Science • Technology • Engineering • Math

POSTER PROCEEDINGS

The 2015 STEM Education Teacher Workshop

February 7, 2015

McAllen Convention Center
700 Convention Center Blvd
McAllen, Texas

Curriculum Posters

Teacher Presenter	Lesson Title	Subject	Grade Level(s)	School District
Angela Camargo	Dare to Drink	Chemistry; Biology; Life Science	8	McAllen ISD
Cesar Castro	When Do Engineers Use Linear Equations	Algebra; Linear Functions	9	Donna ISD
Nancy Farrell	Designing Motorized Cars	Algebra I	9	Weslaco ISD
Frances Wells	The Lebron Bridge	Ratios and Proportional Relationships	6	IDEA Public Schools
Julio Navarro	Sola Cell Circuit Systems	Science and Technology	11	Donna ISD
Maricela Reyes	Joints and Range Motion	Life Sciences; Biology; Principles of Biomedical	9	PSJA ISD
Andrew Thompson	Engineering K'NEX-tions	Science and Technology; Reasoning and Proofs	8	McAllen ISD
Jorge Juarez	Launching Objects at Different Angles	Algebra I & II	9	Weslaco ISD
Portia Abad	Amazing Rays	Physical Sciences; Physics and Chemistry	11	La Joya ISD
Daniel Garcia	All About Circuits	Physics	11	IDEA Public Schools
Gina Miquiabas	Heartbeat Gone Wild	Pre-Calculus; Biomedical Sciences	12	PSJA ISD
Juan Salinas	Water Flow Analysis	AP Calculus AB	12	South Texas ISD
Gordon Moore	Full Speed Ahead	Measurements; Science and Technology	4	Sharyland ISD
Miguel Ramirez	Mapping with Servos and Sensors	Geometry; Computer Science	10	Edinburg ISD

Dare To Drink

Angela Camargo, McAllen ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

The measurement of turbidity is a key test of water quality as it may indicate the presence of disease causing organisms. Can contaminated water be filtered for safe consumption? (figure 1) Teams are modeling the work of water resource engineers by designing and building water filters. Students will then test their design by testing the turbidity in the filtered water. Like engineers they will follow the design process and redesign their filter to run a second water test as well as share their findings with the class. Using turbidity probes, students will evaluate how effective their design was and if the water they filtered is safe to drink.

Figure 1. Can water be filtered for safe consumption?

Engineering Connection

Water resource engineers are working to design new ways to clean contaminated drinking water that is faster and cheaper. They estimate that most tap and well water in the U.S. is not safe for drink and filtration stations consume a lot of electrical energy. Students will get the opportunity to make water filters that model after nanofibers, which promise cheaper drinking water for the city!

Learning Objectives

After this activity, students should be able to:

- Evaluate the design of a water filter made with fishing line of different diameters.
- Construct a graph that compares the diameter of the fishing line and turbidity of filtered water.
- Identify the steps of the engineering design process.

Subject Area(s) Chemistry, Biology, Life
Grade Level 8 (6-8)

Lesson Background & Concepts

Water is the basis for life and without it, life is not possible. Contaminated water can kill more survivors of a nuclear attack than the explosion itself. The atomic bomb on Hiroshima killed roughly 45% of the population, over many years however more died from the later effects; effects such as burns, radiation, and diseases acquired from contaminated drinking water. Thanks to unique qualities, nanofibers have the greatest potential in the field of water filtration. Nanofibers are the hope for millions of people who do not have access to drinking water especially after a catastrophic event. (figure 2 and 3)

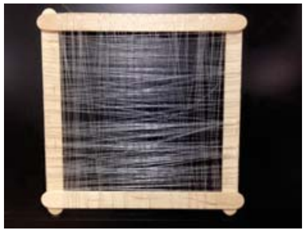

Figure 2. Sample Water Filter Design made from 8 lb. monofilament Fishing Line

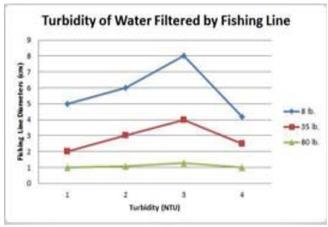

Figure 3. Sample Class Data graphed for analysis

Activity

Activity lesson exposes students to the full design cycle.

<u>Brainstorming, Building and Testing</u>

- Brainstorm with group members ideas for water filter design. Draw a sketch that will help the team plan and build an effective water filter.
- Build water filter using the sketch as a guide. Using fishing lines of various diameters will help the team imitate water filtration with nanotechnology.
- Test the quality of filtered water by measuring the water turbidity. Turbidity Sensors measure the cloudiness in water and is a good indicator of safe drinking water.

<u>Modify Design, Re-Test and Evaluate</u>

- Brainstorm and plan for modified water filter. The goal is to think of ways that the filter design can improve in order to lower the turbidity in the filtered water.
- Build the modified water filter and re-test the turbidity in the newly filtered water.
- Graph the lowest turbidity of the two filters in the class graph for comparing. This will help the class analyze the effect of the fishing line on the turbidity of the filtered water. Is your water safe to drink?

Assessment

Pre-Activity Assessment
Assess what students already know about evaluating the design of an object, the steps professional take when solving a problem and their graphing skills.

Activity Embedded Assessment
Students will collect two turbidity values, one from the first design and on from their modified design. They will describe the steps they followed when solving challenge and explain to class their approach when solving their challenge.

Post-Activity Assessment
Assess student's overall understanding of the engineering design process, the ability to interpret graphs and describe how engineers work while meeting specifications and requirements of design.

Conclusions and Future Work

In concluding this lesson students will gain experiences that will allow them to think and perform like engineers. Immersed in the complete Engineering Design Cycle will help students understand the steps engineers take when designing technologies that make the world a better place for everyone living in it. This lesson will expose students to new technologies such as nanotechnology and they will get the opportunity to imitate nanofiber production as well as evaluate nanofibers by comparing the performance of their water filters.

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.

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

When Do Engineers Use Linear Equations?

Cesar Castro, DONNA ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students use the quadcopter to record a video and obtain the distance travelled and time. A quad copter provides a real time-live-view on a mobile device (iphone, android or tablet) that allows learners to take photos and videos (Figure 1). Students collect data and represent the relationship between time and distance quantities using tables, graphs and linear equations (y=mx + b). Finally, students evaluate their solutions by using the graphing calculator (TI-NSPIRE CX).

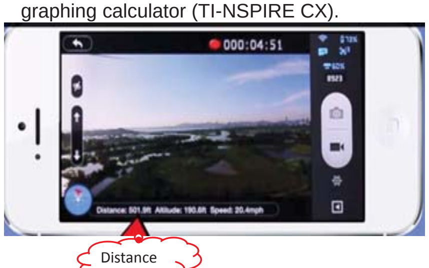

Figure 1. Students record a video including distance and time from the quadcopter

Engineering Connection

The aerial drone is a unique remote sensing platform that allows real-time collection of remote sensing data. This data allows learners to find patterns and represent it as an equation. Aerial robots are able to do various task such as aerial footage in filmmaking search, rescue operations, inspecting power lines and pipelines, delivering medical supplies to inaccessible regions, weather monitoring, oil, gas and mineral exploration by using linear equations.

Learning Objectives

After this activity, students should be able to:

- Represent relationships among quantities using concrete models, tables, graphs, diagrams, verbal descriptions, equations, and inequalities.
- Make and interpret scatterplots (including recognizing positive, negative, or no correlation for data approximating linear situations),model, predict, and make critical decisions.

