

Science • Technology • Engineering • Math

POSTER PROCEEDINGS

The 2013 STEM Education Teacher Workshop

January 19, 2013

**McAllen Convention Center
700 Convention Center Blvd
McAllen, Texas**



RET

**UTPA Research Experiences for Teachers
in Emerging and Novel Engineering Technologies (RET-ENET)**



Curriculum Posters

Teacher Presenter	Lesson Title	Subject	Grade Level(s)	School District
Jorge Acuna	Pressing for Data	Algebra; Data Analysis	8	PSJA ISD
Marc Braden	Be! an Engineer! Design and Build an Electric Balance	Physics; Dana Analysis	10-12	McAllen ISD
Elma Pinon	Sensors and Scatterplots	Data Analysis	8	McAllen ISD
Rocio Nava	The Invisible Radar Triangle	Geometry	7	McAllen ISD
Luis Avila	Catching the Perfect SAR Waves	Math Models and Applications	11	McAllen ISD
Agustin Arias	Catch Me if You Can!	Geometry	10	La Joya ISD
Constance Garza	Let's Get Breezy!	Earth and Space; Science and Technology; Physical Science	8	La Joya ISD
Jesus Ruiz	Model Your Own Walk	Algebra	9	La Joya ISD
Alyssa Smith	Hold on Tight! Hand Dynamometer Algebraic Investigation	Algebra I	9	La Joya ISD
Thomas Padilla	Solar Charging Station	Science and Technology	11-12	Weslaco ISD
Laura Alvarez	Power Your Home with Sunshine!	Measurements	7	La Joya ISD
Josue Galvan	Solar Racers	Physics (Energy, Force, Motion)	7	La Joya ISD



Pressing for Data

Jorge Acuña (PSJA ISD)

Research Experiences for Teachers Program

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Summary

Students will construct a pressure sensor with conductive foam for data analysis. They will apply forces to the sensor to generate data representing pressure as voltage. The data will be used for exploring relationships involving voltage versus time, pressure versus time, and impact force: force versus time. By engaging students in these activities, students will observe linear relationships, calculate rates of change, and create their own graphs representing real world applications.



Figure 1. Karate Tournament: students wear protective equipment to minimize impact forces and maximize safety (Getty images)

Engineering Connection

Engineers work very closely with manufacturers to produce products for everyday consumers. Using math and science, engineers have been able to design sensors that impact our health and our safety. For example, sensors are used to activate and deactivate passenger airbags in cars. Engineers have designed monitoring devices containing sensors that detect whether there is more than one person in a vehicle. Airbags are deployed only on the person(s) in a vehicle in a collision. This helps to reduce unnecessary costs. Engineers even designed sensors to measure the impact of force when one is running or playing various sports such as football, boxing, or basketball. In this way, engineers are able to design shoes and equipment that minimize bodily injuries while also providing comfort and support (Figure 1).

Learning Objectives

After this lesson, students will be able to:

- Explain the relationships between voltage versus time, pressure versus time, impact force: force versus time
- Identify regions of increasing and decreasing rates
- Compute rate of change from a set of self generated data
- Create a relational situation of a real world event

Subject Area(s) Algebra, data analysis & probability
Grade Level 8 (7-9)

Lesson Background & Activity

Students will build a pressure sensor from conductive foam and copper plates to explore the relationship of pressure, force, and area using an instructional handout (Figures 2 & 3). They will integrate their foam sensor in a voltage divider circuit that will allow them to generate voltages relative to pressure (Figure 4).

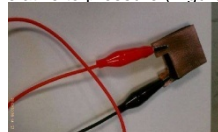


Figure 2. Student created conductive foam pressure sensor for generating data

Using Newton's 2nd Law of motion, students will manipulate mass and acceleration to produce different amounts of force that affect pressure. The data will be generated by squeezing the plates together with different amounts of force. This will develop a better understanding of real world situations and form a connection between data represented in graphs and tables to real time changes.

With the use of data logging hardware and software, students will analyze the data and represent it in tables and graphs. Students will identify and prove which sections of the graphs demonstrate higher rates of change (Figure 5).

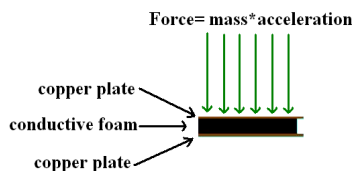


Figure 3. Cross-sectional view of pressure sensor with indication of applied force

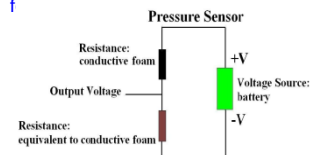


Figure 4. Conductive foam pressure sensor implemented in a voltage divider for generating data when squeezed

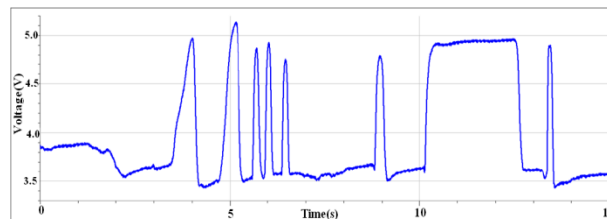


Figure 5. Graph displaying voltage versus time as a foam pressure sensor is pressed and depressed at different rates

Assessment

Pre-Activity Assessment

"Going on a Ride with the Data Rollercoaster" will access the students' prior knowledge with questions about plotting data and rates of change.

Activity Embedded Assessment

"Analyzing Our Conductive Foam Pressure Sensor" is a guide on how to explore the sensor and impact force through rates of change.

- What does rate of change represent in regards to the function of the conductive foam pressure sensor?
- Which section of the graph would have the greatest rate of change?

Post-Activity Assessment

"How Fast Am I?" assesses the targeted standards to see if they have been met by the activity.

- Compare and contrast the two regions of the function
- What is the rate of change at this particular region?

Conclusions & Future Work

Engineers use math and science to help them analyze relationships that can aid in the design of better products. By observing data, they can configure certain parameters that will provide desired performance in products. Students can implement this sensor to measure or detect the amount of a force or pressure on an object under different circumstances. With this information, they can then design products that can help reduce the amount of stress around it. In the hands of a creative student, there are limitless applications to help assist and aid in product design.

Acknowledgement

This lesson was developed through The University of Texas-Pan American's Electrical Engineering Research Experiences for Teachers in Emerging and Novel Engineering Technologies (RET-ENET) program, National Science Foundation grant no. CNS-1132609.



<http://www.utpa.edu/ret>



Be an Engineer! Design and Build an Electric Balance



Marc Braden (McAllen ISD)

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Summary

There is a lack of engineering exposure before high school graduation – students will not likely choose to enter a professional program they don't know anything about.

