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| **Lesson Title :** Different Factors Affecting Ramp Safety and Efficiency | **Unit #:** 1 | **Lesson #:** 2 | **Activity #:** 4 |
| **Activity Title:** Ramp Design and Proposal |

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| **Estimated Lesson Duration:** | 6 days, 50 minute classes |
| **Estimated Activity Duration:** | 4 days, 50 minute classes |

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| **Setting:** | Classroom and possibly external ramp locations |

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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. I can make a claim about the relationship between mass and velocity, then support my claim through experimental evidence.
3. I can synthesize my understanding of the relationship between ramp incline, ramp length, and acceleration rate through experimentation and construction of a ramp that meets my desired function and location.
4. I can further demonstrate my understanding of the relationship between ramp incline, ramp length, and acceleration rate through the construction of three different graphs (position vs time, velocity vs. time, and acceleration vs time) from data gathered through experimentation on my ramp.
5. I can apply my knowledge relating to the safety regulations and general restrictions in the construction of my ramp.

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| **Activity Guiding Questions:** |

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

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?

What restrictions exist for different types of ramps?

In relation to ramps, how is form related to function?

| **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
  + Use technology and mathematics to improve investigations and communications;
  + Formulate and revise explanations and models using logic and evidence (critical thinking);
  + 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.
* Acceleration vs. time graph:
  + Objects moving with uniform acceleration will have a horizontal line on this graph.
    - This line will be at the x-axis for objects that are either standing still or moving with constant velocity.
  + The area under the curve gives the change in velocity for the object.

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

* Challenge Rubrics (1. 2. 4f RampDesign\_Acc&Veloc\_AGunderman\_021415)
* Copies of Ramp Proposal Peer-Feedback Paper (1. 2. 4g RampDesign\_Acc&Veloc\_AGunderman\_021415).
* Various supplies for ramp model construction
  + Supplies provided by the teacher for this implementation included:
    - Hotwheels car tracks
    - ¾-in x 6-ft Foam Plumbing Tubular Pipe Insullation
    - ½-in. x 4 ft. x 8 ft. R-3.2 Polyiso Rigid Foam Insulation Board
    - Project Panels ¼ in. x 2 ft. x 4 ft. Birch
    - Plaskolite 18 in. x 24 in. Corrugated Plastic Sheet
    - Retractable Utility Knives (carefully monitored)
    - Various cardboard boxes and scraps
* Graph paper
* Metric measuring devices
* Stop watches

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| **Teacher Advance Preparation:** |

* Make copies of the Challenge Rubric (1. 2. 4f RampDesign\_Acc&Veloc\_AGunderman\_021415)
* Make Copies of the Ramp Proposal Peer-Feedback Paper (1. 2. 4g RampDesign\_Acc&Veloc\_AGunderman\_021415).
* Gathering supplies and tools needed for ramp construction
* Research school policies on safety that may affect the challenge

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| **Activity Procedures:** |

**Day 1 –** (50 minutes):

1. Put the students into groups of 3-4 students (or allow them to select their own groups…use your discretion based off of the range of abilities in your class). Remind them of the challenge (it is a good idea to have the challenge posted clearly on the board).

**Challenge:** Select a real life location for a needed ramp. Make a proposal for your ramp that you will present to the rest of the class. Your proposal needs to include a sketch or labeled diagram with measurements, a detailed description, justification for your ramp length and incline (using experimental data), and 3 graphs (position vs time, velocity vs. time, and acceleration vs time).

1. Students will identify and define the details of an existing ramp that they believe needs modified, or a location that they believe needs to have a ramp implemented. Students will define the type of ramp that they want to implement or redesign.
2. Students will research both the specific location (dimensions and regulations of the area) and the type of ramp that they plan to propose. Important components that they will need to focus on include safety regulations, desired function of the ramp (and the necessary design to allow this function), and pros and cons of existing designs.
3. Each student will sketch out one design for their group’s ramp, complete with dimensions and instructions. Students may use a digital program (such as SketchUp) or pencil and paper.
4. Various supplies will be made available already, however students may bring in additional supplies and / or submit a list of requested supplies to build their prototype / model to the teacher. The teacher maintains the right to deny any requests due to safety or cost reasons. (Based on teacher discretion).