Subject Area(s) Algebra, linear functions
Grade Level 9 (9-12)

Lesson Background & Activity

Solving equations are widely used by engineers, scientists and mathematicians to solve real life situations. Engineers translate the real world situation into assumptions and crate a mathematical model. This activity is focused mostly on the mathematical analysis and problem solving skills, especially the application of linear equations.

TIME (sec)	DISTANCE (ft)
Initial	476
1	505.5
2	537.3
3	560.7
4	unknow
5	614.4
10	735.4
15	877

Figure 2. Students use a table to represent data

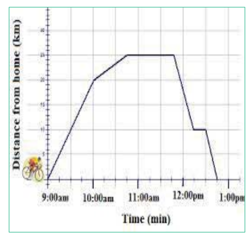

Figure 3. Students use a graph to represent data

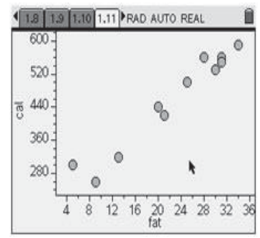

Figure 4. Graphing calculator displaying time versus distance as the quadcopter is moving a constant rate

Day 1: Diagnostic exam

- Provide enough time to complete the diagnostic exam and survey
- Show students a presentation regarding what careers use linear equations.
- Start a discussion related to what careers use linear equations

Day 2: Introduction and work stations

- Show the introduction video.
- Station 1-Students use their prior-knowledge on linear equations to make a graphic organizer.
- Station 2-Students will play the role of engineers, where they are required to collect and represent the relationship among time and distance using tables [Figure 2], graphs [Figure 3] and linear equations.
- Students use the quad copter to get and record the flying data [Figure 1].
- Station 3, with the use of a graphing calculator, students will interpret, predict and make decisions for linear equations [Figure 4].

Day 3: Introduction and work stations

- Students present information collected and results. Learners are required to summarize the activity, create charts and tables that represent the data collected on lesson, provide results and conclusion, and present their finding by using a computer program such power point, prezi, powtoon, emaze, go animate, google docs, slidericet .
- Students complete a post-survey.

Assessment

Pre-Activity Assessment

- Survey
- Brainstorming: The class is involved in open discussion regarding the survey's responses.
- Diagnostic exam [Pre-test]: The purpose is to identify the students' current knowledge, their skill sets and capabilities, and to clarify misconceptions before teaching takes place.

Activity Embedded Assessment

- Formative assessment: Throughout day 2, teacher will use question and answer sessions both formal-planned and informal-spontaneous. The purpose is to get feedback and information while learning is taking place.

Post-Activity Assessment

- Summative assessment [Project]: On day 3, students present a project that includes:
- Post-survey: Comparing the survey and post-survey help us to measure what students think or perceive to be different because or lesson.

Conclusions and Future Work

This activity gives students a real-world situation in which linear equations, problem solving strategies and the use of 21 century technology is required. It gives students the opportunity to be exposed to the field of Engineering and increase student's interest in STEM (Science, Technology, Engineering and Math). In addition, this activity introduces high school students to potential careers en the various field of engineering such as electrical, aerospace and design engineering.

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.

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

Designing Motorized Cars

Nancy Farrell, Weslaco ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students work in teams to build a motorized car using LEGO Technic Simple and Powered Machines kits (see Figure 1). First they use a schematic to build the "Lug Nut Labs" car currently in production. Then, they modify the cars in order to maximize speed and directional control for next year's model. Students may modify many aspects of the structure including its chassis, placement of the motor, size of gears, number of wheels, wheel diameter, wheel width, position of the wheels on the chassis, car mass, etc. Students will collect two data sets (a) distance vs time and (b) deviation from straight path vs time. Students will calculate the slope and derive the equation of the line to understand slope as a rate of change.

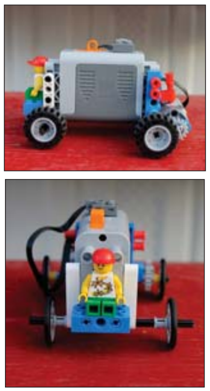

Figure 1. Lego Model 11 with two types of wheels.

Engineering Connection

Automotive Engineers design and test cars to make them safer, cheaper, faster, more fuel efficient, more comfortable, or even drive themselves. Parts and whole systems are designed and tested individually by the Product Engineer. The final evaluation though, has to be conducted at the automobile level to ensure that all systems work together correctly.

Learning Objectives

- Collect and organize data sets from a motorized car into tables and graphs. If the graph is linear, determine the slope, y-intercept, and the equation of the line from the graph.
- Interpret the graph of the motion of a motorized car by describing what the slope and y-intercept represent.
- Make and test a prototype motorized-car and evaluate the design by making observations and necessary adjustments.

Subject Area(s)	Algebra 1
Grade Level	9 (8-12)

Lesson Background & Concepts

We take a lot for granted. For example, cars. A tremendous amount of work goes into designing not just the whole car, but every part in the car. Take tires. Design engineers have modified the shape of tires to provide responsive handling, steering, and agility. There are specialized tires for trucks, SUVs, airplanes, farm machinery, bicycles, wheelchairs, and weather (see Figure 2). When engineers test a component's new design, testing includes mathematics and the data generated is often organized into a table, chart, or graph (See Figure 3). The ability to interpret the meaning of the data is critical to understanding the characteristics of any given component or system design.

Figure 2. Tire on the left is designed for highway driving; for mud on the right.

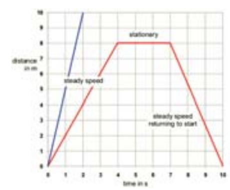

Figure 3. Sample distance vs time graph communicates speed.

Activity

Day 1: Introduction & Motivation
1. Watch *Future Cars 2020!* video. Predict and test the motions of toy cars.
2. Identify problems in the world. Watch "The Design Process in Action."
3. Take a pre-test on the Design Process and the meaning of slope.
4. Research what kinds of engineers there are and what they do.

Day 2: Build a Prototype
1. Read and discuss the Design Challenge (See Figure 4.)
2. Learn the procedures and expectations for testing prototype cars.
3. Design and build a prototype car to meet project criteria.

Day 3: Apply the Design Process
1. Build. Test and evaluate. Redesign.
2. Graph and analyze the data.
3. Prepare presentations for an audience.

Day 4: Presentations
1. Present findings to an audience.
2. Take a post-test to asses learning.
3. Watch *Nanotube Technology and the Future of Cars.* Discuss.

Figure 4. Lego Model 18. Baseline model before Design Process applied.

Assessment

Pre-Activity Assessment: Do students know what engineers do in general? Can they name several engineering fields and describe the type of work the engineers do? Can students put the steps of the Design Process in order? Can students organize data into a table and graph? Can they write an equation to express the relationship between the distance and time from a graph, determine the slope of the graph, and describe what the slope represents?

Activity Embedded Assessment: Students apply the Design Process, collect and organize data into tables and graphs, and then complete questions requiring them to analyze the meaning of the data and the Design Process.

Post-Activity Assessment: A repeat of the pre-test with different graphing problems to assess student growth.

Conclusions and Future Work

Engineers use math to measure the effectiveness of their designs. In this activity students develop an understanding of the attributes of design and relate algebra to the real world.