In this activity, student teams are challenged to design and build the best possible electric balance using a conductive rubber band as the transducer.

This activity will give students the chance to work like engineers while also:

- getting to build something;
- practicing collecting, analyzing, and making reasonable conclusions from data;
- working as a team to meet a challenge.



Figure 1. Stretching the rubber band results in a change in its resistance.

Engineering Connection

Engineering is the application of science and mathematics.

Engineers solve problems by designing within constraints.

Students will play the role of engineers as they use the design cycle and apply their knowledge of electricity, sensors and mechanics to make an optimized electric balance.

Learning Objectives

Students will be able to:

- apply the design cycle to create a product,
- describe what engineers do and how they interact with society,
- apply knowledge of electricity and circuits to design a working sensor,
- interpret and make conclusions from collected data,
- effectively communicate the process and results of design work.

Subject Area(s) physics, data analysis and probability, science and technology

Grade Level 10-12

Lesson Background & Concepts

Students will already have had instruction on electric circuits and transducer characterization (data analysis).

Students will be introduced to the engineering design cycle, and will have several design challenges, including:

- the basic electrical properties of the rubber band are challenging to characterize;
- the required mass range for the finished product is outside the ideal range for the rubber band;
- the challenge requires a linear relationship between input and output, forcing students to quantitatively describe the measurement limits of their product.

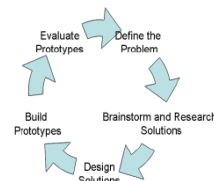


Figure 2. The engineering design cycle.

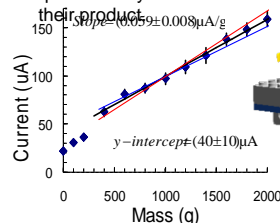


Figure 3. Data sample showing the linear range of the balance.

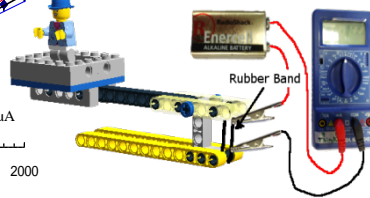


Figure 4. The balance will need to be optimized (possible student design).

Activity Timeline

Day 1

Introduce the challenge through a PowerPoint presentation prompting students to

- think about how a rubber band could be used as a transducer,
- predict the electrical changes that will occur in the rubber band as it is stretched,
- discuss the design cycle and how it applies to previous work they have done,
- work with the rubber bands to begin to find out how they will use them as sensors.

Note: Students should be given one or two weeks to get feedback on their designs and to build their prototypes.

Day 2

Students will display their working balance, present their analysis of results, and show off its abilities for all to see. Students will then vote on the best team and post their presentation and balance in a highly visible place for the rest of the school to appreciate.

Assessment

Pre-Survey

How do students feel about math, science and engineering?

Progress Report

Introduction/overview, assignment of roles, rubber band characterization, initial research and proposed designs.

Product Presentation

A short PowerPoint presentation

- describing the balance,
- presenting the data analysis,
- describing the limitations,
- and finishing with a live test of the balance.

Post-Survey

How have student's attitudes changed towards math, science and engineering?

Conclusions and Future Work

allow students to consider engineering as a career, and make students aware of how important engineering is in our everyday lives.

Further work must be done obtaining the equipment necessary to carry out the activity with several classes, and then to actually use the activity once school begins. The results will be evaluated and improvements made before submitting the unit to TeachEngineering.com with the hope of online publication.

Acknowledgement

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Sensors and Scatterplots

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Summary

In this activity, students are introduced to several types of common medical sensor devices such as ear thermometers, forehead thermometers, glucometers and wrist blood pressure monitors. They will use the wrist blood pressure monitors to measure their blood pressure and pulse. The students will also measure their heights and weigh themselves in order to calculate their Body Mass Index (BMI). Then, they will use the collected data to create and analyze scatterplots of the various variables to determine if any relationships exist between the measured variables. Discussions about the trends observed and possible health concerns will conclude the activity.



Figure 1.
Student using a wrist blood pressure cuff to measure her blood pressure and pulse rate.

Engineering Connection

Sensor devices are tools designed by engineers, and there are a variety of these sensors used in different applications including the medical field. Engineering research and development effort is ongoing as engineers work to design new and better sensors. As part of the design cycle, engineers often need to measure, collect and analyze data. When investigating relationships between two variables, scatterplots can be utilized to enable engineers to examine any trends that may exist.

Learning Objectives

After this activity, students will be able to:

- Collect and organize data.
- Construct scatterplots.
- Analyze a scatterplot by determining the relationship and the trend.
- Draw line of best fit and make predictions.

Subject Area(s):

Data Analysis

Grade Level : 8 (7 – 9)

Lesson Background & Concepts

BMI is used as a screening tool for children to identify possible weight issues that may lead to health problems. The greater the BMI, the greater risk of contracting diseases associated with obesity such as high blood pressure, diabetes, high cholesterol and arteriosclerosis (narrowing and thickening of the arteries). Thus, it is important for students to learn about BMI and blood pressure. This activity will introduce students to both and will show them how easy it is to monitor these values using medical sensors designed by engineers. Engineers continue to develop new and better medical sensors for purposes such as these.

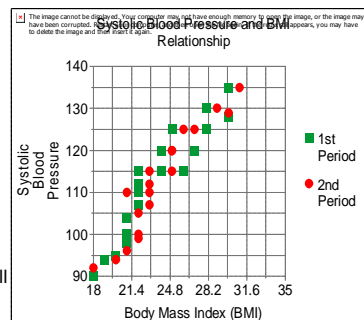


Figure 2.
Sample scatterplot showing a positive relationship between BMI and blood pressure.

Associated Activities

Students will complete these activities in teams of three. They will use the data they collect to construct scatterplots.

Day 1: Collect Data

- Obtain weight and height measurements.
- Calculate BMI using formula.
- Use a wrist blood pressure cuff to measure blood pressure and pulse rate.
- Record data on a class data sheet.



Figure 3.
Weight measurement.

Day 2: Construct and Analyze Scatterplots

- Construct (by hand) and analyze a scatterplot of systolic blood pressure versus BMI.
- Construct (by hand) and analyze a scatterplot of pulse rate versus systolic blood pressure.
- Construct (using technology) and analyze a scatterplot of BMI versus pulse rate.
- Construct (using technology) and analyze a scatterplot of male versus female data of systolic blood pressure versus BMI.
- Present scatterplots and results of analysis.

