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| **Lesson Title: Stop and Go!** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **4** |
| **Activity Title: Design a Traffic Management System and**  **Model** |

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| **Estimated Lesson Duration:** | **240 minutes** |
| **Estimated Activity Duration:** | **200 minutes** |

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| **Setting:** | **Classroom** |

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| **Activity Objectives:** |

Students will be able to:

1. Use the engineering design process to simulate one or two models of a busy intersection and test out a solution for the safest, most efficient traffic management system given a set of constraints.
2. Understand a car’s movement to have magnitude and direction and use vocabulary such as speed and velocity.
3. Demonstrate Newton’s 3 laws of motion
4. Collect, organize, graph, and analyze data.

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| **Activity Guiding Questions:** |

1. How do cars move around in traffic? What is the difference between a roundabout, an intersection with a stop sign or a traffic light? What are the pros and cons to using these? When is each system best used? How exactly does a stop sign and traffic signal work? What is the definition of a safe intersection?
2. 3) How fast can vehicles travel on each type of system?

4) How can we find out information about crash rates?

How do crash rates compare before and after a traffic management system is constructed?

Who collects this type of information?

Who oversees traffic management?

How can we compare this data?

How can we graph this data?

How can we compare crash rates before a traffic system is constructed with crash rates after a

system is constructed?

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☒ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| ☒ Developing and using models | ☐ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☒ Analyzing and interpreting data | ☒ Systems and system models |
| ☒ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☒ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function. |
| ☐ Engaging in argument from evidence | ☐ Stability and change. |
| ☒ Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☒ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☒ Demonstrating Science Knowledge **(D)** |
| ☒ Interpreting and Communicating Science Concepts **(C)** |
| ☒ Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| ☒ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☒ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☒ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

Forces have magnitude and direction. (PS8. 2 ONLS)

Understanding Sampling 7.SP.1, 7.SP.2

Using Mean and Mean Absolute Deviation 7.SP.3, 7.SP.4

Making Comparative Inferences about Two Populations 7.SP.3, 7.SP.4

Simulations 7.SP.8.c

Investigate patterns of association in bivariate data 8.SP.A.1, 8.SP.A.2, 8.SP.A.3, 8.SP.A.4

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| **Materials**: |

3 Poster papers of a hand-drawn street intersection with a stop sign, with a stop light, and a roundabout

Markers

Oversized, laminated word cards featuring vocabulary (motion, speed, velocity, acceleration, direction, magnitude, force, Newton’s three laws, inertia)

Vocabulary words (listed above) written on index cards (number of cards equivalent to number of students)

Box of toy cars, fire trucks, jeeps, police cars, etc.

One or two small doll figures

Yardsticks, stopwatches, colored sticky notes

Stoplights (prepared in previous lesson)

Colored paper for students to make stop lights and stop signs

Glue

Wood strips for sign handles

20 – 30 Battery operated cars (optional; if time permits)

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| **Teacher Advance Preparation:** |

Pre-draw a poster paper of a street intersection

Write out vocabulary words (one word per index card) onto index cards. (For example, for twenty students, each of the vocabulary words would be on two different cards, except for two which would be only written once on one card in order to add up to twenty cards)

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| **Activity Procedures:** |