The design portion of this activity may be extended by adding additional constraints to the problem. For example, students may be given a budget they must stay within, be required to analyze different gear ratios, or even add a second motor to the car.

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 Lebron Bridge

Frances Wells, IDEA Public Schools (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students learn about the engineering design cycle and how engineers must build and test scale models before they build anything in real life. Students are given real-world constraints as if they are real engineers and then design, build, and test their own bridge made of Legos. Students get to experience two iterations of the engineering design process. This activity emphasizes the use of ratios and proportions to help engineers make informed decisions about their designs. The activity involves a design challenge in which students are competing to win a bid to build a bridge for Lebron James.

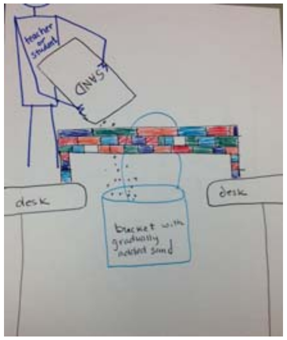

Figure 1. A sketch of the load capacity evaluation of the bridge.

Engineering Connection

Civil and architectural engineers are trusted to build bridges that keep people safe. They must also work under real-world constraints like a required load capacity, limited time, limited cost, limited availability of supplies, and the possibility of severe weather that can compromise the safety of their structure.

Learning Objectives

After this activity, students will be able to:
•Apply and articulate the steps of the engineering design cycle
•Explain the concepts of scale, ratios, and proportions and how these concepts are related
•Determine the scale factor of a model to an actual item
•Use ratios and proportions to solve real-world problems

Subject Area(s)	Ratios and Proportional Relationships
Grade Level	6 (5-7)

Lesson Background & Concepts

Students will have already been introduced to ratios and proportions one time through a previous activity that also uses Legos, "Dare to Compare." Students will be introduced to the engineering design cycle (Figure 3) and will have several design challenges that cause them to constantly take measurements and set up proportions as they make decisions involving the design of their bridge, including constraints on cost, limited resources, demands for load capacity, and demands for a minimum boat clearance.

Figure 2. Shown here are a few of the many approaches students could take for their initial design.

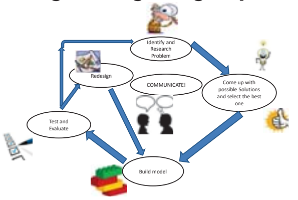

Figure 3. The engineering design process students will refer to during this activity.

Activity Timeline

Before this activity, students must have encountered ratios and proportions at least once; otherwise, students may get frustrated performing calculations.

<u>Day 1: Design and Building Attempt #1</u>
- Introduce students to the activity and discuss the constraints.
- Give students time to design and build a model (Figure 2).

<u>Days 2 and 4: Bridge Evaluation</u>
- Students present their model and share details about its cost, size, and weight as a model and as a real structure that spans 4,500 meters.
- Students add weight to their bridge until it collapses and calculate the load capacity to mass ratio (Figure 1). Students use proportions to solve for the load capacity of the actual bridge, taking into account the fact that the actual building material (hypothetically) is 2.3 times stronger than a Lego of equal size would be.

<u>Day 3: Redesign and Building Attempt #2</u>
- Students redesign, build, and reflect on the engineering design process.
- Teacher visits with each group to push their understanding of the engineering design cycle and what ratios and proportions truly represent

Assessment

<u>Pre-Activity Assessment</u>
•Can students clearly state a ratio and what it represents?
•Can students solve for a missing value in a proportion?

<u>Activity Embedded Assessment</u>
•Can students set up the proportions necessary to make continuous modifications to their bridges as they design them?
•Can students describe each step of the engineering design process as they experience it?

<u>Post Activity Assessment</u>
•In addition to setting up and solving for missing values in proportion problems, can students articulate the conceptual relationship between ratio, proportion, and scale?
•Can students explain the steps of the engineering design process and describe this activity using those steps?

Conclusions and Future Work

This activity gives students a real-world situation in which being able to solve proportion problems is essential. It gives students the opportunity to experience the constraints, stresses, competition, and excitement that true engineers experience.

Further work is necessary to obtain materials and implement the lesson to evaluate its effectiveness in helping students develop a lasting understanding of proportions. Modifications to the lesson may be necessary post implementation and prior to submission.

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.

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

Solar Cell Circuit Systems

Julio C. Navarro, Jr., Donna ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students will learn about a system by identifying the input, process, and output. They will build circuits with Photovoltaic Solar Cells, Potentiometer, and various loads (Motor, LED, Speaker) to observe a system first-hand. They will learn about how a Solar Cell is a system that produces power to drive the various circuits similar to how a car battery powers the motor, lights, and radio. The students will also see how each component of the circuit they build is a system itself also (loads). The Students will use multimeters to measure the voltage and current through the system to practice taking measurements as well.

Figure 1. Closed system.

Engineering Connection

Every electronic device and automatic piece of technology in our life is composed of systems. Systems exist everywhere from a light switch to moving a car. Even in renewable energy technology, a circuit can explain the "how" of its inner workings. Understanding systems will enable students to more easily comprehend the more complex engineering concepts they will see at the university level.

Learning Objectives

After this activity, students should be able to:

- ➢Explain what a system is
- ➢Build simple circuits using a Solar Cell as a battery
- ➢Identify the components in the circuits they build
- ➢Measure Voltage and Current with Multimeter
- ➢Compile observations and data into a report
- ➢Give examples of other systems or circuits in their daily lives

Subject Area(s)	Science and Technology
Grade Level	11 (**10**-**12**)

Lesson Background & Concepts

As part of the activity, students will be expected to already have been introduced to circuits. The students are expected to know how to calculate the current through the circuit as well as how to read a circuit diagram. The Student will also be introduced to solar energy, so they will understand this technology better as they work on their assignment. The end result of this activity should be that the students know what a system is, with the PV Cell as the first example of a system in Figure 2.

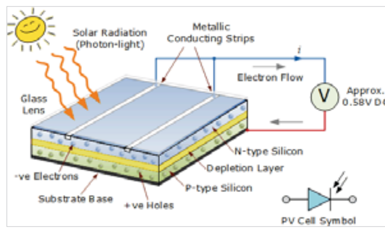

Figure 2. Components of a PV Cell.

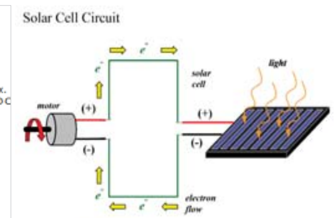

Figure 3. An example of a simple circuit with a PV Cell as a battery.

Activity

As the lead engineer of small engineering team traveling with renewable energy system's supplies, the students will band together with to devise a way to use their materials in a working circuit. The student teams will then employ the Engineering Design Cycle

<u>Design Cycle Steps</u>

- State The Problem
- Brainstorm Solutions
- Follow through on the best solution
- Record result on solution

<u>Survival Challenge</u>

As the students come up with ways to use their supplies to, you will guide them to one of three different conclusions.

- Circuit emphasizing a strong motor setup (simple example in Figure 3).
  - -This setup indicates taking the group out to sea.
- Circuit emphasizing LED Lights.
  - -This setup indicates Signaling passing craft at night
- Circuit emphasizing the Speaker.
  - -This setup indicates signaling relatively close passing vehicles.

