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	**Protecting Precious Cargo**
Economic Cluster	Human Performance
Targeted Grades	5
STEM Disciplines	Science, Technology, Engineering, Math
Non-STEM Disciplines	English/Language Arts, Social Studies

Section I: STEM Unit Overview

Unit Overview	In most car accidents, the bumper is the first point of impact and defense. The better the bumper is designed, the less possibility for damage and injury. Impact barriers, such as the barrels you see at a highway exit or the barriers separating oncoming traffic, are also important for limiting vehicle damage or human injuries. While learning about forces and motion, students will investigate how energy can be transferred from a moving object to another object reducing the potential for passenger injury. Students will design impact barriers out of common material and determine which materials best reduce the force of impact. Students will look at the complex relationship between desired goals, such as cost, mass, width and effectiveness of the barrier they design.
Essential Question	How can changes in forces and motion affect the outcome of a collision? Using knowledge of energy transfer, how can engineers make collisions safer?
Enduring Understanding	Forces acting on an object have the ability to change an object's motion. The mass of an object also affects an object's motion. Energy is transferred between objects, and that transfer can be controlled through engineering design. Fraction data can be collected, displayed and analyzed using line plots.
Engineering Design Challenge	Students are challenged to create a new highway barrier for cars. As they assume the roles of structural engineers, student teams will work collaboratively to research, design, and test the best material that will bring a toy car on a track to a complete stop with the least amount of recoil. Throughout this unit, students will apply science, technology, engineering, and math knowledge as they utilize their understanding of forces and motion and energy transfer to design an effective barrier. Designs will be evaluated by effectiveness, thickness, mass and cost.

Time and Activity Overview

Day	Time Allotment	Actvities
1	50 minutes	Introduction to the Unit: Pre-Test; Vehicle accident data and trend research.
2	50 minutes	Measuring Vehicles: Complete vehicle accident data and trend research. Measure mass accurately to the nearest gram. Measure length accurately to the ¼ inch. Review line plots using fractions.
3	50 minutes	Ramp Height and Motion: Discover the relationship between height and distance traveled by toy car. Review adding and subtracting fractions.
4	50 minutes	Car Mass and Motion: Discover the relationship between mass and distance traveled by toy car.

5	50 minutes	Transfer of Energy: Explore the transfer of kinetic energy from a moving object to another object. Consider the relationship between mass and reaction.
6	50 minutes	Materials Test: Test multiple materials for barrier use.
7	50-150 minutes (several days)	Engineering Design Challenge: Design, create and test a model barrier. Use design matrix to improve the barrier.
8	50-150 minutes (several days)	Post-Test; Technical Writing/Poster: Write a report on the effectiveness of the original design and redesign of the barrier. Teams work collaboratively to present their findings in multiple ways.

Pre-requisite Knowledge & Skill	Students need to know how to use a ruler to measure to the nearest quarter inch. Students needs to know how to use a digital scale to measure mass to the nearest gram. Students need to know how to make a line plot and add and subtract fractions.

Academic Content Standards

Add Standard	Mathematics
Grade/Conceptual Category	5
Domain	Measurement and Data
Cluster	Represent and interpret data
Standards	5.MD.2. Make a line plot to display a data set of measurements in fractions of a unit (½, ¼, ⅛). Use operations on fractions for this grade to solve problems involving information presented in line plots.

Add Standard	Mathematics
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	English Language Arts
Grade	5
Strand	Informational Text
Topic	Integration of Knowledge and Ideas
Standard	5.IT.7. Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

Add Standard	English Language Arts	
Grade	3, 4, 5	
Strand	Writing	
Topic	Text Types and Purposes	
Standard	W.2. Write informative/explanatory texts to examine a topic and convey ideas and information clearly.	

Add Standard	English Language Arts	
Grade	5	
Strand	Writing	
Topic	Production and Distribution of Writing	
Standard	5.W.6. With some guidance and support from adults, use technology, including the internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of two pages in a single sitting.	

Add Standard	English Language Arts	
Grade	5	
Strand	Writing	
Topic	Research to Build and Present Knowledge	
Standard	5.W.7. Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.	

Add Standard	English Language Arts
Grade	3, 4, 5
Strand	Speaking and Listening
Topic	Comprehension and Collaboration
Standard	SL.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade-level topics and texts, building on others' ideas and expressing their own clearly.

Add Standard	English Language Arts
Grade	5
Strand	Speaking and Listening
Topic	Presentation of Knowledge and Ideas
Standard	5.SL.4. Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

Add Standard	English Language Arts
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	Social Studies	Ohio
Grade	5	
Theme	Regions and People of the Western Hemisphere	
Strand (pk-8 only)	Economics	
Topic	Economic Decision Making Skills	
Content Standard	14. The choices people make have both present and future consequences.	

Add Standard	Social Studies	Ohio
Grade		
Standard		
Benchmark		
Indicator		

Add Standard	Science	Ohio
Grade	5	
Theme	Physical Science	
Topic	Light, Sound, and Motion	
Content Standard	The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.	

Add Standard	Science
Strand	
Course Content	
Content Elaboration	

Add Standard	Science
Grade	
Standard	
Benchmark	
Indicator	

Add Standard	Fine Arts
Grade	
Subject	
Standard	
Benchmark	
Indicator	

Add Standard	Technology	
Grade	3-5	
Standard	Technology for Productivity Applications	
Benchmark	B	
Indicator	Use appropriate tools and technology resources to complete tasks and solve problems.	

