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| **Lesson Title :** Different Factors Affecting Ramp Safety and Efficiency | **Unit #:** 1 | **Lesson #:** 2 | **Activity #:** 3 |
| **Activity Title:** Foam Trials |

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| **Estimated Lesson Duration:** | 6 days, 50 minute classes |
| **Estimated Activity Duration:** | 2 days, 50 minute classes |

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| **Setting:** | Classroom |

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| **Activity Objectives:** |

1. Keeping the ramp length the same, I can manipulate the velocity of an object through the adjustment of other ramp characteristics.
2. Based off of my own experimental data, I can predict the velocity of an object traveling down an incline.
3. I can make a claim about the relationship between mass and velocity, then support my claim through experimental evidence.
4. I can demonstrate my understanding of the relationship between ramp incline and acceleration rate through experimentation and construction of a graph.
5. I can demonstrate my understanding of the relationship between ramp length and acceleration rate through experimentation and construction of a graph.

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| **Activity Guiding Questions:** |

What can cause the velocity to change given that the ramp length remains the same?

How can we predict the velocity of an object traveling down an incline?

Does the mass of the object affect its velocity?

How does the angle / incline of a ramp affect its rate of acceleration?

How does the length of a ramp affect its rate of acceleration?

| **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):** |

(ONLS)

* Science Inquiry and Application:
  + Identify questions and concepts that guide scientific investigations;
  + Design and conduct scientific investigations
  + Recognize and analyze explanations and models; and
  + Communicate and support a scientific argument.
* Motion Graphs:
  + Instantaneous velocity for an accelerating object can be determined by calculating the slope of the tangent line for some specific instant on a position vs. time graph.
  + Instantaneous velocity will be the same as average velocity for conditions of constant velocity, but this is rarely the case for accelerating objects.
* Position vs. time graph:
  + Increasing in speed, slope becomes steeper; Decreasing in speed become less steep.
* Velocity vs. time graph:
  + The slope indicates the acceleration:
    - Increasing in speed, slope away from the x-axis; decreasing in speed, slope toward the x-axis.
    - Straight line (not necessarily horizontal): acceleration is constant.
    - Acceleration is positive for objects speeding up in a positive direction or objects slowing down in a negative direction.
    - Acceleration is negative for objects slowing down in a positive direction or speeding up in a negative direction.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

* Lab materials (3 different lengths of ramp, [foam piping cut in half lengthwise], 3 different masses of ball bearings, a stop watch, a metric ruler or tape measure, graph paper, and notebook paper)
* Exit Ticket (either have students copy questions from the board on notebook paper or print enough copies for students).
* Google Doc

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| **Teacher Advance Preparation:** |

* Create a Google Doc for recording data
* Gather lab materials listed above
* Print copies of the Exit Ticket (enough for each student to complete one individually, unless posting the questions on the board instead)

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| **Activity Procedures:** |

**Day 1 –** (50 minutes)

1. In their small groups, students will conduct an experiment to determine the relationship between ramp length, mass, and degree of incline.
2. Provide the class with the following instructions: “Provided with the following materials, design and conduct an experiment to determine the relationship between ramp length, mass, and degree of incline. Before starting your experiment, be sure to make a hypothesis about the relationship. You must display all of your results in a table / tables, and eventually convert your table(s) into a graph(s).”
   1. Note: (This activity is inquiry-based and will require the students to design their own procedure for gathering the necessary data. In a way, this will help scaffold their learning and work them slightly closer to the level of independence that the Challenge will demand of them).
   2. The groups must write a procedure and make a hypothesis before they can retrieve the supplies and begin their experiment.
3. After the teacher has checked for a procedure and hypothesis, each group will need to get the following supplies:
   1. 3 different lengths of ramp (foam piping cut in half lengthwise)
   2. 3 different masses of ball bearings
   3. A stop watch
   4. A metric ruler or tape measure
   5. Graph paper
   6. Notebook paper
4. As the students work, circulate around the room and monitor their progress. If needed, ask guiding questions that will help the students get on the right track if they are completely lost.

**Day 2 –** (50 minutes)

1. Judging from the previous day’s progress and the students’ level of understanding, begin the class with a brief introduction of the type of graphs that should be created from this experiment. If possible, select a group of students who are on the right track to give a brief presentation of their graphs. This should only last about 5 minutes total. This is just a check point to help any groups that are slightly lost get back on track.
2. Have the students get back into their groups and continue their experiments where they left off the previous day.
3. When about 20 minutes remain in the class (or when all of the groups are done with their graphs / getting close), bring the class back together.
4. Pair two groups together, and have them compare their results (both the tables and graphs). Give them about 5 minutes to do this.
5. Then have the large double groups come up to the front of the class, one large group at a time, and share their data (possibly use a Google Doc again to record, share, and compare the data across the different physics classes).
6. If there are any major inconsistencies, discuss them as a class and have the students “trouble shoot” the problems.
7. If needed, repeat trials to get a conclusive answer to the relationship between the different ramp variables.
8. As a formative assessment and exit ticket, have the students answer the following questions on a sheet of notebook paper (individually) and turn them in before leaving the class. These questions can be written on the board.
   1. What was your hypothesis?
   2. Did your results support or refute your hypothesis?
   3. Support your answer with experimental data (this should include numerical values!).

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

* Group procedure and hypothesis prior to starting the experiment
* Monitoring student progress during student-created lab
* Class discussion on findings (including discussion on graphs and Googledoc)
* Exit ticket

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

* Completed student data tables and accompanying graphs.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

* Visual learners’ needs will be met through writing questions / notes on the board. Also, multiple class discussions will take place as additional support for auditory learners. Kinesthetic learners needs will be addressed through the hand-on activities with the lab.
* Student ability levels were taken into account when grouping students (I paired highs with mediums, and mediums with lows), which successfully allowed the higher of the two in each group to help guide and bring the lower to a higher level of understanding and mastery.
* More teacher modeling and assistance was provided for lower-achieving students.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

* Successes:
  + The exit tickets helped me to get a good understanding of what portions of the activity needed to be reviewed with the students before moving on to the Challenge.
  + The Googledoc allowed for the data to be compiled and discussed verbally, while still having the data available visually. The engagement level of the students also increased.
  + The intentional grouping of my students by academic ability level and social / behavioral tendencies (I paired highs with mediums, and mediums with lows) successfully allowed the higher of the two in each group to help guide and bring the lower to a higher level of understanding and mastery. To scaffold, I intentionally provided more assistance for medium – low groups.
* Shortcomings:
  + Some of the students really struggled with creating their own hypothesis and procedure from the provided materials and previous activities. I had to provide more assistance than I had expected at the beginning. Some groups worked really quickly, but incorrectly, and got pretty far before I could correct them and get their groups back on track. In future implementations of this unit, I will place teacher check-points into the lab so that they have to get me to sign off on their progression before they can work toward the next teacher check-point.
  + The open-endedness of the lab was good because it allowed for creativity, but the lack of structure was a great struggle for many of the students.
  + The part that the groups struggled with the most was the creation of the graphs. Their graphing skills are incredibly poor.