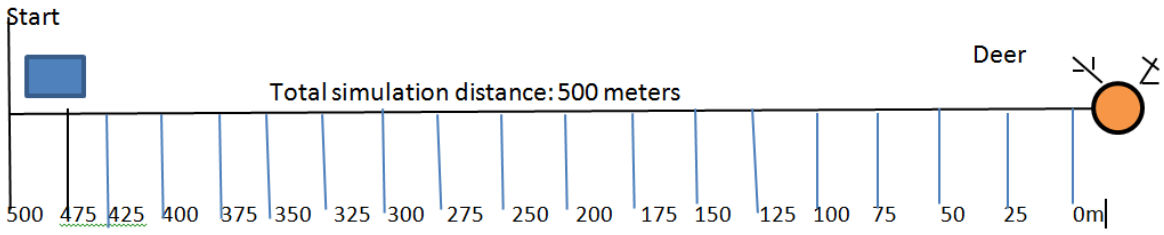
- How much stopping distance does each vehicle require to stop safely at different driving conditions?
- Which vehicle will stop in a shorter distance? Why do you think that?
- What other factors might affect stopping distance?
- Why might your calculations have been off?
- How is the simulator different than the real world?

Main Lesson:

Introduction:

Because these students are at a particular age when driving begins to be relevant to their lives, the simulation assists in their understanding of the concept of friction in a way that relates to their futures in driving. By using this real world scenario as a teaching tool, the students are more likely to engage in the classroom and be prone to learning. Before completing the simulation,

students are to make predictions of how much stopping distance is required. After the simulation, those predictions are to be proven true or false, therefore, correcting any misconceptions or reinforcing the concept. Below is a rough drawing of what the simulation will look like:



Lesson:

1. The teacher splits the class into their Simulation Groups (about 3 students) and each team is assigned a combination of variables (BMW+0.85 COF, BMW+0.4 COF, BMW+0.2 COF, Expedition+0.85, Expedition+0.4, or Expedition+0.2).
2. Students will then plug in their variables to the stopping distance equation found below.

$$d = \frac{v_0^2}{2\mu g}$$

v=velocity=50mph=22.352meters/second
g=gravity=9.8meters/second^2
μ=coefficient of friction
d=stopping distance

3. After the groups have computed their stopping distance they have to take turns driving the simulator. When one group is driving the rest should be journaling about what they predict will happen and how much stopping distance they will require to stop safely. The students can also practice the simulation by walking through what might happen and applying the mathematical equation above. Students within the groups driving the simulator assist the driver by recording the road maker at which they applied the brakes, the marker at which the vehicle came to a complete stop, and whether or not the vehicle hit the deer or stopped safely before it.
4. After driving the simulator the groups write another journal entry about the experience, whether their calculation was accurate, and whether they successfully completed the simulation.
5. When all groups have finished the simulation and journaling any remaining class time is to be used to discuss the results. The following class time will focus on these results and use official graphs from the simulation to interpret which team did a better job at stopping under each condition.
6. After completing the simulation students journal about their findings and defend or reevaluate their predictions from day one. If remaining class time allows, the entire class can discuss what each group's results were and whether or not they correlate with the mathematical calculations.

Differentiation:

Students with Special Needs:

- For those students who are unable to be in the simulator because they get motion sickness, are unable to drive due to physical or mental disabilities, or have a health condition that prevents them from driving arrangements can be made to watch other students drive or to watch a video of someone driving in order to still see the results.
- Students who are unable to physically drive the simulator could serve the role as a stopping distance recorder or team coach to satisfy their participation during the simulation.

ESL Students:

- For those who are ESL students, additional pictures, a vocab list, definitions, or modeling may be beneficial. Such vocab list could include the following terms: mass, velocity, stopping distance, and meters.
- A modified thinking guide may also be used for students whose first language is not English. More definitions or instructions may be used to aid the student, or a guide could be created incorporating their native language.

Advanced Learners:

- For advanced learners, a modified thinking guide with less structure or information may be possible.
- Another opportunity for advanced learners would be the equation below. This equation is too advanced for most middle school students. This equation is used to calculate how much time it takes to accelerate to 0mph from 50mph as opposed to the stopping distance calculation used with non-advanced learners.

$$a = \frac{v_f - v_o}{t}$$

a = average acceleration
v_f = final velocity
v_0 = initial velocity
t = time

Assessment:

- By use of journaling and verbal explanation to the opposing teams the teacher can see how well each student understands why their results were the way they were and how the experiment is validated by this information.
- Students will construct an explanation as to how friction played a role in the results they got from the simulation. They will also explain why their calculations were similar or different from the results they obtained in the simulation. Finally, students will explain how differing masses and coefficients of friction would change how much stopping distance is required.
- After each group records their results from the simulation students will give a verbal explanation defending or refuting the results that they received.