## STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

| | |
|---|---|
| **STEM Unit Title** | **Saving Runaway Gramps** |
| Economic Cluster | Manufacturing, Materials Engineering, Civil Engineering |
| Targeted Grades | 6 |
| STEM Disciplines | Science, Technology, Engineering, and Mathematics |
| Non-STEM Disciplines | English Language Arts and Fine Arts |

## Section I: STEM Unit Overview

### Unit Overview

Students are engaged to consider the challenges faced by people in wheelchairs and develop remedial strategies following engineering design. While modern building designs follow specific regulations to provide safe accessibility to wheelchairs, many older neighborhoods still contain designs inaccessible and dangerous for people in wheelchairs. For example, many ramp designs have slopes too large or lengths too short to safely stop a rolling wheelchair. Therefore, students are challenged to design accessible ramps using common rocks and minerals to modify ramp surfaces that can safely and efficiently stop wheelchairs. In completing the design challenge, students will demonstrate understanding of mathematical relationships between speed and motion and differentiation of potential and kinetic energy. By maintaining an Engineering Log, students will also develop skills in writing quantitative ideas and evidence-based argument.

### Essential Question

How can rocks and minerals be used to regulate the speed of a moving vehicle?

### Enduring Understanding

Rocks and minerals are not only for natural beauty, they can be used for practical and technical purposes.

Physical forces that oppose motion of matter can regulate speed of the matter.

### Engineering Design Challenge

For 49 years a grandpa that is an Eagle Scout has hosted an Annual Family Reunion and Pinewood Derby on the Fourth of July. In the past, the Pinewood Derby challenged family members to develop the fastest pinewood car. The Derby champion takes home a bronze mold of Grandpa's teeth to proudly display for one year. However, this year with grandpa's weakening state, it's necessary to adapt his wheelchair ramp so that he can use it more safely. Because grandpa is unable slow his wheelchair manually, the family members have been challenged to find a way to help him slow his wheelchair down.

Grandpa's house is in a historic neighborhood with strict local building codes regarding front porches of houses. The neighborhood association is currently accepting proposals for handicap accessible ramps that will fit within their strict aesthetic guidelines. Although grandpa's ramp does not comply with ADA (American with Disabilities Act) guidelines for handicap accessible ramps because it is located within a private residence, it is possible to modify the ramp provided that a wheelchair will not reach an unsafe speed while traveling down the ramp.

Your team must use natural rock and mineral materials for modifying grandpa's ramp. Also, you may not intervene with the wheelchair in any way to create a braking effect on the wheelchair when demonstrating your team's design. Will your team be able to hold grandpa up without letting him down?

May the force of resistance be with you!

Since Grandpa's ramp locates in his front yard, adaptations to the ramp would need to be applied in an aesthetically pleasing manner and/or blend in or stand out with the surrounding environment, such as Grandpa's prized roses. Students could add color to various rocks and/or minerals to either connect with the surrounding environment, i.e. Grandpa's yard, while keeping in mind safety requirements to prevent a trip hazard to visitors. Students will complete a building permit application based on their ramp modifications.

### Time and Activity Overview

| Day | Time Allotment | Actvities |
|---|---|---|
| 1 | 50 minutes | Pretest<br>Video Clips: Runaway Vehicles<br>Brainstorming- What can we do to slow things down?<br>Introduce Engineering Team Roles |
| 2 | 50 minutes | Review Motion Concepts<br>Practice Timing/Speed Calculations<br>Review Potential and Kinetic Energy |

| | | |
|---|---|---|
| 3 | 50 minutes | Explore How different Rocks and Minerals Affect Rolling Objects |
| 4 | 50 minutes | Research rocks and minerals and explore their application |
| 5 | 50 minutes | Build Prototypes and Test |
| 6 | 50 minutes | Build Prototypes and Test |
| 7 | 50 minutes | Final Test Demonstration |
| 8 | 50 minutes | Class Competition (variables have changed with ramp) |
| 9 | 50 minutes | Building Permit Proposals |
| 10 | 50 minutes | Post Test- Present Building Permit Proposals |

## Academic Content Standards

Choose the appropriate subject and version of the standards for your curriculum. Refer to www.ode.state.oh.us.

**VERY IMPORTANT: Please do not delete any content standards below! The administrator will remove any unused standards. If you delete them from the form, you will not be able to get them back.**

| | |
|---|---|
| Pre-requisite Knowledge & Skill | 5th grade concepts of matter and motion.<br>6th grade concepts of the of rocks, minerals and soils.<br>-Minerals have specific, quantifiable properties.<br>-Igneous, metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification and form in different ways.<br>-Soil is unconsolidated material that contains nutrient matter and weathered rock. |

| Add Standard | **Mathematics** |
|---|---|
| Grade/Conceptual Category | 6 |
| Domain | Expressions and Equations |
| Cluster | Represent and analyze quantitative relationships between dependent and independent variables. |
| Standards | Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time. |

| Add Standard | **Mathematics** | |
|---|---|---|
| Grade/Conceptual Category | 6 | |
| Domain | Number System | |
| Cluster | Apply and extend previous understandings of numbers to the systems of rational numbers. | |
| Standards | Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate. | |