Assessment

Activity Embedded Assessment

Engineering Design Cycle Rubric: The students will receive the appropriate rubric that will guide all of their actions. As they fill out the engineering design cycle steps with their decisions, they will be able to go through most of the engineering design cycle steps by the end of the activity.

- -State the problem.
- -Brainstorm Solutions
- -Decide Best Solution
- -Implement Circuit on paper and build.
- -Test Circuit

By the end of the handout, the students will have recorded most of the steps of the engineering design process.

Post-Activity Assessment

Systems Quiz: The students will take a quiz on the components of their systems. They will have to identify their inputs, process, and outputs as well as define some of the vocabulary words.

Conclusions and Future Work

By the end of the lesson, I hope to teach the students about how systems work and shed light onto this concept which will carry on to university and graduate level academia. Having a hands-on activity that makes an abstract concept more tangible to the student will make it easier to learn.

For future work on this activity, the students will have to expand on the circuit systems they developed. That is to say, the students will make a practical application of their circuit onto a usable vehicle or device while still using the Engineering Design Cycle as a guide.

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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Joints and Range of Motion

Maricela Reyes, PSJA ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students will learn to measure Range of Motion (ROM) for specific joint movements, using a regular goniometer. Joint range of motion will also be measured using software and sensor technology, allowing students to observe graphed data representing the angle at which joints are moving. Data from both methods will be compared for positive and negative aspects . By engaging students in this activity, they will understand the role of engineers in developing and testing new technology that can provide medical doctors possibly a faster and more precise way to measure range of motion to detect injury and its impact on health care and society.

Figure 1.
Health care professionals measure ROM using a goniometer

Engineering Connection

Students will learn about the role of engineers in the development of new technology that can facilitate orthopedics, chiropractors, physical therapist among other medical doctors, innovative and effective methods to measure joint range of motion and diagnose joint related injuries and disease.

Learning Objectives

- •Define range of motion
- •Identify anatomical terms of motion
- •Demosntrate how to measure joint range of motion using a goniometer
- •List various types of technology developed by engineers to measure range of motion and detect injury

Subject Area(s)
Life Sciences, Biology, Principles of Biomedical Sciences

Grade Level 9 (9-12)

Lesson Background & Concepts

Students will watch a short video presentation to review basic anatomical terms of motion and learn about the use of a goniometer device. Engaging discussions will introduce students to common activities in which joint ROM can be measured. The use of newly developed technology to measure and detect joint movement will be introduced to encourage students to research about engineers and their important role in society.

Figure 2.
Students using technology as the sensors in the goniometer detect ROM from elbow flexion

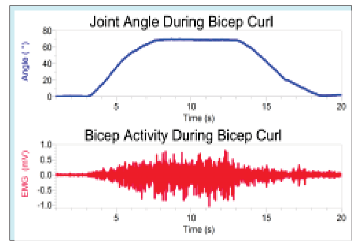

Figure 3. Angle measurements from sensor goniometer are graphed on Vernier software equipment

Activity

This activity requires two class periods. Students in groups of two will use a regular goniometer (***Figure 1***) to measure ROM manually in Day 1. On DAY 2 it is recommended to group students in teams of four and assign them different roles necessary to effectively use the sensor equipment (***Figure 2***)

<u>Day 1</u>

- Answer Questionnaire
- Watch Introduction PPT and Video deliver by teacher
- Students will measure their partner's joint movements and record data on data table/worksheet
- Students do a quick online research on technology developed by engineers

<u>Day 2</u>

- Class discussion – Abnormal ROM, Causes, Diagnosis & Consequences
- Students will use technology to collect graphed data (***Figure 3***) and compare with the first set of data from Day 1
- Compare data from Day 1 and Day 2 and explain
- Students answer conclusion questions
- Short discussion will follow to wrap up the lesson to assure that students understand the connection between range of motion, disease and diagnosis methods

Assessment

Pre-Activity Assessment

<u>Descriptive Title</u>: *Scaffolding Questionnaire* (must be given prior to introduction presentation).
•All students will be given a pre-assessment (10 questions) to be tested on essential vocabulary and concepts previously mentioned allowing them to build on previous knowledge.

Activity Embedded Assessment

<u>Descriptive Title</u> : *Measuring Range of Motion*
•Students will be tested on their ability to measure range of motion. Using a goniometer, they will determine the type of movement that is necessary in order to gather precise measurements. They will also compare data with another group to determine differences and similarities.

Post-Activity Assessment

<u>Descriptive Title</u>: *Conclusion Questions*
•Students will answer ten open-ended questions and justify their answers. These questions will allow them to explained activity concepts and apply the techniques learned to real world scenarios.

Conclusions and Future Work

In this activity, students experience the use of sensor technology. They see a connection between the work of engineers, their background knowledge in the human body and Science. Students also reflect on the importance of engineers research and its role in society, health care, biomedical fields and other industries. Allowing students to explore about engineering concepts may interest them highly enough to consider pursuing a career in related fields.
After implementing this activity and testing its effectiveness, possible changes may be done to improve student's performance and help them reach their maximum learning potential.

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.

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

Engineering K'NEX-tions

Andrew Thompson, McAllen ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students learn to study a mechanical system as a dynamic system under their control as opposed to a static image on a screen. Student teams act as engineers and brainstorm, design, build, and test their ideas for altering a motor's motion to maximize speed. In this activity, students are guided through an example engineering analysis scenario for a K'NEX car. Then they perform an analysis on the design solutions they came up with through testing and measurement. Students will then race their team's car against their peers' cars.

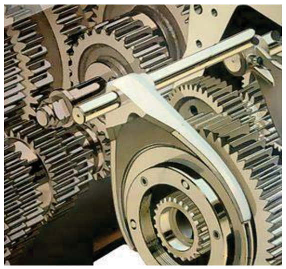

Figure 1. Multiple Gear Train

This activity gives students a chance to act as engineers by:

- Using the engineering design cycle
- Practicing collecting analyzing, and making reasonable conclusions from data

Engineering Connection

Students are introduced to gears and the mechanical advantages they provide. Engineering analysis can be described as the breaking down of an object, system, problem or issue into its basic elements to get at its essential features and their relationships to each other and to external elements. Analysis of design before building often leads to increased efficiency or safety.

Learning Objectives

After this lesson, students should be able to:
•Describe and apply the engineering design cycle to other challenges
•Use measurement equipment such as meter sticks and stopwatches correctly and accurately
•Compare and contrast design alternatives
•Provide a written summary of their progress through the design process
•Establish a connection between the variables tested and changed and the speed of their car

Subject Area(s)	Science and Technology/Reasoning and Proof
Grade Level	8 (6-8)

Lesson Background & Concepts

In this activity, students will be taking on the role of an engineering team seeking to solve a problem. To solve this problem, they will need to create a design, test the design, analyze the outcome of those tests, and then cycle back through the engineering process until an optimal design is reached. They will alter two types of variables, gears and tires, to determine the best design.