Add Standard	Technology	
Grade	3-5	
Standard	3: Technology for Productivity Applications	
Benchmark	C	
Indicator	Use productivity tools to produce creative works and prepare publications.	

Add Standard	Technology	
Grade	3-5	
Standard	4: Technology and Communication Applications	
Benchmark	B	
Indicator	Develop, publish and present information in print and digital formats.	

Add Standard	Technology
Grade	3-5
Standard	6: Design
Benchmark	B
Indicator	Describe how engineers and designers define a problem, creatively solve it and evaluate the solution.

Assessment Plan

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

Performance Task, Projects	Design, create and test a model barrier that will reduce the effects of impact. Students will be assessed using a rubric.
Quizzes, Tests, Academic Prompts	Pre/Post Test
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Observation: Measurement: mass to the nearest gram, length to the nearest quarter inch. Work Sample 1 : Student line plots showing car length data Work Sample 2: Materials test data Work Sample 3: Design matrix and barrier redesign Artifact: Report on the effectiveness of the original design and redesign of the barrier. Presentation of findings in multiple ways. Rubrics for assessing.
Student Self- Assessment	Design Selection Matrix

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.	Interactive Whiteboard Internet Videos
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Rulers and yardsticks Digital Scales Calculators Document Camera
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Youtube video examples of advertisements Websites of advertisements http://www.ndnadvertising.com/10reasons/Ten-Components-Of-A-Good-Ad-Layout.pdf http://pbskids.org/dontbuyit/advertisingtricks/
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.	Websites as a sample for persuasive writing http://www.thewritesource.com/studentmodels/we-adptpet.htm or http://www.thewritesource.com/studentmodels/we-tchrdiff.htm).
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Computers to type persuasive essay
	**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

Crash protection has many career connections. In this unit, the focus is on creating a safe environment for cars in the transportation system: STEM career fields can make contributions to the many areas of increased transportation safety.

Bio-medical engineer: focuses on closing the gap between engineering and biological sciences. The BME has a range of roles available spanning from medical devices and safety improvements through prosthetics and medicine development and delivery.

Human factors engineer: makes improvements to the interfaces between people and their environment. The HFE may choose to specialize in safety where displays, automation, and control systems are developed for humans to function with increased efficiency and safety.

Chemical engineer: develops materials by inventing processes to manufacture new materials. The ChemE applies knowledge of continuous processes to design continuous processes that will be used to produce advanced material.

Chemist: performs basic research to increase the body of knowledge in combining materials. The chemist uses knowledge of chemicals to combine them into new materials that may be usable in future products.

Materials engineer: has a deep understanding of new materials and their properties of the new materials. The materials engineer will design applications and manufacturing methods to transform new materials into products.

Mechanical engineer: focuses on the physical properties of materials and construction for specific purposes. The MechE may choose to specialize in areas that relate to how materials can be used to protect people in the case of impacts.

Industrial Engineer: is known as the “people engineer” who improves efficiency through workstation design and production processes. The IE has a wide range of responsibilities that may include developing production lines, establishing production processes, improving production processes, and supervising or managing production. Additional roles of the IE may include improving the efficiency of the transportation network and the safety of the transportation enterprise.

Civil engineer: primarily concerned with infrastructures such as buildings, bridges, roadways, and large public works projects. With respect to transportation systems, the CE will improve safety to road users through designing and building safer roadways.

Automotive engineer: designs cars and subsystems in cars to improve efficiency, styling, and comfort. The automotive engineer could make a career of improving safety features in automobiles, making cars more crash-survivable for occupants, and designing cars that have crumple zones to absorb the energy of impacts and crashes.

Section II: STEM Lesson Plan

Title of Lesson	**Lesson 1: Introduction to Impact Protection**
Time Required	50 minutes
Materials	Appendix A - Pre-Test (1 per student) Appendix B - Engineering Design Process (1 per student) Appendix C - Engineering Design Challenge (1 per student) Appendix T - Traffic Safety Facts Article-Modified (1 per student) Appendix U - Traffic Safety Facts Article, also available at http://www-nrd.nhtsa.dot.gov/Pubs/811892.pdf (optional)

Objectives	Students will complete the pre-test. Students will gather information about vehicle collision deaths by reading an academic article and analyzing a table.

Instructional Process

Lesson Preparation:

1. Make copies of Appendices A, B, C, and T.

2. Organize students in teams of four. Plan for diverse groupings of students.

Lesson Process:

1. Give students the pre-test. Allow students approximately 20 minutes to complete the test. Explain to the students that there may be questions that they do not know the answers to, but they should try their best.

2. Introduce the Design Challenge to the students. Pass out Appendix C, which explains the design challenge. Students are challenged to create a new highway barrier for cars. As they assume the roles of structural engineers, student teams will work collaboratively to research, design, and test the best material that will make a toy car bounce back the least amount possible.

3. Pass out Appendix B - Engineering Design Process. Explain the design process to the students. The engineering process is the method engineers use to find the solution to a problem. This process does not end with a solution, as engineers will then go through the process of testing and revising the prototype. Explain that they will be following this process throughout the unit.

4. Hand out a copy of Appendix T to each student. Discuss the following vocabulary words to aid in student comprehension: occupant, fatality and restraint.
NOTE: Students may be sensitive to the topic of deaths caused by vehicle collisions.