| Add Standard | **English Language Arts** | |
|---|---|---|
| Grade | 6-8 | |
| Strand | Science and Technical Subjects Grades 6-8 | |
| Topic | Key Ideas and Details | |
| Standard | Cite specific textual evidence to support analysis of science and technical texts.<br>CCSS.ELA-LITERACY.RST.6-8.2<br>Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.<br><br>CCSS.ELA-LITERACY.RST.6-8.3<br>Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. | |

| Add Standard | **English Language Arts** | |
|---|---|---|
| Grade | 6-8 | |
| Strand | Science and Technical Subjects Grades 6-8 | |
| Topic | Integration of Knowledge and Ideas | |
| Standard | CCSS.ELA-LITERACY.RST.6-8.7<br>Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).<br><br>CCSS.ELA-LITERACY.RST.6-8.8<br>Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.<br><br>CCSS.ELA-LITERACY.RST.6-8.9<br>Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. | |

| Add Standard | English Language Arts | |
|---|---|---|
| Grade | 6 | |
| Strand | Tests Types and Purpose | |
| Topic | Write Arguments to support claims with clear reasons and relevant evidence. | |
| Standard | CCSS.ELA-LITERACY.W.6.1.A<br>Introduce claim(s) and organize the reasons and evidence clearly.<br><br>CCSS.ELA-LITERACY.W.6.1.B<br>Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.<br><br>CCSS.ELA-LITERACY.W.6.1.C<br>Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons.<br><br>CCSS.ELA-LITERACY.W.6.1.D<br>Establish and maintain a formal style.<br><br>CCSS.ELA-LITERACY.W.6.1.E<br>Provide a concluding statement or section that follows from the argument presented. | |

| Add Standard | Social Studies | Ohio |
|---|---|---|
| Grade | | |
| Theme | | |
| Strand (pk-8 only) | | |
| Topic | | |
| Content Standard | | |

| Add Standard | Science | Ohio |
|---|---|---|
| Grade | 6 | |
| Theme | Physical Science | |
| Topic | Matter and Motion | |
| Content Standard | There are two categories of energy: kinetic and potential.<br>Objects and substances in motion have kinetic energy. Objects and substances can have energy as a result of their position (potential energy). | |

| Add Standard | Science | Ohio |
|---|---|---|
| Grade | 6 | |
| Theme | Physical Science | |
| Topic | Matter and Motion | |
| Content Standard | An object's motion can be described by its speed and the direction in which it is moving. An object's position and speed can be measured and graphed as a function of time. | |

| Add Standard | Science | Ohio |
|---|---|---|
| Grade | 6 | |
| Theme | Earth and Space Sciences | |
| Topic | Rocks, Minerals, and Soil | |
| Content Standard | Rocks, minerals, and soil have common and practical uses. | |

| Add Standard | Science | Ohio |
|---|---|---|
| Strand | | |
| Course Content | | |
| Content Elaboration | | |

| Add Standard | Science | Ohio |
|---|---|---|
| Strand | | |
| Course Content | | |
| Content Elaboration | | |

| Add Standard | Fine Arts | Ohio |
|---|---|---|
| Enduring Understanding | | |
| Progress Points | | |
| Grade Level | | |
| Content Statement | | |

| Add Standard | Fine Arts | Ohio |
|---|---|---|
| Enduring Understanding | Personal Choice and Vision: Students construct and solve problems of personal relevance and interest when expressing themselves through visual art. | |
| Progress Points | E. Connect the content of visual artworks to interdisciplinary concepts, issues and themes. | |
| Grade Level | 6 | |
| Content Statement | 4PE Connect selected ideas, concepts and processes used in visual art with those used in other academic disciplines. | |

| Add Standard | **Fine Arts** | Ohio |
|---|---|---|
| Enduring Understanding | Authentic Application and Collaboration: Students work individually and in groups to focus ideas and create artworks that address genuine local and global community needs. | |
| Progress Points | E. Connect the content of visual artworks to interdisciplinary concepts, issues and themes. | |
| Grade Level | 6 | |
| Content Statement | 1PR Demonstrate technical skill and craftsmanship in the use of materials, tools and technology to solve an artistic problem. | |

## Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

| | |
|---|---|
| **Performance Task, Projects** | Grandpa's Ramp Prototype<br>Permit Application |
| **Quizzes, Tests, Academic Prompts** | Pretest/Post-test |
| **Other Evidence** (e.g. observations, work samples, student artifacts, etc.) | Research Grids<br>Practice with grit materials<br>Building Permit Proposal |
| **Student Self- Assessment** | Engineering Log Reflections |

Technology Integration

## ADISC Technology Integration Model*

| | Type of Integration | Application(s) in this STEM Unit |
|---|---|---|
| A | Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners. | Smart-Phone Speed App<br>Stopwatch |
| D | Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display. | SMART board for class speed calculations |
| I | Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods. | Computer with internet connection |
| S | Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships. | Work/friction simulation |
| C | Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration. | Movie Capture timing<br>Google Docs for submitting proposal |
| | **The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton* | |

Career Connections

## Career Description

Architects:
An architect is someone who loves to design and is specifically trained and licensed to work on the planning and design of buildings and landscapes. Architecture is an art that works hand and hand with science to design places where people can live, work, eat and play. The aspect of an architect's work can be divided into 3 main phases; design, documentation and construction. During the documentation phase, architects produce detailed drawings and use technology, such as CAD, to test if their designs will work. This stage can involve many revisions based on client needs, requirements and budgets. Depending on the project, the architect may need to take into consideration laws surrounding the preservation of the local environment and any historic parts of a building. Architects work closely with Civil Engineers.