Assessment

Pre-Activity Assessment

- Do the students understand which variables they will be investigating and the types of trends they will be analyzing in the scatterplots?

Activity Embedded Assessment

- Student Data Sheet
 - Were the weight and height measured accurately?
 - Was the BMI value calculated correctly?
 - Were the blood pressure and pulse rate values measured correctly?
- Worksheet 1 and 2
 - Were the scatterplots constructed and analyzed correctly?

Post-Activity Assessment

- Select two variables that have not been compared.
- Construct and analyze a scatterplot.
- Explain the relationship between the two variables and draw a line of best fit for the scatterplot.

Conclusions and Future Work

and seeing my students become excited about STEM careers. This lesson will expose them to engineering design as they see how medical sensors work, how engineers analyze relationships through scatterplots and the necessity for future engineers and scientists to continue developing new and improved medical sensors that will benefit society.

Acknowledgement

This lesson was developed through The University of Texas-Pan American's Electrical Engineering Research Experiences for Teachers in Emerging and Novel Engineering Technologies (RET-ENET) program, National Science Foundation grant no. CNS-1132609.



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The Invisible Radar Triangle

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Summary

In this activity, students learn about radar imaging and its various military and civil applications. They learn how similarity and scaling are used in radar imaging to create three-dimensional models of various targets. Students use the critical attributes of similar figures to create a scale model of a radar imaging scenario using an infrared range sensor (to emulate the functions of a radar) and a toy airplane (to emulate the target). They use technology tools to measure angles and distances.



Figure 1. Radar tracking an airplane (U.S. Air Force)

Engineering Connection

Engineers have designed radars that transmit radio waves to detect objects, such as aircraft and terrain, for military surveillance and other applications. They use similarity and scaling to create three dimensional models of targets being studied in radar imaging and use radar imaging simulators to generate radar images of these models and adjust parameters until desired quality is accomplished.

Learning Objectives

After this activity, students will be able to:

- Use critical attributes of similar figures to determine if two figures are similar or not;
- Find the measure of an angle in a triangle when given the measure of the other two angles;
- Learn how technology is used to measure angles and distances;
- Connect similarity and scaling concepts to real-world application such as radar imaging.

Subject Area(s)

Geometry

Grade Level

7 (6-8)

Lesson Background & Concepts

In radar imaging the radar, target and a point of reference on the ground form a right triangle which is used by engineers to calculate distances and be able to detect and identify the target. Attributes of similar figures can be used to create a scale model of this scenario. Ratios and proportions of corresponding sides can be used to test the proportionality of a scale model and to calculate distances.

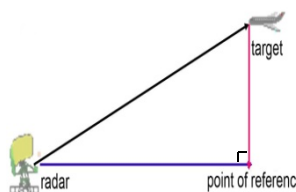


Figure 2. Radar imaging scenario (Radartutorial.eu)

Associated Activities

Day 1:

- Students view "The Invisible Radar Triangle" power point presentation.
- Students work in their groups to come up with a plan to create a model of the radar imaging scenario and present it to their teacher.

Day 2:

- Students assemble the infrared range sensor and calibrate it.

Day 3:

- Students use the materials provided by the teacher to create their models.
- Students use the infrared range sensor to measure the distance between the radar and the target. They use a TI-84 calculator to convert the voltage readings from the multimeter to centimeters.
- They complete the worksheet "The Invisible Radar Triangle".

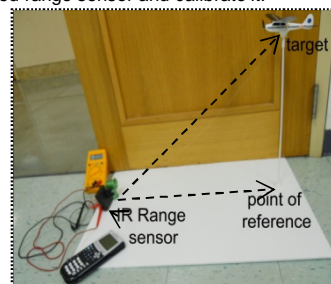


Figure 3. Scale model of radar imaging scenario

Day 4:

- Students present their models to the class and justify their answers in their worksheets.
- Students complete a 4-question mini assessment after the presentations.

Assessment

Pre-Activity Assessment

- Brainstorming:* Teacher and students brainstorm ideas on how they can design a model of the triangular scenario in radar imaging.

Activity Embedded Assessment

- Pre-design presentation:* Each group presents their design plan to the teacher and receives feedback.
- The Invisible Radar Triangle worksheet:* Each group completes a worksheet in which they use critical attributes of similar figures to determine if their model is similar or not.

Post-Activity Assessment

- Group presentations:* Each group presents their model and findings to the class.
- Mini-Assessment:* Students answer four standardized questions on attributes of similar figures.

Conclusions and Future Work

dimensional models of targets being studied in radar imaging. Students constantly struggle to understand similarity, scaling and proportionality. The engineering connection and experience provided in this activity improves students' understanding of these concepts and increases their motivation to learn math. It also raises their awareness of the importance of being well educated to become productive members of society.

Acknowledgement

This lesson was developed through The University of Texas-Pan American's Electrical Engineering Research Experiences for Teachers in Emerging and Novel Engineering Technologies (RET-ENET) program, National Science Foundation grant no. CNS-1132609.



<http://www.utpa.edu/ret>



Catching the Perfect SAR Waves!

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Summary

Students learn the importance of the Pythagorean Theorem as applied in radar imaging. Students use an Infrared (IR) sensor to measure triangle distances and to verify those measurements using the Pythagorean Theorem. Sensors will be calibrated by a group of students to ensure accurate measurement of distances. An outdoor radar imaging model will be provided to the groups for sensor testing.

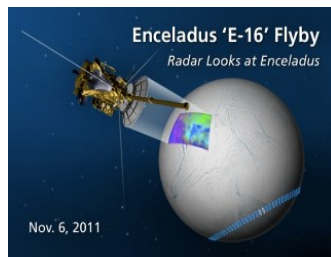


Figure 1. NASA's Cassini spacecraft captures radar images of Saturn's moon.

Lesson Background & Concepts

Radar imaging is used to detect, classify objects, and identify a target's size and direction of movement for the purpose of military surveillance and civilian applications. A SAR uses a single beam-forming antenna mounted onto a flying platform such as an aircraft. The aircraft flies over a target, continuously illuminating it by sending radio waves from different angles to the target, the radio waves reflect back into the antenna. The reflected waves are stored and transformed into images of the target object. ISAR is a technique used to get an image of a target that is constantly moving. In this case the antenna is stationary and sends radio waves to the moving target.