5. Begin by having students analyze Table 1.
   a. Ask, "What trends about seat belt use and deaths caused by vehicle collisions can you see in the table?" (Students should note the percentage of people wearing seat belts has increased and the number of deaths due to vehicle collisions has decreased.)

6. Read and discuss the first page of the article as a class.
   a. Ask, "Why do you think the number of deaths caused by vehicle collisions has decreased over the years?" (Students may identify seat belts, car seats, air-bags, safer vehicle models, highway barriers, etc.) The videos listed below may also help students generate ideas.
   b. Introduce the careers featured in this unit - see Career Connections.

7. Lesson wrap-up: Have students write about how vehicles are now safer. Brainstorm not only seat belts, car seats, etc. but also changes in how cars are designed, working in the engineers mentioned in Career Connections. Have students complete the writing as a homework assignment.

8. Homework for students: each student will need to bring in 2-3 Matchbox or Hot Wheels types of toy cars & trucks (if they have them) for the following day.

Optional: The following internet links are for YouTube videos that deal with auto crashes. Viewing one or several of these videos will help students build prior knowledge about impact barriers.

NOTE: The following videos depict graphic vehicle collisions. It is important to preface the showing of the videos by explaining test dummies are used when testing vehicle designs and barriers.

Concrete barriers
https://www.youtube.com/watch?v=IEqfJoefdkU
https://www.youtube.com/watch?v=RGNARg-1A4E
https://www.youtube.com/watch?v=WG89EmezYts

Water barrier
https://www.youtube.com/watch?v=JExQpWK0yiE
https://www.youtube.com/watch?v=Gy2BD5APvxU

Motorcyclist
https://www.youtube.com/watch?v=fbcUu-tpvEg

	1959 car smashed into a 2009 car https://www.youtube.com/watch?v=C_r5UJrxcck Cable guardrails https://www.youtube.com/watch?v=qp-AkaQt5iY
Differentiation	Modify pre-test for students with special needs if necessary. The original Traffic Safety Facts Article can be used with students on a higher reading level.
Assessments	Pre-test Student writing

Section II: STEM Lesson Plan

Title of Lesson	**Lesson 2: Measuring Vehicles**
Time Required	50 minutes
Materials	Student Selected Toy Cars and Trucks (Extra toy cars for students who do not have any at home) Scales accurate to the nearest gram (1 per team) Rulers (1 per student) Appendix D - Measuring Length in Inches (1 per student) Appendix E - Data Collection Sheet for Measuring Toy Cars (This is simple graph paper to allow students to create a data table, similar to the one shown on Appendix D. This can be done in a journal or using plain graph paper, if available)

Objectives	Students will find the mass of different objects and measure objects to the nearest quarter inch.

Instructional Process

Lesson Preparation:

1. Label the cars and trucks that students bring in with masking tape - A, B, C…

2. Make copies of Appendix D and E.

Lesson Process:

1. As a class, read page 2 of the article on Traffic Safety Facts.

2. Have students analyze table 2 and consider the length and mass of the vehicles listed ("Type of Passenger Vehicle") .
   a. Ask, “Do you think the length and mass of a vehicle make a difference in its safety when involved in a collision?”
   b. Have students make a hypothesis and state facts from the article to support their hypotheses. If students do not currently use a science journal, this can be written in a writing journal or on an index card.

3. As a class, finish the article by reading page 3. Refer back to the Engineering Design Challenge and remind students that not only seat belts, but also barriers can help save lives during vehicle collisions.

4. Introduce measuring to the nearest half and quarter inch. Discuss how measuring

to the nearest quarter inch could lead to measurements of 1/4, 2/4 (which would be one-half), 3/4, or 4/4 (which would be a whole inch, which could also be thought of as 0/4). Discuss how measuring to the nearest half inch could lead to measurements of 1/2 or 2/2 (which would be a whole inch, which could also be thought of as 0/2). Review the meaning of diameter prior to students measuring the diameter of car wheels on Appendix D.

5. Have students independently measure the cars on Appendix D. Show students how to draw a straight line under each vehicle so they have a reference point to find the height of the vehicle. As a class, go over the correct answers for this sheet. This is to practice measuring before students measure the actual cars & trucks they brought in.

6. Next, have students measure the length and mass of each toy car brought in by those on their team, recording findings of each on Appendix E. Instruct students to create their own data tables as seen on Appendix D. Time permitting, students can then go on to measure as many different vehicles as possible. Students' skills in measurement will improve with more practice.

7. Have teams share their data on the length of their team's Vehicle A only. Record each team's measurement (to the nearest 1/4 inch) on the board.

8. Lead the class on creating a line plot of all the different lengths of Vehicle A.

9. Have students work collaboratively in their teams to create a line plot of all the different lengths of their team's vehicles, labeling each point with the letter of that particular vehicle.

Differentiation	Diverse groups allow for differentiation
Assessments	Appendix D Appendix E Student line plots

Section II: STEM Lesson Plan

Title of Lesson	**Lesson 3: Ramp Height and Motion**
Time Required	50 minutes
Materials	1 Toy Car (1 per team) Cardboard Ramp (about 9 inches x 12 inches) (1 per team) 3 Large Books (about 1-2 inches thick) (per team) Yardstick/Meterstick (1 per team) Masking Tape (1 per team) Appendix F - Adding and Subtracting Fractions Practice (1 per student) Appendix H - Ramp Height and Distance (1 per student)

Objectives

Students will predict, observe, and draw conclusions about the relationships between the height of a ramp, the distance an object has rolled and the forces acting on the object.
Students will practice adding and subtracting fractions/mixed numbers.