City Inspectors & Code Officials:
City inspectors often have specific disciplines of competency and work to aid the overall code official or plan reviewer in making decisions that affect meeting the minimum standards of the built environment. "Code officials play a major role in ensuring that all commercial, residential, public assembly and other buildings within a governmental jurisdiction are constructed in accordance with the provisions of the governing building code." (International Code Council, ICC) These individuals "may be responsible for building inspections, plumbing inspections, fire prevention inspections, mechanical and electrical inspections, building and zoning administration…" (ICC)
Each discipline specific worker is often certified they are qualified to be an expert in their field:
"Building inspectors review drawings and specifications for planned repairs of existing buildings, construction of new building projects, and building sites being considered for development."
"Electrical inspectors check the quality of materials, the installation work, and the safeguards in electrical [wiring/power] systems." (ICC)
Mechanical inspectors review heating, ventilating, and air-conditioning (HVAC) equipment, flues for chimneys, energy efficiency provisions, air characteristics, and water heat transfer systems.
"Plumbing inspectors check for proper design and installation of plumbing systems, including sanitary and storm drainage systems, sanitary facilities, water supplies, and storm water and sewage disposal in buildings."(ICC)
"Property maintenance or housing inspectors inspect existing buildings to check for health or safety violations and the condition of the exterior property."(ICC)
"The plan reviewer examines the construction documents used to describe a project, including architectural, structural, site plan, mechanical, plumbing, electrical and fire protection drawings as well as the corresponding specifications, structural design calculations and soil report." (ICC)

City/Urban Planner:
Urban planners identify community needs and develop short and long term plans to create, grow, or revitalize a community. They may examine plans for proposed facilities, such as schools, to ensure that these facilities will meet the needs of a changing population. As an area grows or changes, planners help communities manage the related economic, social, and environmental issues, such as planning a new park, sheltering the homeless, or making the region more attractive to businesses. City planners promote the best use of a community's land and resources for residential, commercial, or recreational purposes. Planners work with public officials, community members, and other groups to identify community issues or goals. Using research, data analysis, and collaboration with interest groups, planners formulate strategies to meet goals. Planners use a variety of tools and technology in their work, including geographic information systems (GIS) tools that analyze and manipulate data, statistical software, visualization and presentation programs, financial spreadsheets, and other database and software programs.

Civil Engineer
Civil Engineering is the oldest engineering discipline. A Civil Engineer works manmade and natural environments to design structures that define modern civilization. A few examples of these structures include bridges, highways, dams, railroads, airports, sewer systems, and buildings.

Civil Engineers also manages construction projects for public and private sectors. Civil Engineers reviews construction plans and cost to determine if a project feasible. Many Civil Engineer will work outdoors at construction sites to monitor construction projects.

Civil engineers need a bachelor's degree in civil engineering and generally must obtain a license to work on public sector projects.

Counseling and Disability Service Coordinators:
“Businesses that serve the public must modify policies and practices that discriminate against people with disabilities; comply with accessible design standards when constructing or altering facilities; remove barriers in existing facilities where readily achievable; and provide auxiliary aids and services when needed to ensure effective communication with people who have hearing, vision, or speech impairments.”(DOJ:ADA)
These service provider coordinators work in various fields of service ranging from non-profit organizations to for-hire assistance service providers and often carry technical certifications above and beyond basic requirements for bachelors and masters degrees in Higher Education, Counseling and Guidance, Special Education, Social Work, or Psychology and include roles such as:
ADA Coordinators work to “establish grievance procedures, communicate policy, coordinate departments, and conduct evaluation plans“(ACTCP) for overseeing program resources.
Education Development Instructors drive programs that assist in lifelong learning.
Home\Activities Coordinators are often trained as registered nurses and assist with directing individuals towards interests that help maintain healthy lifestyles or mobility.
Interpreters work with various visual and audio tools to assist the hearing or visually impaired, fluent in sign language, are certified to interpret, and/or are required to obtain a bachelor’s degree in education.
Rehabilitation Technicians assist with individuals recovering from life altering injuries by helping with “paperwork, treatment setups, lifting/ relocating patients, or cleaning medical equipment.”(Rehab Aide)
Workforce Development Coordinators or Job and Community Connections Coaches lend a hand in instructing individuals with disabilities in job task training, job placement, and may do program follow-up to ensure ADA anti-discrimination laws are being followed. “[Coordinators link businesses to individuals with disabilities looking for employment.]”(DOR)

Geologist:
Geologists study the Earth. This study includes the materials the Earth is made of, the structures of those materials, and the processes that shape the Earth over time. The information learned from Earth’s geologic past can be used to understand the present and provide evidence to predict how these past processes and events can impact the future. Geologists usually choose an area of focus, including mineralogy, volcanology, hydrology or oceanography. Because all people use earth materials on a daily basis, natural resource companies, environmental consulting companies, government agencies (U.S. Geological Survey), universities, and nonprofit organizations often hire geologists for research and problem-solving assignments. Although most geologists spend some time doing field work, they also require skills that would allow them to work in laboratories, classrooms or offices preparing reports and doing calculations.

Materials Engineer
Materials engineers develop and work with materials to create a range of products to solve problems. They study the physical and chemical properties of materials to design new ways to use existing materials and to create new materials. Materials engineers are good at planning and evaluating projects, working with other engineers and managers, and writing proposals and reports. Therefore, they have good analytical and problem-solving skills. Teamwork requires good speaking and writing skills.