If the number of teeth on the output gear equals the number of teeth on the input gear, the gear ratio is equal to 1:1. If the ratio is 1:1, then the speed of the car will be the same as the output force of the motor. A gear ratio less than 1, which corresponds to the output gear having fewer teeth than the input gear, increases speed. A gear ratio greater than 1 increases torque, but decreases speed; in this gear train, the output gear has more teeth than the input gear. Additionally, expect students to gain an understanding of how the size of the tires also has an effect on the design's motion

Figure 2. K'NEX Car Demonstrating Compound Gear Train

Figure 3: Proportional lengths of K'NEX ensures easy construction

Activity

This activity requires five (5) class days. Students work in groups of 3-4. The instruction for each day are outlined as follows:

Day One: Introduce lesson and show Youtube videos, complete gear ratio worksheets

- Divide into groups, assign roles, and brainstorm possible designs

Days Two-Three: Students will begin building their brainstormed ideas and quantifiably testing using their measuring tools and recording results in their packet

- Students will take notes, and answer questions about, the engineering design cycle

Day Four: Students will gallery walk the other teams' designs and discuss how what they see will impact the competition

- Move to the competition area and prepare for the race
- During the race, the students will place a marker at the cars' location every 5 seconds
- Record results and distance data and return to class
- Use collected data to calculate their car's speed through the course

Day Five: The winning team will explain to the class how they used the design cycle and how they used their data to revise their designs

- Students will complete writing samples as outlined in their Group Packet
- Students will create a graph showing their class' speed data
- Students will finish all uncompleted work from packet and worksheets

Winning designs from each class will compete in a grand championship, and the overall winner will be saved for display for the rest of the school to see.

Assessment

Pre-Activity Assessment
Brain Storming and Gear Ratio Worksheets- Do students understand the theoretical mechanical advantage of gears?
Activity Embedded Assessment
K'NEX Engineering Group packet- Students document their use of the design cycle, and answer all questions in packet according to the appropriate day's instructions
Post-Activity Assessment
Writing Sample: Answer long answer questions according to the K'NEX Engineering Group Packet
Class period based competition- Students will race their designs on the course to show a real life connection between their work and their results while gathering data for speed calculations post-race.
Create A Graph- Students use the data gathered to calculate speeds, answer several questions about their results, and create a graph showing their data using the Create A graph hyperlink

Conclusions and Future Work

Math and science help engineers analyze relationships. between variables and outcomes. This helps with the design cycle. By measuring data and making comparisons, desirable outcomes can be created. Students will make changes to their designs and record the results, and by using this data, they can alter their designs until an optimal one is achieved.
This activity teaches students about the direct connection between changing variables and resulting outcomes. They will measure these changes and be able to explain and graph these changes. The creative nature of the K'NEX building pieces creates a virtually unlimited number of possible designs for students to use.

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.

Launching Objects at Different Angles

Jorge Suarez, Weslaco East High School (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students learn about how an object can be launched at different angles to produce the maximum distance. This is done by using the Lego Mindstorms NXT 2.0 or Lego Mindstorms EV3 to launch objects at different angles. The students make multiple attempts at launching objects at different angles and use tables to decide which angle delivers the maximum distance. This will activity will encourage students to think about different ways angles can be used in real life applications.

Figure 1. This image shows the trajectory of a golf ball at evenly distributed intervals of time. The procedure produces 100 images of the golf ball during its trajectory.

Engineering Connection

Engineers are responsible for designing and testing equipment used by consumers. Some engineers work with rockets to ensure they meet the high standards of the user. Exposing students to the process involved in launching objects at different angles gives them an opportunity to experience the pros and cons of being an engineer. Being able to use a robot gives the students an opportunity to compare their calculated results with that of an experiment. Students are able to see how math (changing an angle) can affect the outcome of their calculation or experiment. A real life application of launching an object can be seen by looking at Figure 1.

Learning Objectives

1. Calculate the launch time by using the quadratic formula.
2. Compare the measurements of time, distance and height of their calculated values to the experimental values.
3. Determine the ideal angle to reach a maximum distance.

Subject Area(s)	Algebra I & II
Grade Level	9th (9-11)

Lesson Background & Concepts

Students have seen how the game angry birds can be used to hit targets. They don't realize it, but they are using physics (approximations) to launch objects. Using the Lego Mindstorms NXT 2.0 the students will be able to launch objects at different angles to see how far they will travel. They will use the launching system that is shown in Figure 2. This will be connected to the intelligent brick (cpu), which is depicted in Figure 3. This system will be programmed to allow the user to launch objects at any angle.

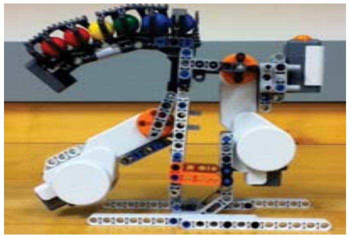

Figure 2. The Lego Mindstorm NXT 2.0 launching system.

Figure 3. The Lego Mindstorm NXT 2.0 intelligent brick (cpu).

Activity

The students need to be divided into groups of 4, since each of them will have a task to do in the experiment.

Prior to the activity:
The students will see a video about the game angry birds, this will lead them to thinking about projectiles.

Activity:
- Students will launch spheres at different angles.
- Every student will perform a task: launch the spheres, measure the height, measure the distance or record the time.
- Each group will take the measurements for 10 different angles and record them on a table (height, distance, time).
- They will calculate all of the measurements for each of the 10 different angles and record them on a table.
- They will compare their measurements to their calculations by using the percent error calculation.
- They will determine the angle for maximum range.

Assessment

Pre Assessment:
Students will work on similar problems that will be seen in the experiment.

Activity Embedded Assessment:
Students will perform calculations that will be compared to the experiment. They will also be asked questions about the accuracy of their launching system. These type of questions will challenge the students to think about how their experiment can be changed to improve its precision.

Post Assessment:
Students must use some of the knowledge gained in the experiment to solve certain problems they might encounter on the STAAR test.

Conclusions and Future Work

This activity will give the students a better understanding of how projectiles work according to calculations. They will have a good understanding of how the quadratic formula can be used to solve real life situations. If they want an object to travel the maximum distance the ideal angle of launch would be 45°. In the activity they will have answer certain questions that will make them analyze their experiment. This type of project will give the students a first hand look at the difficulties an engineer must face in their jobs. An engineer might be thinking of another type of robot that can be invented to improve the performance of this experiment.

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.

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

Amazing Rays

Portia Joy Abad, La Joya ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students will learn how to monitor the radiation from various household materials. They will formulate a relationship between distance and intensity or level of gamma radiation. They will witness how changes in distance affect the rate of radiation exposure. Students will develop a model for the intensity of radiation as a function of distance from the source. The model will help explain why users of radiation sources can use distance to reduce their exposure.

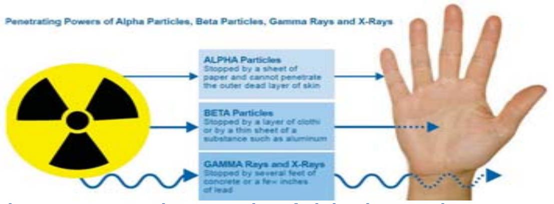

Figure 1. Penetrating capacity of alpha, beta and gamma rays

Engineering Connection

Industrial and environmental engineers, scientists and health care workers using higher intensity radiation sources are often told that the best protection from the dangerous side effects of radiation is to maintain a safe distance from the source, that is, the best way to minimize exposure to radiation is to stay not so close from it.

Learning Objectives

After this activity, students should be able to:
1. Compare and contrast the types of nuclear reactions such as nuclear fusion, nuclear fission and radioactive decay (alpha, beta and gamma rays). See Figure 1.
2. Detect which household materials are highly radioactive.
3. Analyze how distance is inversely proportional to radiation.
4. Create an experimental shield to reduce radiation exposure in case distance is not possible for a design challenge.