Instructional Process

Lesson Preparation:

1. Students should be familiar with adding and subtracting fractions/mixed numbers.

2. Make copies of Appendix F and H for each student

3. Gather the materials required for this lesson.

4. Group students in teams of 4.

Instructional Process:

1. Explain the meaning of potential (stored energy) and kinetic (energy of motion) energy. Use examples such as a stretched rubber band, roller coaster, and a wind-up toy. Ask students, “How does the height of a ramp affect the distance a car will travel down a ramp?” and have students share their ideas.

2. Review how to add and subtract fractions. Pass out Appendix F. This handout can be used for extra practice in the classroom or sent home to be completed for homework. Students will be using the knowledge of adding and subtracting fractions to analyze the data they gather from the ramp height experiment.

3. To begin the experiment, have one student from each team get the cardboard, books, and a toy car.

4. Demonstrate how to build a ramp using a piece of cardboard and a large book. Have the teams set up the ramp for the toy car to roll down with the yardstick at the end of the ramp to measure the amount of distance the car has rolled. Remind the students to use the same toy car throughout the experiment in order to control variables.

5. Instruct students to let the car roll down the ramp without any added force (i.e. no pushing the car down the ramp). Then they will measure how far the car traveled and record the data on Appendix H. Have students record measurements to the nearest ¼ inch and conduct 3 trials.

6. Instruct students to put another book under the cardboard to increase the height of the ramp and follow the same procedure as before, also doing 3 trials at this height.

7.Have students add the third book under the ramp and record these 3 trials.

8. When all 3 trials are completed, have students answer the questions on Appendix H. Students should notice the higher the ramp, the longer the toy car travels. The higher the ramp, the more potential energy the car will have due to the force of gravity. If more practice is needed with line plots, create a line plot as a class displaying the data collected during the experiment.

NOTE: When finding the "average" of trials, students may choose to estimate, round the fractions to the nearest whole number before adding, or use a calculator. Finding the mean of a set of numbers is not introduced until 6th grade standards; however, it is important when drawing conclusions about data gathered during an experiment.

9. Discuss results with the teams while the students are running their trials to ensure their understanding of potential and kinetic energy. Explain that potential energy is when the car is at the top of the ramp and kinetic energy is while the car is moving. A car placed on a ramp that is higher have more potential energy due to the force of gravity; therefore, the car will have more kinetic energy when rolling down the ramp and will travel farther than if the ramp were lower to the ground.

10. Have students answer the question, “How does the height of a ramp affect the distance a car will travel down a ramp?” in their science or writing journals, or on an index card as an exit slip.

Differentiation

Heterogeneous groupings will allow for differentiation
Degree of accuracy could be altered to the nearest ½” or 1”.
Students may choose to find the average of the trials by hand instead of estimating, rounding or using a calculator.

Some students may choose to do more trials. They can find the mode, median, and range of their data.

Assessments	Appendix H and F Teacher Observations

Section II: STEM Lesson Plan

Title of Lesson	**Lesson 4: Mass and Energy**
Time Required	50 minutes
Materials	1 Toy Car (per team) Cardboard Ramp (9 inches x 12 inches) (1 per team) 3 Books (per team) Yardstick/Meterstick (1 per team) Scale (accurate to the nearest gram) (1 per team) Masking Tape Pennies (approximately 20 per team) Appendix I - Vehicle Mass and Distance (1 per student)

Objectives	Students will predict, observe, and draw conclusions about the relationship between the mass of an object and the distance it will roll and how this relates to the forces acting on the car. Students will analyze the data they collected by subtracting fractions.
Instructional Process	Lesson Preparation: 1. Students should be familiar with adding and subtracting fractions/mixed numbers. 2. Students should be in teams of 4. 3. Make copies of Appendix I for each student. Lesson Process: 1. Review how to add and subtract fractions. Also review the concepts of potential and kinetic energy from Day 3. Ask students, “How do you think the mass of a car affects the distance it will travel down a ramp?” and allow students to share their ideas. 2. Have students find the mass of the car to the nearest gram and record on Appendix I. 3. Have students set up the cardboard ramp with 3 books and the yardstick just like they did for Lesson 3. Instruct students to add pennies to increase the mass of the car so they are testing the distance the car rolls with three different masses. Students should conduct 3 trials for each car.

4. Instruct students to fill in tables and answer questions on Appendix I.

5. Have students answer the question, “Does the mass of a car affect the distance it will travel down a ramp?” in their science or writing journals, or on an index card to use as an exit slip. Students should see that increasing the mass of the car increases the distance the car rolls. A car with a heavier mass takes longer to be slowed down by the force of friction.

Differentiation	Heterogeneous grouping allows for differentiation.
Assessments	Completion of Appendix I Teacher Observations

Section II: STEM Lesson Plan

Title of Lesson — **Lesson 5: Transfer of Energy**

Time Required — 50 minutes

Materials

Variety of Marbles (6-10)
Ruler with ridge down center (1)
Variety of toy cars (4-5 per team, different masses)
Track for “Hot Wheels” type cars OR C-Channel track (approximately 6 feet per team)
Appendix J - Energy Transfer (1 per student)
Pencils

Objectives

Students will predict, observe and draw conclusions about the transfer of energy between marbles/toy cars during collisions.