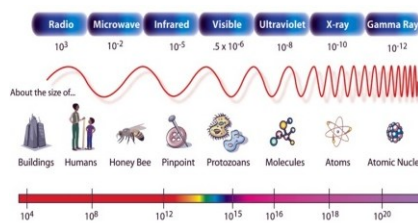


Figure 2. The Electromagnetic Spectrum (NASA)

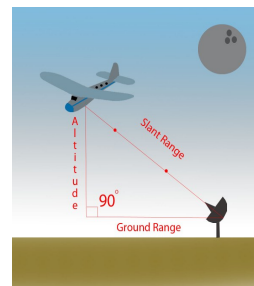


Figure 3. Radar Geometric Model

Associated Activities

The activity will be conducted over three different days. Students will work in groups of three. Day 1: "radar" system construction, Day 2: sensor calibration, Day 3: apply Pythagorean Theorem to calculate unknown hypotenuse using emulated radar model



Figure 4. "Radar" System Unit Kit

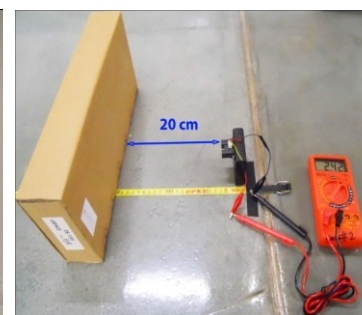


Figure 5. "Radar" System Unit Calibration

Assessment

As part of day two of the activity, students will formulate a tabular and graphical model that describes the relationship between distance and voltages readings. Students will then use their sensor to calculate distances in an outdoor setup. They will use the Pythagorean Theorem to verify their measured distances.

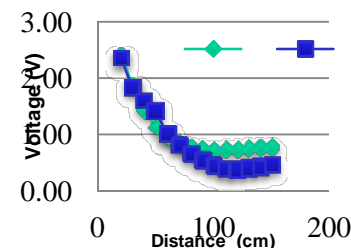


Figure 6. Sample Calibration Results

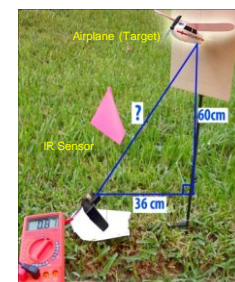


Figure 7. Emulated Radar Model

Engineering Connection

Math, Science, and Engineering play an indisputable role in the creation of modern measuring devices. Without some of these devices, it would be extremely difficult measure to distances. Synthetic Aperture Radars (SAR) use radio waves and their echoes to measure slant range and ground range distances to formulate images. A right triangular model can be used to illustrate the distance relationships formed by the radar, target, and targets altitude. We can use the Pythagorean Theorem to calculate the distances in any right triangle model. Without an accurate measurement of distance, SARs would not be able to produce high resolution images.

Learning Objectives

With this activity, students will be able to:

1. Demonstrate a understanding of a Radar system
2. Formulate a tabular and graphical model that describes the relationship between variables
3. Use the Pythagorean Theorem to calculate sides of a right triangle

Subject Area(s) Math Models & Applications

Grade Level 11 (10)

Conclusions and Future Work

Science, and Engineering as it applies to radar systems. Students will use a piece of technology (built by themselves) that measures distances and see how the Pythagorean Theorem is applied to a real world model. In the future, this activity can be expanded to find the percent error of the data collected. Students may represent their findings on a graph or table to see the accuracy of their "radar" system model.

Acknowledgement

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Catch Me If You Can!

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Summary

Students will be immersed in a fictional spy scenario where they will have to determine if they will be detected by their radar target. Students will use infrared sensors to gather measurements and use trigonometry to find missing lengths and angles.

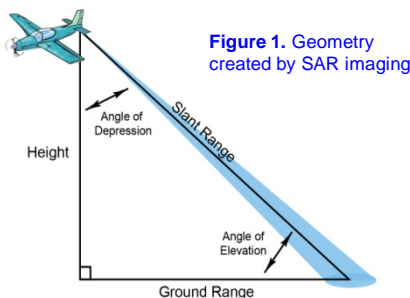


Figure 1. Geometry created by SAR imaging

Engineering Connection

In satellite imaging, engineers use radio waves to create images of flying or stationary targets. In order to obtain clearer images, engineers must find the distances from the radar antenna to their target. Trigonometry is a branch of mathematics that can be used to find distances by using angles and known sides of a triangle to find unknown measurements. Fortunately, the radar antenna and target form a right triangle so that engineers can use trigonometry to indirectly find certain distances.

Learning Objectives

After this activity, students will be able to:

- Use right triangle trigonometry to calculate unknown distances or angles
- Collect, graph and perform equation regression on data collected from sensor calibration and use sensors to measure distances
- Describe how to find unknown distances or angles using trigonometry.

Subject Area(s) Geometry

Grade Level 10th

Lesson Background & Concepts

Trigonometry can be used to find the missing sides or angles of right triangles. This can be accomplished by using trigonometric ratios. These trigonometric ratios are based on three trigonometric functions: sine, cosine, and tangent. These are usually referred to as Sin, Cos, and Tan, respectively. Each of these trigonometric functions takes an angle as their input and output the ratio of two particular sides of the right triangle.

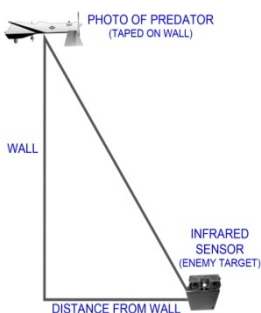


Figure 2. Classroom set up

SOHCAHTOA

$$\sin(a) = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos(a) = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan(a) = \frac{\text{opposite}}{\text{adjacent}} = \frac{\sin(a)}{\cos(a)}$$

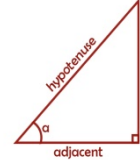


Figure 3. Trigonometric Identities

Associated Activities

Day 1: Overview of Electromagnetic Spectrum and trigonometric ratios

Day 2 – 3: Build and calibrate sensors

Day 4: Simulate secret mission: Students use sensors and protractors to measure varied distances and angles at different stations. Students will use trigonometry to find missing the other missing lengths and/or angles depending on the station.



Figure 4. Unmanned aerial vehicle used in spy scenario (NASA)

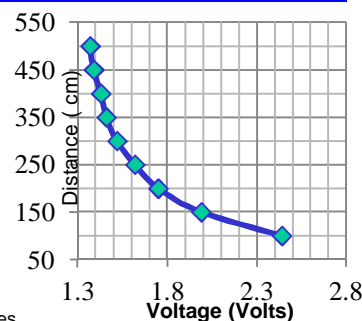


Figure 5. Data collected from sensor calibration

Assessment

Pre-Activity Assessment

As a class, discuss all the different properties of a right triangle.