Subject Area(s) Physical Science, Physics and Chemistry
Grade Level 11(10-12)

Lesson Background & Concepts

Students learn about radiation and the types of nuclear reactions. They will work in groups to visualize, analyze, explore and create the components of radiation. They will see the importance of lead barriers on hand to stop the absorption of these particles. Students will also prove the inverse square law between distance and radioactive sources. Group presentation and class discussion culminates the daily activities and applying them to engineering and other fields. In the end, students will play a role of engineers and apply their knowledge in producing a cell phone radiation shield as a design challenge.

Figure 2. Radioactive sources with labquest ,radiation monitor and shields

Figure 3. Radioactive source with varying distances from the monitor

Activities

Day 1 Students will use bubbles to visualize nuclear fusion and nuclear fission. Power point presentation and videos will reinforce the topic. Students will then use a 3 Venn Diagram.

Day 2 Students will create a 3D model about one type of nuclear reaction. Group presentation will then follow using a rubric.

Day 3 Explore alpha, beta and gamma rays using the radiation monitor and labquest. Common household materials and other safe radioactive sources will be with varying shields and distances . See Figures 2 and 3. Students will record their answers on the data tables then plot the graph. Group and class discussions will be done to summarize the activity.

Day 4 Design Challenge: Back-pocket cell phone radiation shield Students will act as engineers and use their knowledge from the experiment to produce a gadget to serve as a cell phone radiation shield that optimizes for protection, durability and comfort .Cell phone and radio frequency monitor will be used to test the shield,Fig.4. Evaluation is based on the rubric presented before the challenge. Presentation includes the reason for the the design and engineering choices.

Fig. 4 Cell phone and Rf monitor

Assessment

Pre-Activity Assessment:
Students answer some questions about radiation safety and nuclear reactions then listen to their answers to gain a sense of understanding about the topic.
Example: What steps should be taken to prevent high dose of radiation in the dental office.

Activity Embedded Assessment:
Each team member will work together to carefully plan the chart, 3D model and record their results on the data tables to plot the graph. They will answer analysis questions to evaluate their data.

Post-Activity Assessment:
Students will present the results of their models, investigations and designs to the class by group. They will also answer teacher-generated written questions and practical application problems and benefits about radiation exposure and the world.

Conclusions and Future Work

This lesson allows the students to discover that radiation is energy transmitted and is everywhere above the world we live in.
They will learn that the three types of nuclear reactions such as nuclear fusion, nuclear fission, and radioactive decay (alpha, beta and gamma rays) play an important role to the society and the environment. Safety procedures such as shielding and distance help protect themselves from high exposure to radiation. In the future ,many specific questions may arise for exploration as students investigate the various household radioactive materials and other sources that may affect the intensity levels of radiation.

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.

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

All About Circuits

Daniel Garcia, IDEA Public Schools (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students explore the basics of DC circuits, analyzing the light from light bulbs when connected in series and parallel circuits. Ohm's law and the equation for power dissipated by a circuit are the two primary equations used to explore circuits connected in series and parallel. Students also learn how electrical engineers apply this knowledge to solve problems.. Students will then use their acquired knowledge to become electrical engineers and design, build and test a circuit for a small efficient model home. That hey have to build as well.

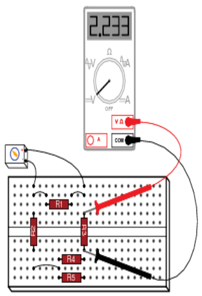

Figure 1. Circuit board with multiple resistors and a multimeter connected reading voltage

Engineering Connection

The concept of Ohm's law is the basis for explaining the relationship between resistance, current, and voltage. Electrical engineers use the equation everyday in the analysis of electrical circuits. All electronic devices are composed of circuits, which engineers must design or debug making it essential to understand Ohm's Law. Students need a strong foundation in Ohm's law while designing circuits on their own.

Learning Objectives

- •Design circuits in series and parallel
- •Calculate current though a series and parallel circuit
- •Calculate resistance of a series and parallel circuit
- •Calculate the power used in the circuits
- •Construct a circuit both in series and parallel for a model home.

Subject Area(s)	Physics
Grade Level	11th Grade

Lesson Background & Concepts

Ohm's Law: Ohm's law is the relationship between voltage, current and resistance. This relationship is made into a formula below. Students will use Ohm's law to calculate the current in a circuit and also visually inspect what happens to the intensity of the light bulb when current or voltage increases/decrease, this will be done by students putting the batteries in series or parallel. *Power:* A light's intensity is proportional to the **power (P)** supplied to it. **Power** is given by **current (I)** multiplied by **voltage (V)**:

Activity

Day 1:
Motivational Speech
Students will receive handout with key terms and vocabulary to cover Ohm's Law. Students will work on Handout # 1 – "Circuits and Symbols" and "types of Circuits and Ohm's Law"
Day 2:
Introduction of Kirchhoff's law
Students will receive Handout #2 – "V,R,and I in Series Circuits" and " V, R, and I in Parallel Circuits" . Each group will then build two circuits following the instructions from the attached Handout #3 – "Circuit Lab."
Day 3:
Students start activity following the instruction from "Let's Start Building" handout.
The designers (2 students) will start to design he circuit required to wire a house from a specific layout (Ex. Figure #1) and have it fully function as stated in the handout.
Day 4:
Students will start wiring the house following the schematics from the design team. Students will need to pass an inspection after completion

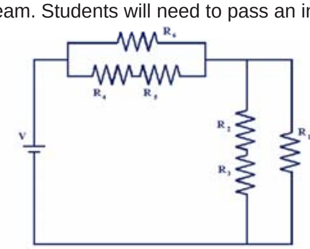

Figure 2. Circuit Schematics that students need to be familiar with

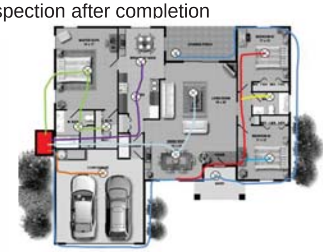

Figure 3: House wiring diagram drawn on the layout

Assessment

Pre-Activity Assessment
Handout #1 – "Circuits and Symbols" and "Types of Circuits and Ohm's Law" : *This assessments will help students with some of the vocabulary and help identify circuits in series and parallel.*
Handout # 2– "V, R, and I in Series Circuits" and " V, R, and I in Parallel Circuits" : this assessment students will be able to understand Kirchhoff's Law and will see how circuits in series differ then those in parallel.

Activity Embedded Assessment
"Let's Start Building" : Students will have to answer specific question during their design and construction of the circuit.

Post-Activity Assessment
"Circuit Quiz" : Students will have a quiz to check for understanding of the concept of circuits and how they are used in every day life.

Conclusions and Future Work

Engineers use allot of math and science to help them design many things that we overlook at times. Students will get a small experience of some technology engineers used to aid them in obtaining the best design. Students will also see how at many times the first design is never the best one and they will go over the process of design multiple times to get the final product.

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.

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

Heartbeat Gone Wild

Gina Olmedo Miquiabas, PSJA, ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

There are many functions of the human body that are periodic in nature, such as breathing and the beating of the heart.
In this activity, students will use technology to measure and investigate the cyclic pattern of the electrocardiogram (EKG) and determine its periodic properties (See Figure 1). Using the graph, students will identify the period, cycle, and amplitude. Students will learn how to transform a function so that it's graph fits real-world data. They will gain this knowledge in four ways: graphically, algebraically, numerically, and verbally.