Instructional Process

Lesson Preparation:

1. View the following link to get a clear understanding of this experiment: http://frugalfun4boys.com/2012/11/14/transfer-of-energy-science-experiment/

2. Practice flicking the marbles to ensure that you can properly demonstrate this task.

Instructional Process

1. Review how mass and force affect the motion of an object.

2. Distribute Appendix J and have students write-in hypotheses.

3. Review the difference between potential energy (stored energy) and kinetic energy (the energy of moving objects).

4. Using a document camera or other projection method, demonstrate the experiment by laying two marbles in the center ridge of a ruler. Ask the students to predict what will happen to the center marbles when a single marble, several inches away, is flicked toward the center stationary marbles. Allow students to share their ideas. (The students will most likely guess that both marbles will roll away from the flicked marble. Instead what they will find is that only one marble moves away from the center point. This shows the transfer of energy from one moving object to a

stationary object.)

5. Conduct the same experiment again this time setting 3 stationary marbles and flick two marbles toward them. (Again, the amount of energy that moves those marbles will be a 1:1 ratio of movement.) As a differentiated lesson, students could find the mass of the individual marbles to see the amount of energy transferred based on their mass.

6. Conduct this experiment again, this time using a larger marble flicked toward several stationary marbles in the center of a ruler. This time the movement will be about 2.5 times the original, smaller marble. Have students record their findings from each test on Appendix J.

7. As a class, discuss the transfer of kinetic energy from a moving marble to a stationary marble. Have students infer how this energy transfer might apply to other stationary objects (like cars) being hit by moving objects.

8. Review Appendix J and have students make hypotheses about car trial collision experiments.

9. Have students set up a track with a single ramp (no twists or turns) and toy cars so that the same energy can be transferred in a similar manner. Set the ramp at a height of twenty-four inches and an angle of between 30 and 60 degrees. The height and angle must remain constant as changes will affect the result. Set two cars stationary on the lower end of the track and release a moving car from the top of the ramp.

10. Have students again predict what might happen to the stationary cars. Will the cars move in the same manner that the marbles moved? Why or why not?

11. Repeat the experiment again varying the number of stationary cars as well as the size of the car that is released down the ramp. Students should see similar results as in the marble experiment. Invite students to consider a real-life, rear-end collision, in which a stationary car is hit from behind by a moving vehicle. Have them consider the effect of collisions between a Hummer and a Mini Cooper.

10. Have students record their observations, including any conclusions they draw, on Appendix J.

Differentiation	Heterogeneous grouping allows for differentiation. For students that need a challenge, additional experimentation may be conducted by sending a variety of sizes of moving objects down the ramp and making predictions as to how far the car in front will move.
Assessments	Teacher observation Student writing

Section II: STEM Lesson Plan

Title of Lesson	**Lesson 6: Testing Barrier Materials**
Time Required	50 minutes
Materials	Variety of household items to "crash" cars into, such as: Styrofoam Bubble Wrap Bags of Sand or Clay Rubber material Sponges Cotton Balls Balloons Aluminum Foil Cardboard Craft Sticks Cloth Paper Towels Track for "Hot Wheels" type cars OR C-Channel track (approximately 6 feet per team) Toy cars (4-5 per team) Brick or Other Heavy, Stationary Object (1 per team) Ruler or Tape Measure (1 per team) Appendix K - Material Testing Data Sheet (1 per team) Appendix G - Material Cost Sheet (1 per team) Pencil
Objectives	Students will test rolling cars down ramp into a variety of barriers at the bottom of ramp to see which item(s) will stop the car or significantly slow its overall impact with the least amount of damage or recoil.
Instructional Process	Lesson Preparation: 1. Assign a price to each barrier item so that students can determine an overall cost of building their own barrier as part of their final project. Instructional Process: 1. Review kinetic and potential energy. Remind students that kinetic energy is the energy of moving objects and potential energy is stored energy.

2. Explain to the students that they will be testing different materials to see how much energy each can transfer or absorb. Transferring or absorbing the greatest amount of energy is the goal of the engineering design.

3. Have students gather the materials they will be testing. Have them write down as many properties of each of the materials as they can in their science or writing journals, or on blank notebook paper. This could be done as a list under each material name, or organized into a data table.

4. Students will assemble into their teams and begin by rolling cars of similar mass down a ramp at a fixed incline. Set the ramp at a height of twenty-four inches and an angle of 30 to 60 degrees (the same setup as the previous lesson). The height and angle must remain constant as changes will affect the result.

5. Place the brick at the bottom of the ramp to have a consistent end barrier. Each material for testing will be placed in front of the brick at the end of the track. A meter stick that runs parallel to the track will aid in measuring the recoil of the cars. Set the meter stick's "zero" at the front edge of the material being tested. The meter stick will need to be adjusted slightly for each material. Demonstrate to students how the cars final stopping point will be where the front of the car stops, and will be measured in inches.

6. Students will place individual "household" items at the bottom of the ramp (in front of the brick) to see what individual item stops the car and measure how far back from the barrier the car stops (the recoil).

7. Allow students to test a variety of items and record the results on Appendix K.

8. Have students compare results and find similarities in materials or structures that best limited the recoil. Discuss the costs of materials at this point.

9. Discuss how to use this data in order to design their team's own barrier and how cost can often impact the decision to make the best and/or safest product.

