Subject Area(s)
Data analysis & probability, measurement, number & operations, physical science, science & technology

Associated Unit:
Electricity in the human body

Associated Lesson
The Nervous System

Activity Title
“Catch me if you can!”

Grade Level:
6th-8th

Time Required:
Two Hours

Group Size:
2

Expendable Cost per Group:
US$0

Summary
Students perform the classic experiment where they catch a falling ruler as fast as they can to calculate their reaction time. They algebraically manipulate the formula to solve for their time and then they get to graph their results on a bar chart. Finally the whole class will interpret the class results to find the person with the quickest reaction time.
**Engineering Connection**
Engineers must be able to take regular mathematical equations and manipulate them so they can extract a value useful to their particular problem. They also must be able to quickly design an experiment and collect data from their activity. They have to graph their experiment data to determine any interesting trends.

**Keywords:**
nerves, brain, reaction time, gravity

**Educational Standards**
- Science: 3.4.10.C
- Science: 10.1.6.B
- Math: 2.1.8.G
- Math 2.2.8.A, B
- Math: 2.7.8. B
- Math: 2.8.3.G, H

**Pre-Requisite Knowledge**
Students should know how to calculate averages and how to make bar graphs.

**Learning Objectives**
After this lesson, students should be able to:
- Identify the parts of the nervous system. Central Nervous System, Brain, Spinal Cord, Nerves, Nerve Endings
- Understand how the 5 senses are related to the sensory system
- Calculate their reaction time based on the distance a ruler drops
- Collect data and graph it to see class trends

**Materials List**
Each group needs:
- Ruler (metric system preferred)
- Calculator
- Graph paper

**Introduction / Motivation**
This lesson continues building on the concepts of circuits and the conduction of electricity but it applies it to the human body. To really get the class attention, choose 3 volunteers to come up to the front of the room. Explain to them that you have a $10 bill and tell them that all they have to do is catch it and if they do then they can keep the money. The trick is to have the students place their elbows on the edge of the table. Then they close their thumb and pointer finger right on top of the president’s face. As you hold the corner of the bill above their
hand tell them to let go of the bill. Then they must close their fingers to catch the bill as soon as you let go of the bill. It should be nearly impossible for the students to grab the bill while their elbow is on the table but students will now be excited to do the activity.

### Vocabulary / Definitions

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
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<tbody>
<tr>
<td><strong>Reaction Time</strong></td>
<td>Refers to how long it takes a person to respond to a given stimulus</td>
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<td><strong>Stimulus</strong></td>
<td>An outside signal that is sensed by the body triggering a signal to be released through the nerves to the brain</td>
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<td><strong>Gravity</strong></td>
<td>The force that attracts everything toward the center of the Earth</td>
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<tr>
<td><strong>Central Nervous System</strong></td>
<td>The nerve tissues that control the activities of the body. It includes the brain and the spinal cord</td>
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<tr>
<td><strong>Nerves</strong></td>
<td>Are the conduction paths for signals traveling between the body and the central nervous system.</td>
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<tr>
<td><strong>Nerve Endings</strong></td>
<td>Are the terminal ends of the nerves, they are the sensors of the 5 senses.</td>
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<tr>
<td><strong>Spinal Cord</strong></td>
<td>The bundle of nerves in the spine that connects nearly all the nerves in the body to the brain</td>
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</tbody>
</table>

### Procedure

#### Background

It is important to talk about the 5 senses and how the brain can interpret different types of signals that are being transduced in many parts of the body, eyes, ears, mouth, nose and skin. Signals are transduced by the nerve endings and then they travel through nerves in a similar way as electricity travels through wires. For example, when something touches your skin a signal is interpreted by the nerve endings, or tiny sensors, on the top layer of the skin and then it travels down nerves to the central nervous system (CNS). The CNS is composed of the spinal cord and the brain. The spinal cord collects nerves from all parts of the body and channels them up to the brain to know how to react. If the nerve endings and nerves were added up together they would stretch for 46 miles. The nervous system is extremely extensive but it is also incredibly fast. A signal will travel from the nerve endings to the brain and back at a speed of 25 meters per second or 1 meter in 0.04 seconds.