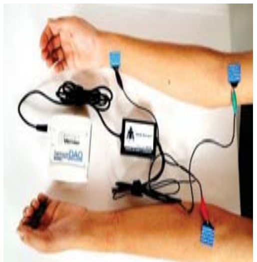

Figure 1. EKG electrode placement for measuring heart activity.

Engineering Connection

EKG monitors measure the human heart rate and are commonplace in hospitals and among emergency response team equipment. EKG measurement information is collected by skin electrodes placed at designated locations on the body. Biomedical Engineers build a bridge between engineering and health care. Medical devices attach to the human body and those devices must be safe for patients as well as for health care professionals. They have to work within established parameters and give accurate readings because a patient's life could depend on it.

Learning Objectives

After this activity, students should be able to:

- Identify cycles and functions that are periodic.
- Describe key properties (e.g., cycle, amplitude, period) of periodic functions arising from real-world applications.
- Make connections, through investigation with technology, between changes in a real-world situation that can be modeled using a periodic function and transformations of the corresponding graph.

Subject Area(s) Precalculus, Biomedical Science
Grade Level 12th (10 – 12)

Lesson Background & Concepts

To understand how and why heart disease occurs, it is important to learn how the heart functions. Biomedical Science has made great strides in developing technology to help monitor the condition of the heart. The electrocardiograph is a sensitive instrument that produces an electrocardiogram (EKG), which is a graphic tracing of the heart's electrical activity (See Figure 2). To human beings, the most important periodic function is the rhythm of the heart. In this activity, students will be introduced to the graphic programming language called LabQuest (See Figure 3) and investigate a variety of situations that can be modeled with periodic functions.

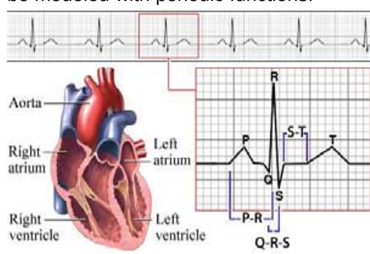

Figure 2. Shows the P-wave to T-wave sequence that represents one heart cycle.

Figure 3. LabQuest 2 is an interface used to collect sensor data with its built-in graphing and analysis application.

Associated Activities

Students work in pairs in days 1 and 3 then groups of four in day 2.
Before the Activity:
- Read an article, "Active Heart Rate for Teens" by Erin Carson.
- Write a reflection about the article and factors that can impact heart rate.

Day 1: Overview - "Pulses and Heart Rate": Properties of a Periodic Function
- Think-Pair-Share: Why are people's heart rates so different?
- With their partners, students will find pulse points on their own body.
- Compare heart rates with those in the class and discuss "normal values for resting heart rate. As a class, using the collected data, sketch a graph.

Day 2: Collecting and Analyzing Data through LabQuest 2
- Think-Pair-Share: Does breathing rate represent a periodic function?
- Use the LabQuest 2 and EKG sensor to measure the heart rate.
- Note all of the key properties (e.g., cycle, period, amplitude) of periodic functions that are contained in an EKG.

Day 3: Exploring Periodic Functions with Technology
- Model each real-world situation with a periodic function.
- Use an iPad/computer to sketch the graphs using the collected data.
- Prepare a report on what the key properties represent.

Assessment

Pre-Activity Assessment
- Periodicity Made Simple. Do the students understand periodic functions and their key properties?

Activity Embedded Assessment
- Pulses and Heart Rate: Till Death Do Us Part.
  - Were the students able to determine the key points for sketching a graph of the periodic function?
  - Were the key points described correctly?
- EKG on the RUN!
  - Were the heart rate values measured correctly?
  - Were the different components of the waveforms labeled correctly?
- You and I Were Meant to Fly.
  - Were the graphs of the periodic functions sketched correctly?
  - Do the students understand the relationship between the amplitude and the range of the function?
- UP, UP and AWAY! - Do the students understand phase shift?

Post-Activity Assessment
- Students will bring all the vocabulary together in modeling periodic functions.

Conclusions and Future Work

Doctors and other trained personnel can look at an EKG tracing and see evidence for disorders of the heart. In this activity, students will use the EKG sensor to make a graphical recording of their own heart's electrical activity. Electrodes detect the electric activity of the heart and record it. This is an example of biomedical engineering. When it comes to aiding medicine, engineers have never been more crucial. Students will see the integration of the sciences and technology and learn how biomedical engineers work through and solve a problem.

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.

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

Water Flow Analysis

Juan Salinas, South Texas ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students will learn how derivatives can be used to calculate water flow. They will analyze the water flow generated by a micro-pump that is pumping water into a container of known dimensions by measuring the height/depth of water at different times. Figure 1 shows how water will be transferred, while a timer will be used to keep time and height. By calculating the rate of change of the height and solving a related rates equation, they will be able to determine the rate of change of volume, which determines the water flow generated by the micro-pump. The data trends in the plots will help them understand how the shape of the container affects the rate of change of the height and they will notice that the micro-pump controls the rate of change of volume and not the shape of the container. The containers consist of five common three dimensional geometric shapes: a cube, rectangular prism, cylinder, cone, and square pyramid.

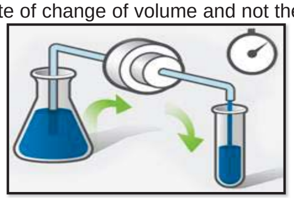

Figure 1. Metering

Engineering Connection

Water flow analysis plays a major role in many applications such as: fish tanks, water wells, public consumption (tap water), irrigation, cooling systems, bottled water production, and water jet cutters. All of these applications have certain requirements and/or regulations. Engineers must study and have a clear understanding of how much water is being used at any given period of time to meet the demands of the application.

Learning Objectives

- Describe how, through experiments and measurements, engineers collect and analyze data to calculate water flow.
- Calculate the first derivative with respect to time of volume equations and use the resulting equations as related instantaneous rates of change.
- Approximate the instantaneous rate of change from graphs and tables of values using the measured data.

Subject Area(s) AP Calculus AB
Grade Level 12

Lesson Background & Concepts

From data collected in this experiment, students will calculate several properties of the water flow generated by the micro-pump. For the case the container is a cylinder, equations (1), (2), and (3) can be developed and used as a system of non-linear equations, see Figure 2. Two applications where liquid flow is studied and analyzed are water dams and insulin delivery systems, see Figure 3. It is important to study the rates of fluid flow to control it and maintain at the optimal required levels.

$$(1)\ V = \pi \cdot r^2 \cdot h$$

$$(2)\ \frac{\Delta h}{\Delta t} = \frac{h_2 - h_1}{t_2 - t_1}$$

$$(3)\ \frac{dV}{dt} = \pi \cdot r^2 \cdot \frac{dh}{dt}$$

Figure 2. (1) Volume for cylinder, (2) rate of change, and (3) instantaneous rate of change equation.

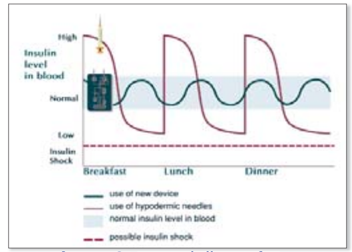

Figure 3. Drug delivery for diabetics: New vs. Old

Activity

Day 1 (45 minutes)

1. Students solve basic skill and discuss application related rate problems by completing the Related Rates Handout.

Day 2 (90 minutes)

2. Students begin by engaging in a discussion on the use and applications of water pumps and the importance to control the flow of water .
3. Students get the Water Flow Analysis handout, the micro-pump, and their assigned container and get a brief overview of the activity.
4. Students read and discuss the instructions in their groups before they get the water and timer.
5. Clarify the pump setup and timer instructions with the class as a whole.
6. Have one student from each group get the water and timer. They may start the experiment now.
7. Students complete the activity sheet packet and create their posters.