Activity Embedded Assessment

Students will fill out their activity worksheet in groups as they find the missing measurements and answer questions.

Post-Activity Assessment

Students will solve several problems based on activity and write a paragraph explaining how to use trigonometric ratios.



Figure 6. Students will receive their spy mission details in "Confidential" files

Conclusions & Future Work

Students will make the connection between engineering and mathematics by learning about how electromagnetic waves create satellite images. Additionally, they will have hands on experience with infrared sensors and use those sensors to measure distances. Furthermore, they will apply their mathematic skills to conduct a "spy mission" and determine if they were detected by the enemy radar. The exposure to engineering concepts will benefit the students by engaging their minds like they have not done so before.

Acknowledgement

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Let's Get Breezy!

Constance Garza (La Joya ISD)

Research Experiences for Teachers Program

Electrical Engineering Department, The University of Texas-Pan American



Summary

Students will use their prior knowledge of heat transfer through convection, conduction, and radiation as they use wireless temperature probes to investigate how fast land and water heat and cool. The sand and water are placed in the same location outdoors under direct sunlight and the temperature change is noted in 1 minute intervals for 15 minutes and then taken indoors and monitored for another 15 minutes. Students then construct a multiline graph to display their data. In addition, students discuss the efficiency and reliability of wireless sensors in real world applications.



Figure 1. Sea breeze blowing over land. (www.HeatherPiazza.com)

Engineering Connection

Engineers are revolutionizing the way scientists can monitor the natural environment by creating an environmental sensor network (ESN) for the purpose of improved forecasting. Engineers design ESNs to get information from the natural environment and send it through an array of sensors to a data receiver in a server. In this activity students, like engineers, use wireless sensors to collect remote data from the environment.

Learning Objectives

After this activity, students will be able to:

- Explain how land and sea breezes are formed;
- Make observations, generate a testable hypothesis, formulate a conclusion and predict trends;
- Collect data and create a line graph to represent measured temperature changes of sand and water using wireless temperature probes.

Subject Area(s) Earth and Space; Science and Technology; Physical Science

Grade Level 8th

Lesson Background & Concepts

Radiation from the sun is the energy that drives the convection currents in the atmosphere as well as in the oceans. Land and water conduct heat unequally thus creating sea and land breeze. A sea breeze is created when the surface of the land heats up quicker than the ocean causing warm, lean air to rise, and cooler less dense sea breeze replacing it. In contrast, when the land is cooler than the water, such as at night, the air over the water slowly begins to rise resulting in the air from the land drawing over the water.

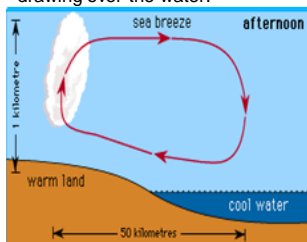


Figure 2. Atmospheric convection currents in the formation of sea breeze (www.britannica.com)

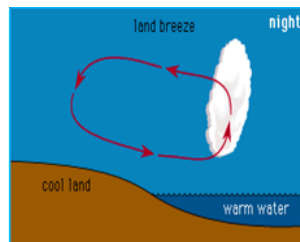
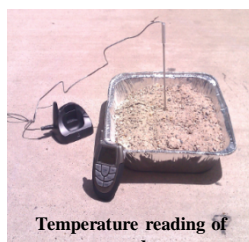


Figure 3. Atmospheric convection currents in the formation of land breeze (www.britannica.com)

Associated Activities



Temperature reading of sand.



Temperature reading of water

Figure 4. Experimental setup of sand and water.

Activity: Investigate the heat capacities of water and sand.

- Students use wireless temperature probes to investigate how fast sand and water heat and cool.
- Sand and water are placed in the same location outdoors under direct sunlight; temperature change is noted in 1 minute intervals for 15 minutes.
- Sand and water are taken indoors; temperature change is measured in 1 minute intervals for 15 minutes.
- Students construct a multiline graph to display their data and discuss the efficiency and reliability of wireless sensors in real world applications.

Assessment

Pre-Activity Assessment: Students will review the concept of heat transfer (convection, conduction, and radiation) and then incorporate these concepts by drawing out the formation of land and sea breezes. Students are expected to identify and label the concepts of heat transfer on their drawings.

Activity Embedded Assessment: During the sand and water temperature measurement lab, students will be assessed as they collect and analyze data by creating a line graph showing the differences in cooling and heating rates. Students will then use their knowledge to answer post-lab assessment questions.

Post-Activity Assessment: Once students complete their lab reports, they will revisit their pre-activity assessment drawing and make revisions if needed. Students will create a T-chart explaining the formation of sea and land breezes and then discuss the efficiency and reliability of wireless sensors in real world applications and generate their own design that could benefit society.

Conclusions and Future Work

Learning by showing them real life applications of engineering concepts through science. An extension activity to this lesson could be setting up an investigation to observe the direction of wind and measure its speed throughout a 24 hour period. In addition, students can investigate the different heating rates of dry sand versus wet sand. The work presented in this curriculum will be disseminating to a group of teachers in a workshop scheduled for January 2013.

Acknowledgement

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<http://www.utpa.edu/ret>



Model Your Own Walk

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Summary

In this activity, students obtain lines with positive and negative slopes using motion detectors, then students model different given graphs by walking at different speeds and finally they graph the motion of two students walking in opposite directions to obtain two intersecting lines and find a graphical solution to a system of linear equations. They do this by analyzing data from the motion detectors. They learn about the effects of changes in slope and intercepts on graphs.



Figure 1. Motion detectors being used in video games

Engineering Connection

Motion detectors are devices that transform the detection of motion of an object into an electrical signal. Engineers are using motion detectors in many different applications such as: motion-sensor gaming (Kinect), car alarms, indoor and outdoor home lights, park assist vehicle, etc. Engineers apply their understanding of math and science to design these devices. Students play the role of engineers as they use motion detectors to model a system of linear equations.

Learning Objectives

After this activity, students should be able to:

- Model and analyze data from motion detectors.
- Graph lines with positive and negative slopes.
- Describe the effects of changes in slope and y-intercept.
- Estimate the solution of a system of linear equations.
- Solve a system of linear equations graphically and algebraically.

Subject Area(s)
Grade Level

Algebra
9th (9-11)

Lesson Background & Concepts

Currently, motion detectors have been successfully used in the video gaming industry as well as the automotive industry. In video gaming, Kinect is a motion sensor device that enables users to control and interact with the Xbox 360 without the need to touch a game controller. In the automotive industry, Active-Park Assist uses motion sensors and electric power-assisted steering to position the car for parallel parking, calculate the optimal steering angle and steer the car into a parking spot. In this activity students will be able to use the same technology by modeling and solving systems of linear equations.