Public Safety Officer:
As the name implies, a Public safety officer is someone whose job it is to protect people from hazards that naturally occur in a community. A public safety officers job may include but is not limited to:responding to emergency calls, administering first aid, directing or using emergency equipment in to fight fires or to address other dangerous situations, controlling  crowds, or leading practice exercises in emergency response.

## Section II: STEM Lesson Plan

**Title of Lesson**

**Day One: Pretest/Brainstorming**

Time Required

50 Minutes

Materials

Appendix A: Pre/Post Test (one per student)
Appendix B: Pre/Post Test Answer Key
Appendix C: Learning Through Failure–Brainstorm (one per student)
Appendix D: Engineering Design Challenge (one per student)
Appendix E: Engineering Design Challenge Rubric (one per student)
Appendix F: Engineering Design Team Career Roles (one per team)
Computer with LCD projection
Video Clips:
-http://www.killsometime.com/videos/5405/Runaway-Truck-Ramp (show first 45s)
-https://www.youtube.com/watch?v=RdrCUEhFiTY - Wheelchair Mishap -(show first 15s )
-https://www.youtube.com/watch?v=HyYlUcbGJIE -Extreme Ramp Sports (2m31s)
-https://www.youtube.com/watch?v=50onj1Y-Cos-Runaway Wheel Chair (30s)

Objectives

Students will be able to describe the dangers of runaway vehicles and why it is important to have a means for slowing them down in extreme situations.

Instructional Process

1. Administer Pre-Test.
2. "Brainstorming" Share videos with class (these situation may seem painful).
3. After each video give students time to write notes on Appendix C: Learning Through Failure–Brainstorm
   What happened- What do you think was the cause?
4. Divide students into teams of 4 and assign or allow students to choose team roles, using Appendix F: Engineering Design Team Career Roles
5. Ask each student to choose one of the “runaway vehicles” and brainstorm a list of 5-10 ways to slow it down safely.
6. Lead a sharing/discussion session with the class.
7. Present the initial Engineering Design Challenge scenario to class.
8. With time left, brainstorm as a class potential problems for keeping a runaway wheelchair safe.

Differentiation

Provide modifications as needed for individual students for the Pre-Test.

Be aware of different learning styles when assigning informal groups. There should be a mix that allows discussion without one personality taking control.

Assessments

Pretest should be a formative assessment of students prior knowledge, and should be a guide for making modifications throughout the remaining unit.

Student responses from the "Brainstorming" handout may be collected and checked for completion.

## Section II: STEM Lesson Plan

**Title of Lesson**

**Day 2: Speed and Energy**

Time Required

50 minutes

Materials

Appendix G: Potential and Kinetic Energy Review (one per student)
Appendix H: Potential and Kinetic Energy Review ANSWER KEY
AND Additional Teacher Information
Appendix I: Team Speed Calculation (one per student)
Appendix J: Team Speed Calculation ANSWER KEY
Appendix K: Team Marble Speed Trails (one per team)
Appendix L: Speed and Energy Assessment (one per student)
Appendix M: Speed and Energy Assessment ANSWER KEY
Calculators (one per team)
Marbles (one per team)
Masking Tape (one role per class)
Stop Watches (one per team)
Graph Paper (one per student)
Computer connected to LCD projector
SMART Board (if available)

Video clip :
https://www.youtube.com/watch?v=Jnj8mc04r9E (1m22s)

Digital Device (one per team) with VidAnalysis Free installed: <https://play.google.com/store/apps/details?id=com.vidanalysis.free&hl=en%20VidAnalysis>

Objectives

Students will review and practice calculating speed of a moving object and graphing results on an X/Y graph.

Students will also review and identify examples of potential and kinetic energy.

Instructional Process

Before class, measure and tape off a 24 square foot area for students to practice measuring speed.

1. Share Wile E. Coyote & Roadrunner video clip with class to engage and review examples of potential and kinetic energy. Students participate in small group and class discussions in order to complete Appendix G: Potential and Kinetic Energy Review
2. Discuss different reasons why it is important to record the speed of objects and review the formula for calculating speed. (distance/time). Divide the distance traveled by the amount of time it took to travel that distance.
3. Have teams of students complete Appendix I: Team Speed Calculation together as a team. Or, you may choose to complete it together as a class on Smart Board.
4. Distribute Appendix K: Team Marble Speed Trails and instruct teams to using the taped off 24 square foot area to practice measuring speed:
   - Allow teams to roll a marble at different rates, using stopwatches to record the time.
   - Instruct teams to complete 3-5 trials.
   - Instruct students to calculate the speed for each trial using their collected and recorded data.
   - Instruct students to graph their trials, making a simple X/Y axis line graph.
5. Distribute Appendix L: Speed and Energy Assessment and allow time for students to complete individually. Optionally, if time is limited, this may be assigned for homework.

## Differentiation

It is recommended that students use digital devices to capture time- stopwatches may be used.

If a spreadsheet program is not available for graphing- hand-drawn graphs on graph paper are completely acceptable.