**Day 2 –** (50 minutes):

1. Students will continue to work on their challenges.
2. The group will build their prototype and run the appropriate tests to collect the data needed to build the following three graphs and justify the efficiency of their ramp (position vs time, velocity vs. time, and acceleration vs time).
3. Within each group, students will share their ramp ideas and for each design, as a group, the students will list two pros and two cons.
4. The group will discuss the designs and incorporate the best components of each to work as a group and design the most efficient ramp for their selected location and function.

**Day 3 –** (50 minutes):

1. Students will continue to work on their challenges.
2. About 15 minutes into the class, pause all of the groups and have them pair up with another group for their half-way checkpoint. Every student needs a copy of the Ramp Proposal Peer-Feedback Paper (1. 2. 4g RampDesign\_Acc&Veloc\_AGunderman\_021415).
   1. Students will share their progress thus far with another group (they will use this as a “dress rehearsal” for their final presentation) for feedback.
   2. The teacher should also observe these presentations and use it as a formative assessment.
   3. The groups will then use the feedback they receive to make modifications to improve their ramps and / or the clarity of their presentation. (This is the iterative portion of the EDP).
3. Utilizing the feedback received from their peers as well as their own self-reflections on their product / proposal thus far, each group will refine their proposal and make necessary adjustments to maximize the efficiency of their ramp.
4. From these adjustments and redesign, the groups will each rebuild / alter their ramp prototype and add their new data to their existing three graphs.

**Day 4 –** (50 minutes):

1. Give students about 5 - 10 minutes to review their proposals and make any last minute plans for their presentations.
2. Students will present their final proposals to their peers and to the teacher.
3. When students are not presenting, they will observe closely and record the title of each other group’s proposal, one suggestion for improvement, one positive comment, and one question. (It may be helpful to write these requirements on the board).
4. End the class with a class discussion about acceleration, velocity, different ramps, and the three different types of graphs constructed in this challenge. Revisit any of the graphs that students appeared to struggle with in their proposals. Be sure to collect these comment / question sheets from the students as well.
5. Administer the post-test and collect it for assessment.
6. If possible, depending on the location of the ramp design, students can make refinements to their ramp designs and arrange to present their proposals to the appropriate audience responsible for making judgment calls for the specific location.

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

* Identification of ramp need / remodel and accompanying sketches
* Prototype
* Half-way checkpoint of peer practice presentations (teacher observations)
* Prototype refinements after checkpoint

**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.

* Evaluation of the Ramp Proposal with accompanying graphs (using the rubric).

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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 challenge.
* 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.
* For the lower-achieving students (during the peer-feedback portion), model suggestions, questions, and feedback will be provided to help them get started.

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

* Successes:
  + 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.
  + The peer-feedback portion of the activity was extremely successful because the students were incredibly honest with each other and they really took the time and effort to evaluate other groups’ proposals. When the groups received their feedback from their peers, they actually took the feedback really well and were energized to make improvements to their proposals.
  + The iterative portion (using peer-feedback to improve their proposal) was highly successful and every group was able to use the feedback to make improvements.
* Shortcomings:
  + The open-endedness of the Challenge 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.
  + Some of the building supplies were difficult to cut / use and most of the groups chose to construct their ramps from the materials that were easier to construct with, such as the cardboard and foam. In future implementation of this unit, I would suggest teachers provide more of these types of materials for building (possibly even recycling) and hot glue. A lot of the groups also wanted to make their ramps visibly impressive, so teachers may want to provide supplies to do this as well.
  + Most of the groups needed assistance with the collection of the data and the creation of their graphs. I would strongly suggest that more rigid requirements be provided to the students in future implementation relating to data table and graph formatting requirements.