MODULE 1: CRASH PREVENTION
LESSON 1: PHYSICS AND REACTION TIME
GRADE LEVEL: 6 - 8

As drivers, we depend on multiple inputs to drive safely in ever-changing conditions. How we respond to those inputs is important to our own safety as well as to the safety of other drivers. Through discussion, analysis, hands-on experiments and group conclusions, students will be able to understand that their own reaction times are not instantaneous and practical reaction time limits affect how driving and driving safety can be affected.

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Lesson 1: Physics and Reaction Time

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Grade Level: 6 - 8	**Lesson in this Module: 1 of 4**
Time Required: 60 minutes	**Lesson Dependency:** None
Keywords: transportation engineering, intelligent transportation systems, crash avoidance, reaction time	

Related Curriculum

Subject Areas	Science; technology; engineering; mathematics
Curricular Units	Intelligent transportation systems
Activities	Calculating reaction time; cooperative learning

Educational Standards

This lesson plan and its associated activities are correlated to the national standards in the each of the core discipline areas of STEM: Next Generation Science Standards, American Association for the Advancement of Science Standards, Standards for Technological Literacy, International Society for Technology in Education Standards, Common Core Mathematics Standards, and the National Council of Teachers of Mathematics Standards.

Materials List

Meter stick, computer or tablet, attached reaction time worksheet

Pre-Requisite Knowledge

None.

Learning Objectives

- Through discussion, students will discover factors that contribute to automotive crashes.
- Students will use the scientific method to calculate reaction times using a hands-on and computer-based method.
- Students will use graphical methods to analyze class data.
- Students will apply their knowledge of reaction time to identify how reaction times affect crashes.

Introduction/Motivation

As drivers, we depend on multiple visual and aural inputs to drive safely along roadways that provide ever-changing conditions. How and how quickly we respond to those inputs is important to our own safety as well as to the safety of other drivers. How quickly we can react to inputs is introduced to students in this lesson plan. Through discussion, analysis, some hands-on experiments and group conclusions, students will be able to understand that their own reaction times are not instantaneous and practical reaction time limits affect how driving and driving safety can be affected.

Lesson Background & Concepts for Teachers

Activity 1 – Discussion

In the past five years (2008-2012), more than 120,000 people have been killed in automotive crashes. Although many factors contributed to each of these crashes, one important factor to consider is how long it takes someone to recognize a hazard and respond appropriately to it. In the transportation industry, we call this the perception-reaction time. Reaction time varies depending on a person's age, gender, and level of attentiveness. In this lesson, students will calculate their perception-reaction time by hand and through the use of a computer-aided program. Students will compile class data and use it to perform statistical calculations and practice graphing with error calculations and error bars.

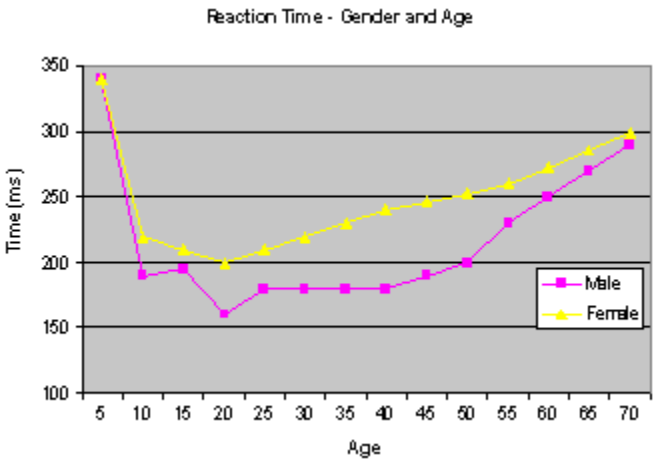

Figure 1: Reaction time differences shown in terms of age and gender (http://www.brianmac.co.uk/reaction.htm)

Activity 2 – Physics of Calculating Perception-Reaction Time

Calculating an individual's reaction time requires a bit of physics background. The equations of motion, or kinematic equations, are used to calculation how objects move with respect to space and time. The basic equation of motion is:

$$\boldsymbol{d = \frac{1}{2} * a * t^2 + v_{initial} * t + d_{initial}}$$

where

$\boldsymbol{d}$ **= the total distance traveled**

$\boldsymbol{a}$ **= the object's acceleration**

$\boldsymbol{t}$ **= the time in which an object moves**

$\boldsymbol{v_{initial}}$ **= the initial velocity of the object**

$\boldsymbol{d_{initial}}$ **= the initial distance or height of an object**

This equation calculates the distance an object travels given a certain amount of time.