## Assessments

Appendix G: Potential and Kinetic Energy Review
Appendix I: Team Speed Calculation
Appendix K: Team Marble Speed Trails
Appendix L: Speed and Energy Assessment

## Section II: STEM Lesson Plan

**Title of Lesson**

**Day 3: Explore Various Rocks and Minerals Effects on Rolling Objects**

Time Required

50 minutes

Materials

Appendix N: Engineering Design Process (one per team)
Appendix O: Engineering Logbook (one per student)
Toy Car 1:64 scale (one per team)
Marbles (one per team)
Golf Balls (one per team)
Ping Pong Balls (one per team)
Grit (one cup per team)
Sand (one cup per team)
Gravel (one cup per team)
Various grades of sandpaper (one sample per team)
Cafeteria trays (one per team)
----------Exit Ticket (Appendix: J)

Objectives

Students will review the Engineering Design process and begin to work through the design cycle as they define the problem that they are working toward solving and constraints to the challenge.

Students will experiment with materials prior to moving into the planning phase of the Engineering Design process and begin to use their log books to record observations and reflections.

Instructional Process

1. Discuss Appendix N: Engineering Design Process and Appendix O: Engineering Logbook.

*Note that the Engineering Design Process is a cycle, there is no official start or end point. You can move back and forth between steps, or repeat the cycle. For example, after you improve your design once, you may want to begin all over again to refine your ideas.

Stress the importance of writing down observations, making sketches, listing the steps used to build, and reflection. Show how and where all of these things will be done in their Engineering Log Book.

2. Ask the following questions to guide students toward defining the problem and constraints:
   -What is the problem? (Grandpa can no longer slow his wheelchair manually so we need to find a way to slow his wheelchair for him)
   -How have others approached the problem? (Possible answers: brakes on the wheelchair, longer ramps, lower ramps etc.)
   -What are your constraints? (Adaptations to the ramp would need to be applied in an aesthetically pleasing manner. Adaptations to the ramp must include some kind of rocks or minerals. The wheelchair must stop within 6 inches of the end of the ramp.)
3. What are some solutions? Brainstorm ideas. Choose the best one.
4. Review the remaining steps in the design process:
   -Plan-draw a diagram, make lists of materials you will need.
   -Create-follow your plan and create something.
   -Test it out!
   -Improve-what works? What doesn't? What could work better? Modify your design to make it better. Test it again.
5. Provide student teams with a sample of all of the materials available to use in the design process along with a variety of items that roll: matchbox cars, marbles, golf balls and ping pong balls. Instruct teams to experiment with rolling things across the tray, then rolling them through each material. Have students complete the chart in their logbook to record their observations.

| | |
|---|---|
| Differentiation | Students should have been placed on Teams based on their strengths. If team are not meshing here - changes are recommended. |
| Assessments | Class discussion<br>Appendix O: Engineering Logbook<br>Appendix P: Exit Ticket |

## Section II: STEM Lesson Plan

**Title of Lesson**

**Day 4: Rock, Roll, and Slow Down!**

Time Required

50 minutes

Materials

Computer with Internet connection
Appendix Q: Rock On and Slow Down (one per student)
Appendix R: Hard as a Rock (relatively) (one per student)
Appendix S: Rolling! Rolling! Rolling! (one per student)
Marble (one per team)
Ruler (one per team)
Shoe boxes (one per team)
Samples: halite, gypsum/talc, sand/quartz (one cup per team)
Paper towels (one role per class)
Large paper rectangle (one per team)
Testing surfaces: glass plates, copper strips, aluminum pie plates (one each per team)

Objectives

Students will research the properties of common minerals
Students will experiment with the resistant properties of common minerals on a slope
Students will become familiar with the hardness of common materials for future reference

Instructional Process

1. Present students with the Essential Questions:
   • Which properties of a rock/minerals would work best to slow a vehicle moving down a slope?
   • What earthen materials would best serve to increase friction to slow a vehicle moving down a slope?
2. Before beginning research, send students to simulation at <https://phet.colorado.edu/en/simulation/legacy/ramp-forces-and-motion> to explore the different forces that are at work on an object moving down a ramp.
3. Instruct students to use the Mineral Test table on Appendix Q: Rock On and Slow Down and go to: <http://geology.com/minerals/> to fill
   in information for the various properties of hardness, texture, common occurrence in nature, and industrial applications.
4. Instruct students to test the hardness of mineral sample (from research activity) and answer the questions on Appendix R: Hard as a Rock (relatively).
5. For the last activity, Appendix S: Rolling! Rolling! Rolling!, instruct students to build a ramp with a ruler inside a shoe box.
6. Using Appendix S: Rolling! Rolling! Rolling! to record information- Instruct students to add bits of the mineral to the ruler and time how long it takes the marble to reach the end.

Differentiation

Some students may need help with the reading of the research exercise.
Students with physical disabilities may need help with the ruler activity as well as the scratch hardness test.

Assessments

Appendix Q: Rock On and Slow Down
Appendix R: Hard as a Rock (relatively)
Appendix S: Rolling! Rolling! Rolling!

## Section II: STEM Lesson Plan

**Title of Lesson**

**Day 5&6 Slowing Grandpas Ride**

Time Required

50 minutes

Materials

Appendix T: Suggested Ramp Design (one per teacher)
Test Ramps (one per team)
Sticky notes for each team (one packet)
Various rocks and minerals as are available (various grades gravel, sand, gypsum, etc.)
Adhesives (glues or double sided tape)
Digital Device (one per team) with suggested free app installed - "VidAnalysis free"
<https://play.google.com/store/apps/details?id=com.vidanalysis.free&hl=en%20VidAnalysis>
Stopwatch
Toy car (1:64 scale)

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Objectives

Using what they have learned about rocks and minerals, students will design and build a prototype ramp in order to decrease the speed of a rolling object.