Differentiation	Heterogeneous grouping allows for differentiation. For students who need a challenge, additional experiments may be added using a variety of sizes of cars or even unusual items they may think of on their own to use as their test-barrier.
Assessments	Teacher observation and guided inquiry will direct the student's use of different materials and designing an effective barrier for their own team.

Section II: STEM Lesson Plan

Title of Lesson	**Lesson 7: Engineering Design Challenge**
Time Required	50-150 minutes
Materials	Materials from Day 6 (Student Selected) Scissors (1 per team) Glue (1 per team) Tape (1 per team) Ramp (1 per team) Toy Cars (Roughly Equal Mass, 1 per team) Brick (1 per team) Scale (accurate to the nearest gram) (1 per team) Pennies (approximately 20 per team) Appendix C - Engineering Design Challenge (1 per team) Appendix L - Design Proposal (1 per student) Appendix M - Design Selection Matrix (1 per team) Appendix N - Team Role Descriptions (1 per team) Appendix O - Design Challenge Data Collection Sheet (1 per team) Appendix P - Data Collection Sheet: Height and Mass (1 per team)
Objectives	Students will design, construct, test, and redesign a barrier based on testing data. Students will design experiments to test how car mass and ramp height change recoil.
Instructional Process	1. Review the engineering design challenge with the class using Appendix C and ensure that all students understand the expectations. This lesson may take one to three class periods, depending on the students' level of interest and engagement in the activity. 2. Introduce the team roles and responsibilities (Appendix N) and have students choose which roles they will take for this design challenge. 3. Pass out Appendix L to each student. Have each student individually draw and label (including cost) a design for the barrier using their notes from previous lessons. 4. After each student has an individual design, have engineering teams get together to compare their designs using the design selection matrix found in Appendix M. Students will likely need teacher guidance through this process. 5. Once students have completed their design selection matrix, have students either

begin putting together the design with the highest overall score OR combine ideas from their different designs into a final team design.

6. Have students assemble the design and calculate the cost of the barrier. Students will need to measure the thickness of the barrier to the nearest 1/4 or 1/2 inch, depending upon the students, and find the mass of the barrier to the nearest gram using a digital scale.

7. Have students test the barrier (running three trials) using the toy car and the ramp using the same setup and procedures from previous lessons. Students will collect their test data on Appendix O.

8. After the barrier is tested, have student score their barrier on Appendix M. Teams will then choose one area in which they would like to improve their score: cost, thickness, mass, or recoil. Teams will adjust their design to improve one of these areas.

9. Have teams repeat steps six and seven with their new design.

10. Set a number of barrier redesigns (if students choose to do more than one redesign) to be the limit or set a time limit on the design and redesign process.

11. Pass out Appendix P: Design Challenge Data Collection: Height and Mass. Have students test their redesigns using various car masses and ramp heights to investigate how it affects the car's recoil.

Differentiation	Groups will be heterogeneously determined. Depending upon the needs of the students, team roles may need to be assigned by the teacher.
Assessments	The completed and successful final barrier. The completed and data collection sheets.

Section II: STEM Lesson Plan

Title of Lesson	**Lesson 8: Advertisement Poster and Persuasive Essay**
Time Required	50-150 minutes
Materials	Examples of advertisements Appendix Q - Advertisement Rubric (1 per team) Poster board Markers/Highlighters/Colored Pencils Rulers Appendix R - Writing Map (1 per student) Appendix S - Writing Rubric (1 per student) Model Texts (1 per student) available online at http://www.thewritesource.com/studentmodels/we-tchrdiff.htm or http://www.thewritesource.com/studentmodels/we-tchrdiff.htm

Objectives

In teams, students will design a poster to advertise a new barrier.

Students will individually write a persuasive essay to advertise a new barrier, including data collected during the design process.

Instructional Process

Part 1: Post-Test

1. Administer Post-Test.

Part 2: Poster Advertisement

1. Pass out (or hang around the room) various examples of advertisements. Look at children's magazines, newspapers, and/or local toy advertisements.

2. As a class, list components found on the advertisements. Create this list on chart paper. For ideas on what can be included in an advertisement, use http://www.ndnadvertising.com/10reasons/Ten-Components-Of-A-Good-Ad-Layout.pdf or http://pbskids.org/dontbuyit/advertisingtricks/

3. Instruct students that they will be creating an advertisement poster for the new barrier they have created. Introduce the Advertisement Rubric - Appendix Q. If students are unfamiliar with using rubrics, explain that the rubric shows how they will be graded. Students should include data such as cost, effectiveness, mass and thickness to advertisement.

4. Allow students class time to work in their small teams to create the poster. Students can also work on portions of this poster at home, if appropriate.

5. Instruct students to use Advertisement Rubric - Appendix Q to evaluate their own advertisement and one other advertisement in the team.

Part 3: Persuasive Writing

1. Introduce persuasive writing using the Model Text sample from website (http://www.thewritesource.com/studentmodels/we-adptpet.htm or http://www.thewritesource.com/studentmodels/we-tchrdiff.htm). Read the article together as a class.

2. Ask students: Why did the author write this article? What is the author's purpose?

3. Have students use colored pencils or highlighters to circle the sections of a persuasive text found in the Model Text (introduction with background information and claim, 3 pieces of evidence/data to support the claim, and conclusion).

