Lesson One: Factors that Affect Motion

Grade level: 6-8
Expected length of lesson: 45-90 Minutes

Overview:

This lesson will serve as an in introduction to the driving simulator activity. Students will collect data and draw conclusions about how different variables such as mass, velocity, and friction affect motion. Students will then be introduced to the stopping distance calculation that they will use in the driving simulation activity.

Standards and Benchmarks:

NGSS:

Performance Expectations:

- MS-PS3-5:
  - Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Disciplinary Core Ideas:

- MS-PS3-1:
  - Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- MS-PS3-5:
  - When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

Cross-Cutting Concepts:

- MS-PS2-1, MS-PS2-1:
  - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

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-PS2-5:
  - Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.

Iowa Core

Science:

- S.6-8.PS.3:
  - Understand and apply knowledge of motions and forces.

Mathematics:

- 6.EE.C.9:
  - Use variables to represent two quantities in a real–world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.
- 6.EE.B.6:
  - Use variables to represent numbers and write expressions when solving a real–world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

Literacy:

- WHST.6-8.1:
  - Write arguments focused on discipline–specific content.
- WHST.6-8.10:
  - Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline–specific tasks, purposes, and audiences.

Learning Goals:

Students will understand that:

- There are many forces and factors that influence motion, including mass, velocity, and friction.
- Friction is a force that opposes motion.
- Velocity is a measure of distance traveled during a certain time.
- Mass is what is pulled on by gravity to determine weight.
- Stopping distance varies with road surface conditions (friction), mass of the vehicle, and velocity of the vehicle.

Learning Performances:

Students will be able to:

- Solve the stopping distance equation: $d = \frac{v_0^2}{2\mu g}$
- Describe the effects that velocity, friction, and mass have on the motion of an object.

Materials:

- Friction Probe #17 *Uncovering Student Ideas in Physical Science* 2010 (by Page Keeley)
- 3 small model cars
- 3 ramps
- Weight to attach to car (to increase mass of car)
- Towel or other material (to increase friction)
- Textbooks to elevate ramps (for control experiment and to increase velocity)

Students' Ideas:

- Students may think there is no friction between stationary objects.
- Students may not know terms such as mass, velocity, and friction.
- Students may not realize what factors affect stopping distance.

Critical Thinking Questions:

- What factors affect motion?
- What factors affect stopping distance of a vehicle?

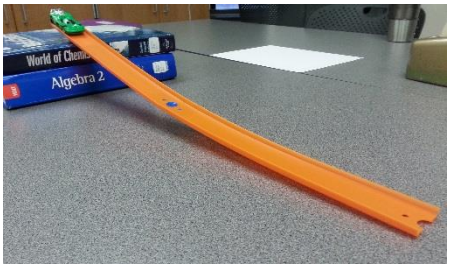
Main Lesson:

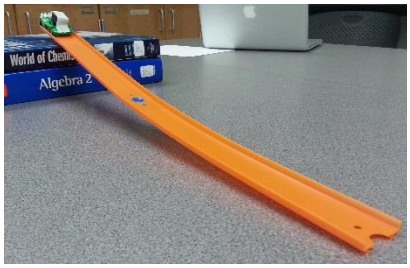
The teacher gives a brief outline of the simulation project and shows a video of the simulator being driven so students know what to expect. This engages students and prepares them for driving the simulator, as they do not have driving experience.

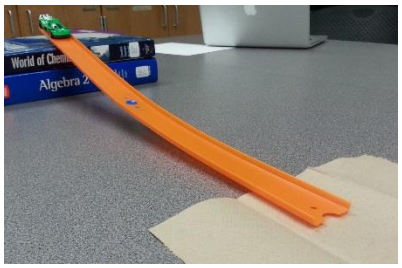
1. The teacher administers the Friction Probe to elicit students' current understanding/misconceptions about friction and forces. The teacher passes out the friction probe, or projects it and students will have 5 minutes to complete it or write their answers in their science notebooks. The teacher collects the probe to see what misconceptions students have about friction and tallies the responses on the board.
2. Students are broken into groups of 3 (Simulation Groups). Within each group, students decide which area of expertise to join, either mass, friction, or velocity (Expert Groups). If there need to be 4 students in a Simulation Group, two students should join Expert Group 2: Friction.

   Expert Groups:
   a. Group 1: Mass
   b. Group 2: Friction
   c. Group 3: Velocity

   The goal is for each student to become an expert in one area, which they will later bring back to their group to assist in the simulation. The three groups do three variations of the activity to see how different factors affect stopping distance. Each student receives a worksheet on which to record their predictions, data, and conclusions.
3. Each Expert Group sets up a ramp and rolls a toy car down it to measure how far from the bottom of the ramp it stops. They record this on their worksheet. Then they perform the activity according to their specific variation.
   a. Expert Group 1 weighs their car, then adds a weight to it and weighs it again. They measure the stopping distance of the car with the added mass.
   b. Expert Group 2 adds a paper towel to the bottom of the ramp (at least as long as the meter stick) to increase friction and records the stopping distance of the car on the new surface.
   c. Expert Group 3 makes their ramp steeper (2 times steeper if possible) so the velocity of the car is increased. They measure their new stopping distance.







4. Students draw conclusions in their Expert Groups, then have a whole class discussion where one or two students from each Expert Group share their findings with the rest of the class by drawing a picture on the board and orally describing their observations. All students should record the conclusions of each group.
5. The teacher passes back the Friction Probe papers and then reviews the correct answers with the students. Students make changes to their original ideas on their papers or in their science notebooks.
6. Students get into their Simulation Groups and the teacher introduces the stopping distance equation used for the simulation activity. Students should understand what each variable means, and they should be exposed to some examples of how to use the equation.

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

d = stopping distance
v = velocity
μ = coefficient of friction
g = gravity

7. Wrap up:
    a. The teacher gives brief instructions for how the simulation day will proceed so that students are organized and prepared.

Differentiation:

Special Needs Students:

- Assistive technologies such as Dragon, Read & Write GOLD, etc.
- Modeling of tasks
- Modified worksheets or notes provided by the teacher

ELL Students:

- Strategic grouping
- Modeling of tasks
- Pictures
- Vocabulary list of difficult terms: mass, velocity, friction, stopping distance, force, motion, ramp, vehicle, variable, control group, experimental group
- Word-bank for worksheet
- Allow use of translation devices

Advanced Learners:

- Can be introduced to more advanced formulas and concepts, such as how friction is determined ($F=\mu N$, Frictional Force=coefficient of friction times Normal Force) and how speed could be adjusted to produce different stopping distances.

Assessment:

- Formative assessment:
  - Friction Probe (pre-lesson and post-lesson)
  - Student presentations of findings from Expert Groups
  - Simulation calculations and performance
- Summative assessment:
  - Activity Worksheet
  - Activity Homework
  - Assessment quiz
  - Class discussion