Instructional Process

1. Review the Engineering Design Challenge with students.
2. Instruct students to create designs in their logbooks before they begin building.
3. Review designs with students and provide time to build designs.
4. When students finish their first designs allow them to test the speed with a timing app and record results.
5. Discuss individual successes and failures with the different groups.
6. After their first test, remind students to record results and instruct them to redesign in order to try to make improvements.
7. Encourage students to work toward a final design that they can test in front of class.

Differentiation

If electronic apps. are not available- allow students to use stopwatches to record their times.

Engineering logbooks- may be reformatted as necessary for student writing modifications.

Teams may require individual guidance with using materials and tools properly -redirect as necessary.

Assessments

Engineering Logbooks will provide evidence or ramp surface plans/designs. They will also be the medium through which students record refections on the Engineering Design Process.

## Section II: STEM Lesson Plan

| | |
|---|---|
| **Title of Lesson** | **Day 7- Teams Demonstrate Final Testing** |
| Time Required | 50 minutes |
| Materials | Digital Device (one per team) with VidAnalysis Free installed: <https://play.google.com/store/apps/details?id=com.vidanalysis.free&hl=en%20VidAnalysis><br>Test ramps<br>Toy car 1:64 scale (one per team) |
| Objectives | Using what they have learned about rocks and minerals, students will test and observe their own and others' attempts to decrease the speed of a rolling object. |
| Instructional Process | 1. Review the Engineering Design Challenge with class.<br>2. Instruct Teams to check final designs in their logbooks before they perform their final test.<br>3. As each group tests- instruct students to record results and details about each attempts.<br>4. Based on the log of test results-lead a discussion on the various successes witnessed among groups.<br>5. Instruct students to record final reflections in their log books. |
| Differentiation | If electronic apps. are not available- allow students to use stopwatches to record their times.<br><br>Engineering Logbooks- may be reformatted as necessary for individual student writing modifications. |
| Assessments | Team Designs graded using the Engineering Design Challenge Rubric. |

## Section II: STEM Lesson Plan

**Title of Lesson**

**Day 8: Resist a Collision**

Time Required

50 minutes

Materials

Test Ramps
Appendix U: Friction no Collision Challenge
Water spray bottle (one per Team)
Shaved ice (one cup per Team)
Cardboard ramp surface (one per Team)
Rocks and Minerals (various grades gravel, sand, gypsum, etc.)
Adhesives (glues or double sided tape)
Digital Device (one per team) with VidAnalysis Free installed:
<https://play.google.com/store/apps/details?id=com.vidanalysis.free&hl=en%20VidAnalysis>
Toy car 1:64 scale (one per team)

Objectives

Using what they have learned about building their test ramp- students will makes modifications to respond to a change in variables (surface conditions).

Instructional Process

1. Read the change of scenario to the students, Appendix U: Friction no Collision Challenge (Grandpa's wheelchair will now encounter ice and snow).
2. Explain to students that the challenge is to use rocks and/or minerals to help slow down his wheelchair down the ramp in rain or snow to prevent a collision with friction.
   *Goal: Stop Grandpa from entering into the street (prevent a collision from the decreased friction).
   **Bonus Goal: Be the team to slow him down closest to the ramp in rain then snow.
3. Mist a random student ramp surface with water:
4. Use the times apps. to test as you allow students to see the changes as the car attempts the drive.
5. Allow students time to make modifications to their ramp surfaces.
6. Repeat the challenge- this time spread shaved ice.
7. At the end of class have a friendly competition for students to see how/if their changes worked.
8. Allow for time for students to reflect in their log books on the change in variables.

Differentiation

If electronic apps. are not available- allow students to use stopwatches to record their times.

Engineering Logbooks- may be reformatted as necessary for student writing modifications.

Assessments

Teams recorded reflections on steps taken to meet changes in conditions in their Engineering logbooks.

## Section II: STEM Lesson Plan

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|---|---|
| **Title of Lesson** | **Day 9: Do you have a permit?** |
| Time Required | 50 minutes |
| Materials | Appendix V: Permit Application Process (one per student)<br>Appendix W: Permit Application Checklist and Rubric (one per student)<br>Appendix X: Build Site Image<br>Structural Guidelines paper (Appendix: O) (one per student)<br>Computer with Internet access and digital accounts (one per student) |
| Objectives | Using the data collected while building their test ramp surface- students will prepare a written application including an argument supporting their design to obtain a permit for a structure outside of community guidelines. |
| Instructional Process | 1. Introduce the permit application process by showing students structural guidelines as well as a permit application.<br>2. Provide students with pictures that illustrate the structure and environment where the ramp will be built . Guide students through the requirements of the rubric.<br>3. Instruct students to use data from their Engineering Logbooks to make their case as they work through the application.<br>4. Answer questions and direct students back to the structural guidelines and pictures as they prepare their permits. |
| Differentiation | Student applications may be prepared as an online document. (ex. google docs)<br>Students may present their applications to the class. |
| Assessments | Appendix P: Permit Application Process<br>Appendix Q: Permit Application Checklist and Rubric |