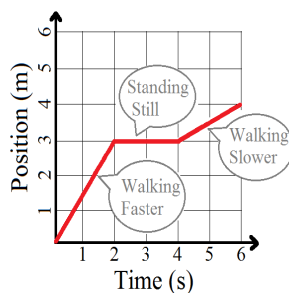


Figure 2. Graph matching exercise

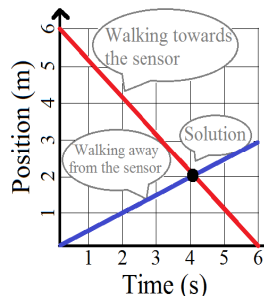


Figure 3. Graphical solution of a system of linear equations

Associated Activities

Practice using the motion detector (Worksheet #1)

- Have students walk at a constant rate so they can graph straight lines with positive and negative slopes.
- Direct students to walk at different rates

Challenge students to match different given graphs (Worksheet #2)

- Using an overhead projector have students match given graphs by walking away/towards the motion detector, standing still for some time and walking at different rates.

Using two motion detectors (Worksheet #3)

- Have two students walk in opposite directions to form two intersecting straight lines.
- Have students find the intersection of the lines.
- Discuss, compare, and analyze the results.

Assessment

Pre-Activity Assessment

Brainstorming: In small groups, have students discuss key vocabulary words for this activity (positive & negative slopes, zero & undefined slopes, x & y-intercepts, equation of a line in slope-intercept form).

Activity Embedded Assessment

Have students work on a real life problem, where they need to describe what the graph is telling them and the meaning of the intersection point. Have the students write a system of two linear equations to model the situation represented by the graph.

Post-Activity Assessment

Oral Presentation: Have students present their real life problems to the class on a poster board. Rubric will be used as an evaluation tool.

Conclusions and Future Work

Teaching algebra with more interactive and real world problems will benefit students' understanding of abstract concepts. In this activity, students will have the opportunity of obtaining their own data to develop algebra problems. Therefore, they are not only solving problems but also involved in designing the problem challenge. Students will become motivated, engaged to learn algebra, and also they will have a sense of ownership over their academic knowledge.

The next activity is to record the successive maximum heights for a bouncing ball and model the bounce height data with an exponential function.

Acknowledgement

This lesson was developed through The University of Texas-Pan American's Electrical Engineering Research Experiences for Teachers in Emerging and Novel Engineering Technologies (RET-ENET) program, National Science Foundation grant no. CNS-1132609.



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Hold on Tight! Hand Dynamometer Algebraic Investigation

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Summary

Students use the hand dynamometer, a device that measures the force applied in grip or pinch, to gather data. They learn the hands-on interpretation of the graphs and tables that this sensor outputs to their calculators. They calculate and compare slope and rate of change for the data



Figure 1. Grip in action
motivational image, Copyright © 2012 Adventures Today Pty Ltd

they create. Students predict graph trends for real-world scenarios in the medical field and ergonomic design. They use their understanding of data gathered by the hand dynamometer to design a product with an on button that specifies the force trend required to activate it, and aligns with the purpose of the product and profile of the product operator.

Engineering Connection

Biomechanical engineers use their understanding of the human body and mechanical engineering to design and monitor medical implants, innovate rehabilitation devices, and help athletes improve their performance. In the related field of ergonomics, designers use information regarding the force the body can produce to aid them in developing product designs that minimize operator exertion. Students will gather, analyze, and interpret data regarding the force produced by the human body and use their data in product design.

Learning Objectives

After this activity, students will be able to

- Calculate and compare slope and rate of change.
- Interpret the meaning of slope/rate of change in the context of a given situation.
- Represent data in a graph, table, and with a written description.

Subject Area Algebra I
Grade Level 9 (7-8)

Lesson Background & Concepts

In this activity, students will use the hand dynamometer and real-world scenarios to develop an understanding of core Algebra I concepts: multiple representations of data, slope, and rate of change. Using technology that enables students to see hand dynamometer sensory data on their calculators, they will record graphs and tables. They will experience how trends in this data were produced, through their own hands-on

on force application. Slope is the measurement of the steepness of a line. Students will learn to calculate slope and interpret its meaning. They will also use tabular data to calculate rate of change and determine whether the rates are constant or non-constant.

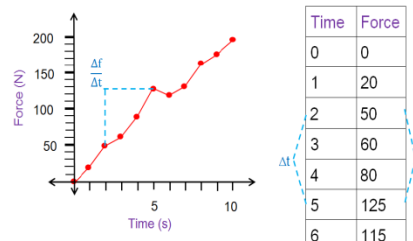


Figure 2. Sample Data: Multiple representations, Finding slope

Associated Activities

Data Introduction and Analysis

- Students will create time vs. force graphs and tables with increasing and decreasing trends and explain how they applied their grip in order to create these trends.
- Students will predict what real-world data of time vs. force would look like for muscle fatigue and ergonomic design; they will justify their predictions.
- Students will calculate the slope and rate of change of their data, compare graph steepness, and determine whether rates are constant or non-constant.



Figure 3. Data Collection, Copyright © 2012 Vernier Software & Technology

Ergonomic design

- Students will design a product with an on button, create a consumer profile for the product and provide graphical, tabular, and written description of the force vs. time trend that will enable the on button to activate

Assessment

Pre-Activity Assessment

Students take a "Tell Me About Data" pre-quiz designed to gauge their skills in interpreting quantitative data. The pre-quiz presents students with graphs and tables generated by the hand dynamometer, and asks them questions regarding line steepness and direction, rate of change, and whether they can provide calculations and explanations to show their understanding of the data.

Post-Activity Assessment

Students take a "Now, Tell Me About Data" post-quiz, which is similar to the pre-quiz in format, but specifically prompts students to calculate slope and rate of change and asks students to interpret and make comparisons in ways that utilize their newly-acquired vocabulary and mathematical understanding.

Conclusions and Future Work

Using the hand dynamometer will aid students to develop a strong conceptual framework for slope and rate of change, because the activity engages a variety of learning modalities. This same technology can be used in exploring other algebraic concepts, including modeling the equation of a line. The ability to gather their own data empowers students to investigate the world around them and take ownership in their learning. For this reason, continued development of activities that allow students to gather and explore data will be an integral part of my commitment to teaching.

Acknowledgement

This lesson was developed through The University of Texas-Pan American's Electrical Engineering Research Experiences for Teachers in Emerging and Novel Engineering Technologies (RET-ENET) program, National Science Foundation grant no. CNS-1132609.