4. On chart paper create a large Writing Map like the one located in Appendix R. Fill in just the introduction information from the Model Text. Handout Appendix R.

5. Have students formulate a claim about the barrier they have created and write in the introduction section of their own Writing Map.

6. Have students use information gathered from Lesson 1 to select background information for the introduction section of their essay. Students organize this information in their Writing Map.

7. On chart paper, model the evidence/data section with information from the Model Text. Have students use information from their own barrier data to complete the middle section (3 pieces of evidence/data) of their Writing Map.

8. On chart paper, model the conclusion section with information from the Model Text. Have students complete the conclusion section of Writing Map.

9. Introduce the Writing Rubric - Appendix S.

10. Students use information from Writing Map to write a 3 paragraph essay.

11. Students use the Writing Rubric to evaluate, revise, and edit their work.

12. Students type their final copy on the computer.

Differentiation	Vary the levels of graphic organizers OR use readwritethink.org interactive map. Students write the persuasive essay as a letter to a company or as a commercial advertisement.
Assessments	Advertisement Rubric - Appendix R Writing Rubric - Appendix S

Section III: Unit Resources

Materials and Resource Master List	Printable Resources (see Printable Resources document): Appendix A - Protecting Precious Cargo Pre-Test/Post-Test Appendix B - Engineering Design Process Appendix C - Engineering Design Challenge Appendix D - Measuring Length in Inches Appendix E - Data Collection Sheet for Measuring Toy Cars Appendix F - Adding and Subtracting Fractions Practice Appendix G - Material Cost Sheet Appendix H - Ramp Height and Distance Appendix I - Vehicle Mass and Distance Appendix J - Energy Transfer Appendix K - Material Testing Data Sheet Appendix L - Design Proposal Appendix M - Design Selection Matrix Appendix N - Team Role Descriptions Appendix O - Design Challenge Data Collection Appendix P - Design Challenge Data Collection: Height and Mass Appendix Q - Advertisement Rubric Appendix R - Writing Map Appendix S - Writing Rubric Appendix T - Traffic Safety Facts Article-Modified Appendix U - Traffic Safety Facts Article Teacher Provided Equipment: Scales accurate to the nearest gram (1 per team) Rulers (1 per student) Extra toy cars for students who do not have any at home Cardboard Ramp (about 9 inches x 12 inches) (1 per team) 3 Large Books (about 1-2 inches thick) (per team) Yardstick/Meterstick (1 per team) Masking Tape (1 roll per team) Variety of Marbles (6-10) Ruler with ridge down center (1) Markers/Highlighters/Colored Pencils Hot Wheels-type track or C-Channel track (approximately 6 feet per team) Brick or Other Heavy, Stationary Object (1 per team) Scissors (1 per team) Glue (1 per team) Consumable Resources: Graph paper for each team (optional) Styrofoam (various types and amounts) Bubble Wrap Bags of Sand or Clay

Rubber material
Sponges
Cotton Balls
Balloons
Aluminum Foil
Cardboard
Craft Sticks
Cloth
Paper Towels
Poster board (1 per team)
Examples of advertisements

Student Provided Equipment:
Toy Cars and Trucks (Students should bring 2-3 Matchbox/Hot Wheels size cars if possible)
2 Colors of Colored Pencils (1 per student)

Key Vocabulary

http://www.wordcentral.com/
http://dictionary.reference.com/science/
http://www.mathematicsdictionary.com/math-vocabulary.htm

absorb: a : to receive without giving back <a sound-absorbing surface> b : to transform (radiant energy) into a different form usually with a resulting rise in temperature <the earth absorbs the sun's rays>

advertisement: a public notice; especially : one published or broadcast

angle: the figure formed by two lines extending from the same point

barrier: something (as a fence, railing, or natural obstacle) that blocks the way

claim: to state as a fact

collision: the act of coming together with solid impact

coordinate plane: a plane formed by two intersecting and perpendicular number lines used to help locate the position of any point on a map or graph.

energy: the capacity (as of heat, light, or running water) for doing work

evidence: a: that which tends to prove or disprove something; ground for belief; proof. b: something that makes plain or clear; an indication or sign: His flushed look was visible evidence of his fever.

height: 1 a : the highest part or point 2 a : the distance from bottom to top of something b : the distance above a level

incline: the degree to which something rises up from a position level with the horizon - (the steep incline of the hill meant that it was impossible to ride a bicycle up it)

kinetic energy: energy associated with motion

line graph: a graph in which line segments join points representing different values

line plot: a graph that displays data as points above a number line or some other line of characteristics or attributes.

mass: the measure of the amount of matter of an object.

mean: a number equal to the sum of a set of numbers divided by how many numbers are in the set - (the arithmetic mean of 3, 4, 6, and 7 is 5)

median: the middle number in a set of numbers, once the numbers are arranged from least to greatest

persuade: to win over to a belief or to a course of action by argument or earnest request

potential energy: the amount of energy a thing has because of its position or because of the arrangement of its parts

prototype: an original model on which something is patterned

recoil: the distance through which something springs back to a starting point

scale: a series of marks at regular interval along a line or curve that helps you measure things. Examples include the scales on a ruler or a protractor.

stationary: a : fixed in a station, course, or position; immobile (a stationary loudspeaker); not moving
b : unchanging in condition

Technical Brief

Sources of energy surround us as we go about our daily lives. The most common form of energy we encounter on earth is the energy from the sun. Energy is the name given to the ability to do work. This lesson will focus on the energy of movement.