## Section II: STEM Lesson Plan

| | |
|---|---|
| **Title of Lesson** | **Day 10 - Concluding Arguments (optional presentation)** |
| Time Required | 50 minutes |
| Materials | Appendix A: Pre/Post-Test (one per student)<br>Computer connected to LCD projector |
| Objectives | Students will demonstrate their argument for acceptance of their permit applications.<br><br>Students will demonstrate understanding of motion and uses of rocks and minerals on a Post Test. |
| Instructional Process | 1. Assign an order by which students may present their Permit Applications.<br>2. Before the presentations begin-review the requirements of the rubric.<br>3. Begin presentations and allow peers to ask questions of the presenter as they might at a zoning hearing.<br>4. Conclude the unit by administering the post-test for the “Saving Runaway Gramps” unit. |
| Differentiation | Student applications may be prepared as an on-line document. |
| Assessments | Students’ permit applications evaluated with the rubric<br>Appendix A: Post-Test |

## Section III: Unit Resources

### Materials and Resource Master List

Appendix A: Pre/Post-Test
Appendix B: Pre/Post-Test Answer Key
Appendix C: Learning Through Failure–Brainstorm
Appendix D: Engineering Design Challenge
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Appendix G: Potential and Kinetic Energy Review
Appendix H: Potential and Kinetic Energy Review ANSWER KEY and Additional Teacher Information
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Appendix S: Rolling! Rolling! Rolling!
Appendix T: Suggested Ramp Design
Appendix U: Friction no Collision Challenge
Appendix V: Permit Application Process
Appendix W: Permit Application Checklist and Rubric
Appendix X: Build Site Image

Digital Device (one per team) with VidAnalysis free <https://play.google.com/store/apps/details?id=com.vidanalysis.free&hl=en%20VidAnalysis>
Alternate purchase apps: (HIDRIV Timing APP (Chrome Store) or SprintTImer-Photo Finish (App Store)
Computer with internet access and digital accounts (one per student)
Computer with internet access (one per teacher)
Smart Board and Projector (one per teacher)
Calculators (one per team)
Marbles (one per team))
Masking Tape (one roll)
Graph Paper (one sheet per team)
Toy Car 1:64 scale (one per team)
Fine sand (one cup per team)
Sandpaper/variety of grades (one sample each per team)
Gravel Of Various Grades (one cup each per team)
Coarse Sand (one cup each per team)
Cafeteria Trays (one per team)
Ruler (one per team)
Shoe Box (one per team)
Sample of Halite (salt) (one cup each per team)
Sample of Gypsum/Talc (plaster mix) (one cup each per team)
Sample of Sand/Quartz (one cup each per team)
Paper Towels (one per team)
Large Paper (one per team)
Glass Plates (one per team)
Copper Strips (one per team)
Aluminum Pie Plates (one per team)
Various Adhesives/Glues and Double Sided Tape (one each per team)
Stopwatch (one per team)
Test Ramps (one per team) (appendix: N)
Water Spray Bottle (one per team)

Shaved Ice (one cup per team)
Sticky notes (one pack per team)
2"x4"x36" boards (one for each ramp)
1"x2"x36" boards (two for each ramp)
3"x36" Strips of cardboard (one for each team)
Assorted screws and nails (at least four of each per ramp)

Video Clips:
"Potential Energy: Wile E Coyote & Roadrunner"
https://www.youtube.com/watch?v=Jnj8mc04r9E (1m22s)
"Runaway-Truck-Ramp"
http://www.killsometime.com/videos/5405/Runaway-Truck-Ramp (first 45 seconds)
"Raw Video: Aide Clings to Runaway Wheelchair"
https://www.youtube.com/watch?v=RdrCUEhFiTY - wheelchair mishap (first 15s)
"Nitro Circus - Exclusive Nitro Mega Ramp training footage"
https://www.youtube.com/watch?v=HyYlUcbGJIE -Extreme ramp sports (2m31s)
"AA Run Away Wheelchair"
https://www.youtube.com/watch?v=50onj1Y-Cos-Runaway Wheel Chair (30s)

## Key Vocabulary

Acceleration: The change in an object's velocity over time, measured in distance per unit time per unit time (for example meters per second per second or m/s2). Acceleration (a) is calculated by dividing the change (symbolized by Δ, the Greek letter delta) in velocity (v) by the change in time. (Vision Learning, 2016)

Atoms: The smallest unit of an element that retains the chemical properties of the element. Atoms can exist alone or in combinations with other atoms forming molecules. (Vision Learning, 2016)

Compound: A material formed by the chemical combination of elements in defined proportions. Compounds can be chemically decomposed into simpler substances. (Vision Learning, 2016)

Energy: An abstract property defined as the capacity to do work. The basic forms of energy include chemical, electrical, mechanical, nuclear, and radiant (light). (Vision Learning, 2016)

Force: An influence (a "push or pull") that changes the motion of a moving object (e.g., slows it down, speeds it up, changes its direction) or produces motion in a stationary object. The strength of a force is calculated by multiplying the mass of the object by its acceleration. In the metric (or SI) system, force is measured in newtons. (Vision Learning, 2016)

Friction: surface resistance to relative motion, as of a body sliding or rolling. (friction, n.d.)

Gravity: The fundamental force of attraction that all objects with mass have for each other. (gravity, n.d.)