Students will need a ruler in order to calculate their individual perception reaction times. Have one student hold the ruler just above the other student's open hand. Instruct the first student to release the ruler without warning the second student. Have the students write down the measurement where the ruler was captured.

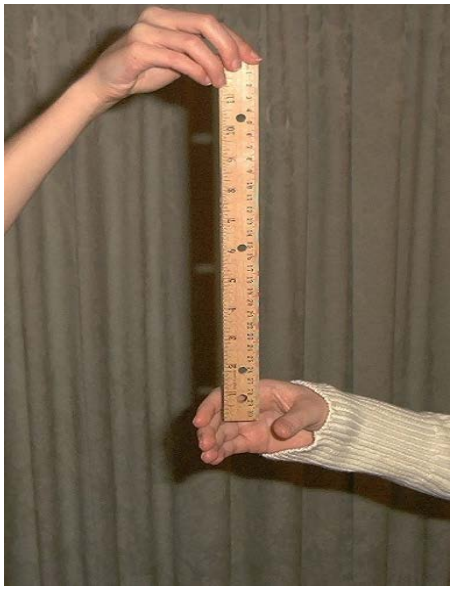

Figure 2: Setup for ruler reaction time: (http://faculty.clintoncc.suny.edu/faculty/michael.gregory/files/bio%20101/bio%20101%20laboratory/science/ruler_drop_technique.htm)

In order to calculate perception reaction time without using a stopwatch, we will need to make some simplifications and rearrange the first formula. Since we are dropping the ruler straight downward, the acceleration that the ruler feels is caused by gravity (9.81 meters per second or 32.2 feet/second). If the ruler is directly aligned with the top of the students index finger prior to the drop and the students measure the post-drop distance from the top of the index finger, then the initial distance ends up being zero and therefore is eliminated from the equation. The initial velocity is also eliminated since the ruler is being dropped from a standstill. That leaves the following equation:

$$\boldsymbol{d = \frac{1}{2} * a * t^2}$$

Since we are solving for t, we can rearrange the equation to get:

$$\boldsymbol{t = \sqrt{\frac{2d}{a}}}$$

Students can use this equation to determine how long it takes them to catch the falling ruler.

Activity 3 – Using Technology to Determine Audio/Visual Reaction Time

The hands-on method of determining reaction time includes a lot of room for experimental errors such as not reading the ruler properly, performing math errors, etc. The following frog-themed website (http://sciencenetlinks.com/tools/zap/) provides an additional method for determining reaction times based on a student's reaction to a visual stimulus (seeing a fly on the radar) versus their reaction to an audible stimulus (hearing the fly buzz). Have students attempt the program several times and average their reaction times together.

Activity 4 – Lab Report

Have students track their class's reaction times and create a graph to show the average reaction times based on method of determination. For example,

Student	Ruler Method	Visual	Audio
Student 1	1.28	0.90	0.96
Student 2	1.50	0.81	1.02
Student 3	1.41	0.76	1.13
Student 4	1.42	0.98	0.77
Student 5	1.41	0.70	0.76
Student 6	1.04	0.58	1.06
Student 7	1.14	0.58	1.01
Student 8	0.96	0.99	0.92
Student 9	1.40	0.98	1.03
Student 10	0.93	1.03	1.24
Student 11	1.04	0.89	0.84
Student 12	1.47	0.51	1.17
Average	**1.25**	**0.81**	**0.99**