The energy of movement is called kinetic energy. The word kinetic comes from a

Greek word meaning to move. A moving train, a moving car, or a high speed electron moving in an electronic device exhibits kinetic energy. There are many forms of kinetic energy – vibrational (the energy due to vibrational motion), rotational (the energy due to rotational motion) and translational(the energy due to motion from one location to another.) To keep matters simple, we will define translational kinetic energy as kinetic energy for our lesson. The amount of kinetic energy that an object has depends upon two variables: the mass (m) of the object and the speed (v for velocity) of the object. The following equation is used to represent the kinetic energy (KE) of an object.

KE = 0.5 * m * v^2 (v squared)

Potential energy is often called stored energy. Objects can have stored energy based upon their position; for example, a rock near a ledge that could be acted upon by gravity. An object sitting on top of a compressed spring will move when the compression is released.

PE = m * g * h

In the above equation, m represents the mass of the object, h represents the height of the object and g represents the gravitational field strength (9.8 N/kg on Earth) - sometimes referred to as the acceleration of gravity.

Energy is constantly changing from potential to kinetic and back again. Every change that takes place represents the change of energy from one form to another. This process is called the transformation of energy.

In 2012, 21,667 occupants of passenger vehicles (passenger cars, pickup trucks, vans, and SUVs) died in motor vehicle traffic crashes. (http://www-nrd.nhtsa.dot.gov/Pubs/811892.pdf) These deaths can be decreased by implementing an array of safety solutions. Some of these safety solutions include safer vehicle construction, better roadway design, additional safety features, and passenger protection.
A related area getting media attention is traumatic brain injuries (TBI) to military personnel and sports participants. The long-term effects of TBIs are being researched and new ways of protecting people from impact injuries are being developed. One way to decrease the effects is to eliminate the exposure to the impact events. Pop-Warner youth league football has seen a 9.5% drop in participation between 2010 and 2012. This has been attributed to NFL football injuries (http://sports.yahoo.com/blogs/nfl-shutdown-corner/report-nfl-head-injuries-led-drastic-youth-football-171008309--nfl.html). Another solution is to add protection. Scientists and engineers are developing improved football helmets to protect players' brains better (http://www.usatoday.com/story/sports/ncaaf/2013/07/30/concussions-college-football-nfl-guardian-caps/2601063/). These principles of protecting heads in helmet to helmet contact can also be applied to improved safety in vehicle operations.

Our unit will start with a car at the top of an incline, where it has potential energy. A slight nudge over the edge will result in the car racing down the incline, here it has kinetic energy. Before the car on the track starts rolling, all of its energy is potential energy and it has no kinetic energy. As the car rolls down the ramp and accelerates, its kinetic energy increases while the potential energy decreases. When the car reaches its lowest point on the ramp, the potential energy will be zero and the only remaining energy will be kinetic. The car will slow and lose kinetic energy until it stops because of friction and air resistance. If there was nothing to stop the car it would continue rolling until the forces of friction acting on the wheels would cause the car to come to a stop. Sometimes we would like the car to stop quickly with little or no damage to the car or its driver and passengers. This process is sometimes called energy management or energy absorption.

A car running out of control toward a stationary object is something we read about all too often. The barrels we see stacked on the highways, the corrugated bumpers we see along the roadside, and crushable foams behind car bumpers are all examples of how we try to manage energy when it gets out of control. In car racing many types of energy management systems are used behind the race wall to help absorb the energy of a car impacting the wall.

Our unit will study different ways to manage the kinetic energy of the car racing down the incline and to measure their effectiveness. In this lesson we may not concentrate on the exact applications of the mathematical formulas; but rather, on qualitative comparisons of energy management solutions.

Safety and Disposal

Care should be taken to avoid getting any particulates, such as sand, if it is used, in students' eyes during materials testing. Eye protection can be worn if needed. Care should be taken with any breakable materials to avoid injury.

References

All internet addresses retrieved May, 2014

Topical References

Auto Safety Barriers

National Highway Traffic Safety Administration - nhtsa.gov

Transportation Research Board - trb.org

Southwest Research Institute - swri.org

Potential and Kinetic Energy

eHow - ehow.com

Energy Home - energyeducation.tx.gov

Difference Between.net - differencebetween.net

Education Portal - portal.com/academy/lesson/kinetic-energy-to-potential-energy-relationship-in-different-energy-types.html#lesson

Section I: STEM Unit Overview

ndnadvertising.com/10reasons/Ten-Components-Of-A-Good-Ad-Layout.pdf

pbskids.org/dontbuyit/advertisingtricks/

Section II: STEM Lesson Plan

frugalfun4boys.com/2012/11/14/transfer-of-energy-science-experiment/

ndnadvertising.com/10reasons/Ten-Components-Of-A-Good-Ad-Layout.pdf

readwritethink.org

thewritesource.com/studentmodels/we-adptpet.htm

Section III: Unit Resources

dictionary.reference.com/science/

displayproductsonline.com

mathematicsdictionary.com/math-vocabulary.htm

nrd.nhtsa.dot.gov/Pubs/811892.pdf

sports.yahoo.com/blogs/nfl-shutdown-corner/report-nfl-head-injuries-led-drastic-youth-football-171008309--nfl.html

usatoday.com/story/sports/ncaaf/2013/07/30/concussions-college-football-nfl-guardian-caps/2601063/

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