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Solar Charging Station

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Summary

As a culminating project, students put their technical knowledge and skills into practice by designing and building a stand-alone photovoltaic system. This will consist of designing and building a solar charging station that can be used for charging small electronics, such as cellular phones. This project will include application of concepts associated with solar charge controllers, battery operations, DC to DC conversions, and USB power capabilities. The project will connect students to the engineering world of power sources, energy conversions, and electrical loads, both metaphorically and physically, as they take a creative, project-based approach to learning.

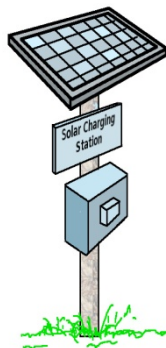


Figure 1. Solar Charging Station

Activity Background & Concepts

Photovoltaic panels take light energy known as insolation and produce an electric current, or flow of electrons. This energy source can be used to supply energy to a load, such as a light bulb or a motor, or can be stored in a battery. Quantitative analysis of these concepts teaches us how to link appropriate devices together to create an innovative system. Looking at values and formulas helps us calculate whether a system is efficient in doing what it is meant to do.

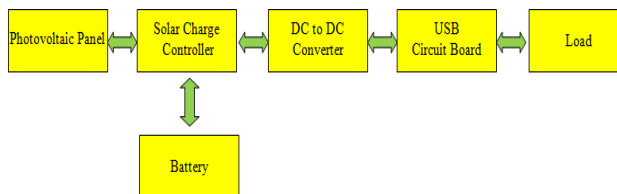


Figure 2. Solar Charging System Block Diagram

Engineering Connection

Photovoltaic panels and systems play a growing role in the energy industry; their presence is continuously increasing and becoming more visible throughout society. These products are conceived by engineers, who design them and their integrated systems to make them more cost-effective and energy-efficient. Students will act as engineers by applying problem solving skills throughout the process of designing and building a usable solar charging station.

Learning Objectives

The students will be able to:

- Calculate loads and photovoltaic size requirements.
- Identify and use appropriate tools to mount solar panels.
- Apply Ohm's Law.
- Describe how a charge controller works.
- Demonstrate how to measure current and voltage using a multimeter.

Subject Area(s): Science and Technology
Grade Level: 11-12

Associated Activities

Wiring Laboratory: Students will go through general procedures for linking the photovoltaic panel, solar charge controller, DC to DC converter, USB connections, battery and load. They must research and use component specifications to discover the best solution for their system. Students will use a multimeter to take measurements, perform calculations and verify values.

Hardware Mounting, Beyond the Electronics: Students use the proper tools to safely mount all components together, bringing the solar charging station to a stand. Once the system is up and running, students check the system's operation and analyze its use through a series of routine m

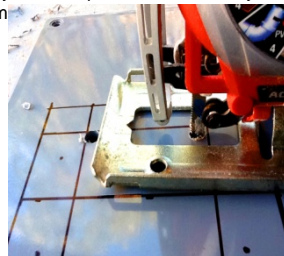


Figure 3. Cutting the enclosure with a reciprocating saw



Figure 4. Examples of solar panel, battery, and charge controller

Assessment

Pre-Activity Assessment – A discussion on the uses for solar chargers, creation of parts and price lists for items needed in making a stand-alone photovoltaic system will be held.

Activity Embedded Assessment - Lab instructions contain stopping points for instructor to grade on progress and to verify properly completed procedures.

Post-Activity Assessment - Students will be graded on measuring voltage and current of the solar charging system while in operation; they will also perform various tests as described in the Post-Activity Handout.



Figure 5. Arranging components in enclosure

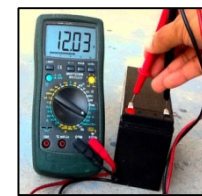


Figure 6. Measuring battery voltage with a multimeter

Conclusions and Future Work

disciplines the opportunity to learn about photovoltaic systems. The activity can be scaled down through the use of a solar power kit, so that lower grade levels can learn about uses for solar energy. The curriculum will be modified and improved as needed to include questions and material for other technical courses.

Acknowledgement

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Power Your Home With Sunshine!

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Summary

Students will verify the importance of using solar energy as an available natural resource to heat water. Using the given information, they will determine the appropriate panel array of the photovoltaic panel and solar collectors to optimize the solar energy according to location and the available area of the roof. After this activity, they will design a storage tank to fit the volume of hot water required and the available installation area. Finally, they will construct a scale model of the house and the solar water heater system and justify their model.

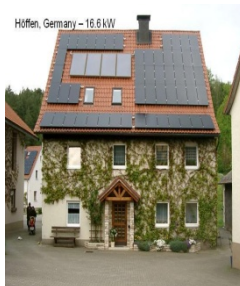


Figure 1. Combined regeneration controllable circulation solar energy heating system.
Copyright © DIY Trade Global B2B Trading Platform.

Engineering Connection

In order to provide electricity to remote or underdeveloped areas in the world, or to simply minimize the cost of electricity and use clean, natural resources, engineers convert solar energy into electricity. They have designed, and tested sophisticated systems. One of these systems is the use of photovoltaic panels and solar collectors to provide hot water. In this lesson students will play the role of an engineer by designing a water solar heater system to meet their needs.

Learning Objectives

After this lesson, students will be able to :

- Justify the use of solar energy to minimize the cost of electricity in their homes.
- Optimize the use of solar energy by determining the appropriate arrangement and location for the solar collectors and photovoltaic panels given, based on the available roof area and the total area of the panels.
- Evaluate the dimensions of a cylindrical water heater when given its volume and the available installation area.

Subject Area(s) Measurement
Grade Level 7 (6-8)

Lesson Background & Concepts

The students will recognize real world applications of mathematics and a different source of energy they do not automatically associate as a producer of electricity – the sun. Using solar energy is not easy; we need to have the knowledge, technology, and materials required to convert solar energy into electricity. Students will learn that before optimizing solar energy to produce hot water, they must first determine if they have the minimum roof area necessary for panel installation. Using mathematical calculations, they will design the best panel array for a given roof.



Figure 2. Panels arrays
Source: Solar Roofs.com

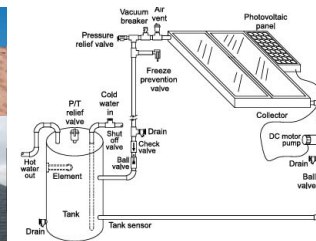


Figure 3. Solar Water Heater
Source: Florida Solar Energy Center 1997

Associated Activities

After the Solar Power lesson, students will illustrate how photovoltaic panels transfer solar energy into electricity by using the Solar Electricity Demonstration Kit. They will also write a reflective journal entry about their observations.