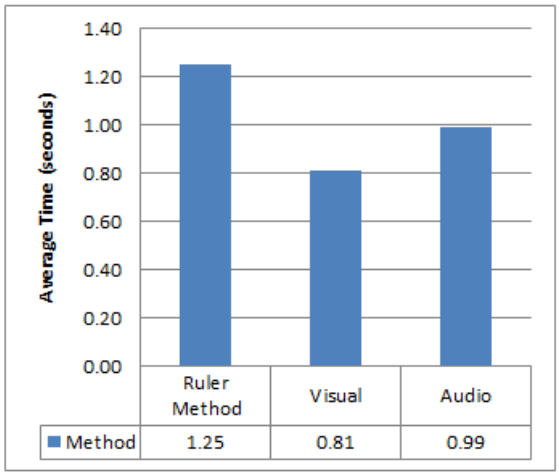

Figure 3: Reaction time graphing example using Microsoft Excel

Perform similar calculations and prepare graphs to show differences in reaction times. It is expected that some of these comparisons will demonstrate varying amounts of effect on reaction time.

Experiments often have various errors that contribute to inaccurate results. For example, if a student measures their reaction time ten times using the exact same method, it is nearly impossible for result will be exactly the same every time. This is due to experimental error. Experimental errors in this lab may include:

- Not reading the ruler with 100% precision
- Not holding the ruler at the exact same drop height every time
- Mistakes in data entry

Vocabulary/Definitions

Vocabulary Word	Definition
Kinematic Equations	Physics equations that describe how objects move with respect to space and time; also called equations of motion
Perception-Reaction Time	The time it takes for someone to see or perceive a problem and react to it (includes cognitive processing time and physical time to move to react)
Experimental Error	Special circumstances that occur during an experiment that may have impacted the validity of the experiment's results

Associated Activities

Activity 1 – Introduction to Crash Physics

- How do crashes happen? Why do crashes happen?
  Crashes happen when people are unable to properly recognize or react to a hazardous situation while driving.

- What are some of the factors that cause some types of people to crash more often than others?
  Distraction, inexperience, visual requirements (wearing glasses/contacts), age, gender, cognitive ability, and attentiveness all contribute to a driver's ability to perceive and react to stimuli in a reasonable amount of time.

Activity 2 – Hands-on Method to Calculate Reaction Time

- Students will use a metric ruler to determine personal reaction times. Students will complete the attached worksheet that follows the scientific method of inquiry

Activity 3 – Additional Discussion Points

- Visual and auditory reaction times: http://sciencenetlinks.com/tools/zap/

- 'Texting Doubles a Driver's Reaction Time' (2:24) : https://www.youtube.com/watch?v=iMWrMZPzx4Y

    - Discuss the importance of refraining from mobile phone use while driving.

- 'Cognitive Distraction – Full Video'(7:43) : https://www.youtube.com/watch?v=mOshfzVsUlU
  This is a longer video published by AAA which talks about ALL types of distractions while driving.

Activity 4 – Lab Report

- Create a graph of class reaction times by method of determination, gender, left/right, dominant hand versus non-dominant hand, etc.

- Write a report that compares the two reaction time methods and summarize your findings. Identify sources of error for each method and propose methods to compensate for this error.

Lesson Closure

Discussion of lab report findings.

Attachments

- Physics and Reaction Time Laboratory Exercise

Extensions/Multimedia

- This is the Official Government Website for Distracted Driving: http://www.distraction.gov/take-action/educators.html ; it has several videos and PSAs; these videos are not 'test data' videos or simulators but real-life scenarios with accidents and messages from or interviews with victims.
- Students may perform statistical analysis on the data using the following webpage as a resource:
    - This on-line tool offers basic, but thorough statistical analysis. All the student needs to do is list their data values, separated by commas and press 'calculate'. https://www.hackmath.net/en/calculator/statistics
    - This website offers explanations of Simple Statistical Analysis ; http://www.skillsyouneed.com/num/simple-statistical-analysis.html

- Utilize Edmodo (www.edmodo.com) to provide further questioning and discussion between students and teacher. Edmodo is safe social learning website made specifically for teachers and students. It is a way to collaborate on assignments, homework, projects, and after-school STEM programs and is used as a communication tool to provide additional questioning and feedback from teachers and students.