Igneous: Formed from the cooling and crystallization of a magma. Igneous rocks can be extrusive, meaning that they cooled on or very near Earth's surface, or intrusive, meaning that they cooled below Earth's surface. (Vision Learning, 2016)

Kinetic Energy: The energy an object possesses by virtue of its motion. An object of mass m moving at velocity v has a kinetic energy of ½m·v2. (Vision Learning, 2016)

Mass: A fundamental property of matter which is a numerical measure of the inertia of an object or the amount of matter that an object contains. The mass of an object is different from its weight as mass is independent of the gravitational field exerted on an object. (Vision Learning, 2016)

Matter: The substance that makes up physical objects. (Vision Learning, 2016)

Metamorphic: Formed through the processes involved in metamorphism, which include deep burial, exposure to high temperatures and pressures, and interactions with hydrothermal fluids. Metamorphic rocks are generally considered to have a parent rock, or protolith, which can be any rock type. The minerals and textures that are produced through metamorphism are indicative of both the protolith and the metamorphic environment. (Vision Learning, 2016)

Mineral: A naturally formed, inorganic solid with a specific chemical composition and characteristic crystal structure. (Vision Learning, 2016)

Molecule: A particle formed by the chemical bonding of two or more atoms. The molecule is the smallest particle of a chemical compound that retains the chemical properties of the compound. (Vision Learning, 2016)

Natural Resources: Materials produced through or contained within Earth's natural systems and used by humans and other species. They include minerals and soil, water, air, and various plant and animal species (such as trees cut for wood, fish eaten for protein, and bees that pollinate plants). (Vision Learning, 2016)

Potential Energy: The energy an object possesses by virtue of its position in relation to a field of force. For example, lifting a mass m by h meters increases its potential energy by m·g·h, where g is the acceleration due to gravity. (Vision Learning, 2016)

Properties of Minerals: Color, luster, density, hardness. (Vision Learning, 2016)

Ratio: The relationship between two or more quantities; relative amounts of two or more values expressed as a proportion. (Vision Learning, 2016)

Rock 3 types: Made of minerals, formed differently. (Vision Learning, 2016)

Sedimentary Rock: Formed from the deposition or precipitation of sediments. Sedimentary rocks consist of sediments that have been compacted and cemented together. (Vision Learning, 2016)

Solids 2 types: Inorganic: Never lived Organic: lived A collection of atoms or molecules that are held together so that, under constant conditions, they maintain a defined shape and size. (Vision Learning, 2016)

Velocity: The speed at which an object is traveling, measured in distance per unit time (for example meters per second or m/s). Compare to acceleration. (Vision Learning, 2016)
http://www.visionlearning.com/

Weight: A measure of the force exerted on an object by a gravitational field. The weight of an object equals its mass times the force of gravity: w=m*g. (Vision Learning, 2016)

Work: The transfer of energy from one object to another, especially in order to make the second object move in a certain direction. Work is equal to the amount of force multiplied by the distance over which it is applied. If a force of 10 newtons, for example, is applied over a distance of 3 meters, the work is equal to 30 newtons per meter, or 30 joules. The unit for measuring work is the same as that for energy in any system of units, since work is simply a transfer of energy. Compare energy, power. (work, n.d.)

## Technical Brief

A wheelchair rolling across a surface will be subjected to two forces. These forces are friction and rolling resistance. For a wheelchair user, both forces are impact the use of a wheel chair. Friction provides traction between the wheel and the surface the chair is rolling across. Without traction, the wheelchair's wheels would slip making it difficult, if not impossible, for the user to move or control the wheelchair. Rolling resistance impacts how hard the user has to work to move the wheelchair across a surface. When rolling resistance is low, it is easy for the user to move the wheelchair across a surface and harder to stop the wheelchair. When rolling resistance is high it is harder to move the wheelchair across a surface and easier to stop the wheelchair. Friction is the force resisting the relative motion of two surfaces sliding against each other. Friction is caused by primarily by adhesion and surface roughness.

The amount of pushing force required to overcome friction is determined by the amount of force the object is exerting on the surface and the coefficient of friction. For example, for objects setting on a table, friction increases with weight. Once an object is moving, the coefficient of friction can change, changing how much pushing force is required to overcome friction. Rolling resistance is the force that resists the motion of an object rolling on a surface. Consider a wheelchair tire rolling on a flat surface. The tire will deform to some extent, and that deformation will cause some resistance to the rolling motion. The surface the tire is rolling across may also deform, particularly if it is relatively soft. For example, sand is a soft, rolling-resistant surface. Moving a

wheelchair across a paved roadway is much easier than across a white sandy beach.

The most significant factors that determine rolling resistance are:

- Weight
- Wheel diameter
- Tread material/hardness
- Floor material/finish
- Floor conditions (roughness, cleanliness, slope, etc.).

The floor material and condition can be impacted by the rocks and minerals with different physical properties, such as hardness, texture, shape, and size. These different physical properties enable rocks and minerals to have real world applications. For example, rocks with a higher degree of coarseness.

Rocks and minerals are used for many common practical uses. They form the aggregate for concrete and asphalt. They are also used in structures including walls and foundations. Rocks perform a both decorative and useful task of forming borders around garden. Finally, minerals are the basis of many indoor building materials including different drywall and plaster components.

## Safety and Disposal

It is recommended that:
-Students work with adult supervision when building with grit and glue
-Students work with goggles whenever using grit materials - either in building or testing
-Grit materials may cause slippery surface if not anchored- sweep work/test areas when finished

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## Section IV: Appendices

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