This can be related to the reaction time activity by explaining to the students that they are going to calculate the time it takes them to notice with their eyes that the ruler is dropped and then to have their brain send a signal to close the hand so it can close its fingers to catch the ruler. This time amounts to the reaction time and it can be calculated with one of the physics motion formulas:

\[ d = \frac{1}{2} g t^2 \]

\[ d = \text{the distance the object falls in centimeters} \]
g = the acceleration of gravity 9.8 m / s²
t = the time the object was falling in seconds (reaction time)

You must manipulate the formula in such a way that the students can easily calculate the time using their calculators. Show the following steps on the board depending on the grade level (6th in my case) they might not understand each step but the important thing is to see that they are manipulating the original formula to find the time.

\[
\begin{align*}
2 d &= g t^2 \\
2 d / g &= t^2 \\
\sqrt{(2 d / g)} &= t \\
\sqrt{(2 d / 100 g)} &= t^* \\
\end{align*}
\]

** Note: the formula is divided by 100 to change the units from centimeters to meters.

Have the students fill out the provided table during the activity and let them use the calculators to find their average reaction time (Table 1).

Next have the students take their reaction time and graph it in a bar chart format for each trial completed. While they are doing that they should also provide you with their average calculated reaction time so you can graph it on the computer for the whole class (Figure 1).

![Figure 1: Image of class data from student's reaction times.](image)

**Before the Activity**
- Gather all materials and make copies of the reaction time table worksheet.
- Check all calculators to make sure they work properly.
- Have excel spreadsheet ready to record the class averages

**With the Students**
Here are the steps to complete the activities. Have your students follow these instructions.

1. Place your elbow near the edge of the table so that your wrist can extend over the side of the table.
2. Hold the meter stick vertically in the air between your thumb and index finger and have your partner write down the starting position of the meter stick on the table provided.
3. Your partner should hold the meter stick at the end of the ruler and now you can let go of the meter stick at the starting position.
4. Now as your partner lets go of the meter stick you should try to catch it as quickly as possible with your thumb and index finger. Record the spot on the meter stick where you caught it (Catch Position).
5. Repeat this 9 times that way you will have data for ten trials.
6. Trade places with your partner and repeat the experiment.
7. Find the average distance the meter stick fell. This can be done by subtracting the catch position from the start position and then adding up the distance column and dividing it by 10.
8. Calculate the reaction time for each of the 10 trials. The following formula relates the time an object falls to the distance the object fell from rest:

\[ \text{time} = \sqrt{\frac{2 \times d}{100 \times g}} \]

\[ d = \text{the distance the object fell in centimeters} \]
\[ g = \text{the acceleration of gravity 9.8 m / s}^2 \]
\[ t = \text{the time the object was falling in seconds} \]

9. Calculate the average reaction time by adding up the reaction time column and dividing it by 10. Give it to your teacher when you are finished.
10. Make a bar graph of your results using your reaction times from all ten trials.

Table 1: Reaction Time Table

<table>
<thead>
<tr>
<th>Trial</th>
<th>Start Position (cm)</th>
<th>Catch Position (cm)</th>
<th>Distance dropped (cm)</th>
<th>Reaction Time (sec)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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Troubleshooting Tips
- Make sure all of the calculators work properly beforehand.
- For simplicity, have all groups measure their distance in centimeters that way the formula can be used without further conversions.
- Draw out the bar graph template on the board that way the students can make their own graphs in an expedient manner.

Assessment
Pre-Activity Assessment
Title: Class Discussion
After the volunteers are not able to catch the $10 bill ask them why they thought it was so difficult. Is it important to have a fast reaction time? What careers require a person to have quick reflexes? How do you think the body knows how to react in certain situations?

Activity Embedded Assessment
Title: Reaction time table and graph
During the activity students have to record the distance the ruler is dropped. From the distance they can calculate the time it takes them to react and then they have to graph their results. Then they will compare it with their partner and as a group they must determine who had the best reaction time. At this point they should write in their notebook which trial gave them their fastest time and then what factors during their experiment contributed to variations in their times. Finally they should write in their notebooks ideas on what they would do to get the fastest time possible.

Post-Activity Assessment
Title: Data analysis and class discussion
At this point the instructor will lead a class discussion on the results of the class bar graph. The students must interpret from the graph who had the fastest reaction time. What things can you do to improve your reaction time? How can you keep your brain and nervous system sharp at all times? Are there any things that will hinder your reaction time?
References

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