1. The students will gather around a table in the middle of the classroom. The table will feature three different posters of street intersection bases (hand-drawn street intersection with a stop sign, with a stop light, and one roundabout) and toy cars. Each student will receive one vocabulary card on an index card.
2. The teacher will review vocabulary cards of ***motion, speed, velocity, acceleration, direction, magnitude, and force*** with the toy cars. Each time the teacher uses a vocabulary word the word vocabulary card will be taped up to the board. If a student is holding the same vocabulary card being mentioned, he/she will raise it up high each time the word is spoken.
3. The teacher will introduce the vocab cards ***inertia*** and ***First Law of Motion***, also called the Law of Inertia, “Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.” This will be demonstrated by pointing out that the cars on the table will not move unless a force is applied. This will also be demonstrated by placing two doll figures in a toy jeep. Students will see how inertia works. The teacher will point out the difference between **balanced** and **unbalanced forces** and write these terms on the board (no vocabulary cards for these terms).
4. The teacher will introduce the vocab card ***Second Law of Motion***, “The relationship between an object’s mass m, its acceleration a, and the applied force F is F=ma.” Placing a small car and big truck side by side with a ruler behind their position, the teacher will demonstrate how far each vehicle will move with the same force. In explaining the equation, the teacher will note the difference between mass and weight.
5. The teacher will introduce the vocab card ***Third Law of Motion***, “For every action there is an equal and opposite reaction.” The students will observe what happens to a car if another car slams into it, noting its direction and describing its speed. (Steps 1-5 total of 10 minutes)
6. Students will go into their research groups from the first activity and “play” with the toys. As they work, they will hold up a stop light to indicate their progress. Each group will need to demonstrate the laws of motion and if possible, they will try to come up with an alternate way to show the laws other than a way demonstrated by the teacher. The teacher will walk around the class, heading towards groups with “red lights” requesting for assistance first. (10 minutes)
7. For the remainder of the class, the teacher will reintroduce the Big Idea which was presented as the Hook: Forces, Motion, and Math all have an impact on traffic management. Students will respond to this idea and discuss what forces are with the cars while on a street intersection. The teacher will hear the responses and review the essential question -- What is the most efficient, and optimal route for cars to travel in a congested area? The students will then share what they feel are the essential questions concerning the guiding question, “Would an intersection with a stop sign or stop light, or a roundabout be the most efficient traffic management system given a set of constraints?” (The constraints will include the following: a maximum testing of 30 vehicles, a range of speed (to be determined once human pace and battery operated vehicle speed are calculated), and a maximum of six entrance ways into the congested area.)
8. The teacher will guide the students to the Challenge based learning activity – Design two models that will show the most efficient traffic management system (an intersection with a stop sign or stop light, or a roundabout), given a set of constraints (as mentioned in step 7) (20 minutes)
9. Students will begin the next day by understanding and redefining their Challenge. Using notecards, everyone will individually write down at least 7 items he/she feels are the necessary steps to complete the challenge. (9 minutes)
10. A scribe will begin writing out the steps in flow chart like form on the board as the teacher calls on each student to add to the flow chart (disregarding duplicate suggestions from other students). (10 minutes)
11. The teacher will confirm that data collection planning is appropriate. Students will need to collect and organize the number of crashes, time, distance traveled, speed) in order for them to analyze the data. (3 minutes)
12. For the remainder of the class, students will be in their groups and design possible intersection schemes with the following constraints: a maximum testing of 30 vehicles, a range of speed (to be determined once human pace and battery operated vehicle speed are calculated), and a maximum of six entrance ways into the congested area. Students will devise “rules of the road.” (18 minutes)
13. For the third class of this activity, the students will practice implementing their rules of the road and using “human cars” test out their design simulation while recording the number of crashes, time, distance traveled, and speed of cars. The simulation will be observed by another group of students and two teachers, all who will provide assessment and input concern the efficiency and safety of the model selected. Once the simulation is complete, input will be given and the students will take the remainder of the class to “redesign” their simulation, by either adjusting distance, speed, entrance way design, number of vehicles, etc. Homework assignment for that evening will be to reflect on how the simulation model went.
14. For the fourth class of this activity, students will do a second simulation in front of a group of students and two teachers implementing their new design model. The group of students and two teachers will reassess the efficiency and safety of the system and the class will determine if there was an improvement in their prototype. (40 minutes)
15. The final class will include a post-test and written reflection comparing the original prototype and redesign. If time permits, students may have the opportunity to begin considering using battery-operated vehicles as another way of modeling the traffic system design. If time does not permit but student interest continues, such an activity can take place afterschool as an optional enrichment. (40 minutes)

**Formative Assessments:**

The utilization of the traffic lights will allow the teacher to assess which students need assistance with the content or tasks required.

Notecards for design flowchart.

Reflection homework assignment.

**Summative Assessments:**

Half of the questions on the post-test will assess the above math objectives. The other half of the questions on the post-test will assess Newton’s laws, concepts of speed, calculation of speed, and definitions of magnitude and direction.

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| **Differentiation:** |

Students with ADHD will be allowed to stand up, take water breaks, and squeeze a stress ball throughout the activity. The teacher will repeat the directions slowly to ESL students and ask if there are any questions they might have. The teacher will write key vocabulary words and their definitions on large colored cards and hang them on the wall for the students to refer to. Students with physical disabilities will be assisted with writing on the board or calculating the mean. Advanced students will be asked to find the mean average deviation for each data set (boys and girls reaction times) and share their conclusions with the class.

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| **Reflection:** |

In addition to steps 14 and 15, I also asked students to write a reflection of the CBL/EDP before the final testing of the model. This gave them the opportunity to confirm their understanding of the model, write about their own contributions, and prepare mentally for the big event. Some of the redesign students went through were width of the intersection and flow of the roundabout (ensuring that it was not backwards). The tape I chose proved to be difficult to peel off. A suggestion in the future would be to test try different masking tapes and to select the one which might peel off easier. Another redesign feature was for the students to implement a rhythm so that the student drivers would uniformly move. Amazingly, this did improve time and reduce accidents!