- Every student will receive the Area Worksheet with the house and solar panel dimensions to calculate the area of the roof and solar panels . Then, they will use this information to find the minimum roof area needed for panel installation.
- Students will use the Volume Worksheet to determine the dimensions of the vertical water heater tank. Dimensions will be based on volume and the available installation area.
- Working in groups of four, students will model how the water solar heater (Figure 3) works by using the Power House Kit, Full Version.
- As a group project and to close this lesson, the students will design a 3D scale model of the house and the solar water system.

Assessment

Pre- Assessment:

Students will:

- Define "Photovoltaic Panel" in their own words.
- Discuss the positive and negative impacts of using photovoltaic panels.

Embedded Assessment:

- Area Worksheet .
- What is the appropriate panel array to optimize the use of solar energy according to location and the available roof area?
- Volume Worksheet.

Post – Assessment:

Students should present their 3D scale model to the class and justify the scale model used. They need to explain what materials they used and why. Can they improve their project? Why? How? Justify the answers.

Conclusions and Future Work

This activity helps students to recognize and value the importance of using solar energy as an available resource to provide electricity at a cheaper cost. Also, they will understand how important it is to be prepared to challenge obstacles in life. This lesson can be extended or modified for high school students by asking to complete the next assignment: Imagine that you belong to a family of ten living in an isolated area, and you do not have access to electricity at all. Design a solar energy system that adequately meets the needs of your family.

Acknowledgement

This lesson was developed through The University of Texas-Pan American's Electrical Engineering Research Experiences for Teachers in Emerging and Novel Engineering Technologies (RET-ENET) program, National Science Foundation grant no. CNS-1132609.



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Solar Racers

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Summary

In this lesson, students learn to define potential and kinetic energy; they also compare and contrast the two. They apply their knowledge of potential and kinetic energy by racing solar-powered cars. This activity enables students to see the conversion of potential energy to kinetic energy. Furthermore, they practice calculating average speed, using data gathered from racing their solar-powered cars. This gives students hands-on interaction with the concept of speed. Lastly, they graph their data in a distance vs. time graph. This gives students a graphical representation of speed.

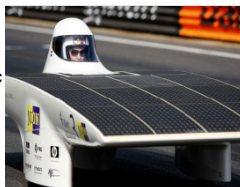


Figure 1. The Nuon solar car, created by students at Delft University in the Netherlands, won the 2007 Panasonic World Solar Challenge in Australia.
Source: Panasonic World Solar Challenge

Engineering Connection

When designing sports cars, engineers ensure the car's energy can be quickly converted from potential to kinetic. Furthermore, since sports cars reach excessively high speeds, the car must be designed to maximize distance traveled within a period of time. To optimize a sports car design, engineers must have a clear understanding of the relationship between energy and speed. In this lesson and activity, students will act as engineers gaining crucial pre-requisite knowledge of energy and speed necessary to build a sports car or other fast-moving object.

Learning Objectives

- In this lesson, students will learn:
- How to define potential and kinetic energy
 - How to communicate similarities and differences between potential and kinetic energy
 - How to calculate average speed given distance and time values
 - How to construct a distance v. time graph

Subject Area(s) Physics (energy, force, motion)
Grade Level 7 (6-8)

Lesson Background & Concepts

Work is movement of an object over distance by a force. Anytime work occurs, energy is used. Energy exists in two main forms: kinetic and potential. Kinetic energy is motion or movement; potential energy is stored and based on position. Energy cannot be created or destroyed, only transformed. An example is racing solar-powered cars, where energy is converted from potential to kinetic. Racing solar cars also lends itself to practicing how to measure average speed (Average speed = total distance ÷ total time). Constructing a distance v. time graph allows for visualization of speed.

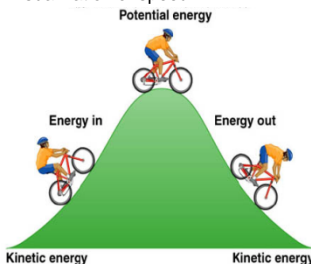


Figure 2. Kinetic energy is motion; potential energy is position.
Source: www.petervaldia.com

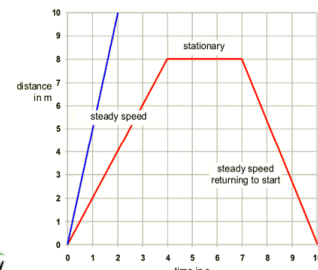


Figure 3. The slope of a distance v. time graph denotes speed.
Source: www.bbc.co.uk

Solar Racers Activity

For the activity, each student will receive a copy of the "Solar Racers" worksheet. Students will work outdoors in groups of three, where each group will race three solar-powered cars. Students will hypothesize which of their group's three cars they believe will display the greatest speed. A "track" with a specified distance, start line, and finish line will be pre-set. Using a handheld timer, students will track the time it takes each car to reach the finish line. As students race the cars, they annotate their data (distance and time values) on the worksheet. Upon completing the lab, students complete the remainder of the worksheet. This will consist of calculating average speed using collected data, creating a distance v. time graph using collected data, and using the scientific method to analyze/compare hypothesis and results.



Figure 4. One of the cars students will race is the Blue Eagle Solar Racer by Kyocera.
Source: www.carolina.com

Assessment

Students will complete several assessments throughout the "Solar Racers" lesson and activity. Assessments were designed to allow students to demonstrate mastery, as well as to expose any gaps in learning. The following assessments will be given:

- **Pre-Activity Assessment:** Students draw a picture of what solar energy means to them. Underneath the picture, students define "renewable" in their own words.
- **Activity-Embedded Assessment:** Students record data (distance and time values) and calculate speed using their data.
- **Post-Activity Assessment:** Students complete the "Solar Racers Activity" worksheet, graphing their data and answering questions about their graphs and the scientific method.

Conclusions and Future Work

Students will race solar-powered cars in order to illustrate speed, potential, and kinetic energy. They will answer scientific method-related questions, calculate average speed, and graph their data. This activity will provide an effortless transition into teaching energy transformations, since it demonstrates the transformation of solar energy into kinetic energy. My goals for this lesson and activity are student engagement and real-world applicability. Using assessment results will help me gauge content mastery. If I find major gaps in knowledge following the lesson and activity, I will revise the lesson to address those gaps in the future. The "Solar Racers" lesson and activity will be taught in the 2012-2013 school year.

Acknowledgement

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