Day 3 (45 minutes)

8. Each group present their results to the class using the poster created on previous day activity. Use their presentation to promote student discourse by asking scaffolding questions geared to assess student learning.

Assessment

Pre-Activity Assessment *Handout:* Have students work in small groups to complete the Related Rates Handout. You may extend the discussion for the beach ball example by discussing the following question. When you inflate a balloon with water, describe the behavior and relationship of the rate of change of the radius and volume?

Activity Embedded Assessment *Handout:* In Water Flow Analysis handout page one, students are to come up with the equations necessary to study the water flow, use a calculator to do the data entry and create the plots, and describe their results.

Post-Activity Assessment *Poster:* Have students create a poster to present their results to the class. The poster should include the three plots and the calculations.

Conclusions and Future Work

With this activity, students will learn how engineers collect and analyze data to calculate water flow. The hands on experience and concrete measurements will enable them to use it as prior knowledge to be able visualize and solve similar application problems. They will have a better understanding of how the first derivative of a function with respect to time represents its instantaneous velocity. They will be able to calculate these values from the data recorded using the rate of change formula. This will help them make the necessary connections between derivatives of functions, applications of derivatives as instantaneous rate of change using experimental data in tabular and graphical form, and the rate of change. As an extension, students may also investigate and analyze the rate of change of the surface area using the same data from this activity.

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.

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

Full Speed Ahead

Gordon Moore, Sharyland ISD (Summer 2014)

Research Experiences for Teachers in Engineering Program

Electrical Engineering Department, The University of Texas-Pan American

Summary

Students will learn the concept of speed by using the formula speed=distance/time. Working in groups of four, students will measure the speed that the Lego Mindstorms NXT robots (Figure 3) will take to follow a black line. The robots will be programmed to follow three different paths at various lengths and speeds (Figure 2). Using the light sensors robots will stop once they have reached the end of the path. Students will average the speed the robot takes at each line distance and collect data on worksheets. Students will then follow up by calculating how many laps the robots will take around an oval shaped track at a constant speed.

Figure 1. High speed truck.

Engineering Connection

Engineers have been coming up with ways to improve our everyday lives. One of these is how engineers have improved the speed of transportation. Engineers must understand the relationships between speed, time, and distance. Today's engineers understand how things used to be done, building on the same mathematical concepts and improve them.

Learning Objectives

After this lesson, students should be able to:

- Calculate the correct formula of speed=distance/time.
- Learn about teamwork and working in groups.
- List and know the engineering process.
- Build, test, and evaluate robots for speed.

Subject Area(s)	measurement, science and technology, and physics
Grade Level	**4** (3-6)

Lesson Background & Concepts

In today's world we use some form of transportation to get to a desired destination (Figure 1). Whether it be a car, bus, bicycle, or our own two feet. Knowing the concept of speed is important to meet schedules and deadlines. We can figure out how long it will take to get from one place to another once we understand the concept of speed. If a robot is moving at a speed of 3 m/s (meters per second) that means that the robot moves a distance of 3 meters every second. When we use the equation of speed we are dividing the distance traveled over the amount of time it took to get there.

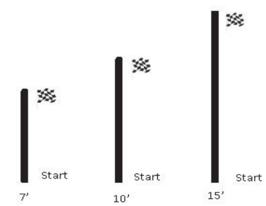

Figure 2. Race line dimensions for activity.

Figure 3. Express-bot used for activity.

Activity

Before the Activity: Students will watch video that shows how robots are being used today to operate cars following lines.

<u>Day 1</u>

- Students will take pre-activity assessment to access prior knowledge.
- Students will review concept of speed with a PowerPoint presentation.
- Students will use instructions and build a race track with three straight lines of different lengths.

<u>Day 2</u>

- Students will work in groups of four to build their robots for the activity.
- Students will work as a team to take the measurements of the speed of the robots.

<u>Day 3</u>

- Students will then construct an oval shaped track.
- Students will calculate how many laps the robot completed around the track.
- Students will take post-activity assessment and share data and have discussion.

Assessment

<u>Pre Activity Assessment</u>: Students will work individually to answer questions on the Pre-Activity Assessment Full Speed Ahead. Students will answer questions that will access their prior knowledge.

- Do students understand what a unit of measurement is?
- How do students feel about learning math, science, and technology?
- What do engineers do?
- Questions calculating the average speed.

<u>Activity Embedded Assessment</u>: Students work in groups to record information on Finding Speed Worksheet Full Speed Ahead. Students will then average the speed the robots took in the five trails. Students will then use Oval Track Challenge Worksheet to calculate how many laps the robot took to complete the oval race track using the speed formula.

<u>Post Activity Assessment</u>: Students will answer questions on Post Activity Assessment Full Speed Ahead to determine if they understood the lesson and if their feelings towards STEM subjects had changed.

Conclusions and Future Work

At the end of this activity students will learn the concept of speed through hands on activities involving robots. Future work involves implementing the lesson to evaluate the students comprehension of the concept of speed.

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.

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

Mapping with Servos and Sensors

Miguel Ramirez, Edinburg School ISD (Summer 2014)
Research Experiences for Teachers in Engineering Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

Students explore the concept of trigonometric ratios using a robot and a layout to find the measure of angles. The robot must be built and programmed to drive the servos and sensors. Students program a robot to determine (estimate) the measures of angles through the use of a sensor. The lesson re-enforces the foundation of how trigonometry ratios work. Once the estimations have been done, a calculator will be used to confirm accuracy. The robot is to be built and be equipped to operate autonomously or remotely (if modified).

Figure 1. Robot with 3 servo motors and sensors copyright

Engineering Connection

Engineers use computers and/or robots to generate accurate estimations. Finding the exact values for distances or angles is not always possible. In many cases, engineers use trigonometric relationships to find approximations. Approximations will dictate whether a structure will hold or crumble. Think of the success of Apollo 13 in calculating the angles to return safely to earth.

Learning Objectives

After this lesson, the students will be able to:

- determine the lengths of sides and the measures of angles in a right triangle by applying the trigonometric ratios of sine, cosine, and tangent .

Subject Area(s) Geometry, Computer Science

Grade Level 10(9-12)

Lesson Background & Concepts

Because it is unpractical to measure large objects with a tape measure, engineers use mathematics and technology to do so. By knowing how to find the measure of angles, we can deal with many real-life applications, Let's test our trigonometry knowledge by doing an engineering design and experiment. Let's calculate measurements of angles using a robot. This robot will use servos and sensors to calculate the measurements that can then be data-logged for further analysis. SERVO motors will move the robot and the sensors will relate the measures. The servo motors that we are using are not limited range. We can program them to turn forward or reverse. Before we start, students review the basic trigonometric ratios concepts.

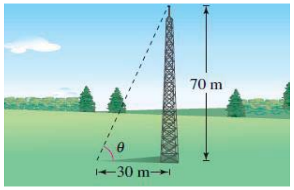

Figure 2. Antenna attached and anchored by wires. copyright

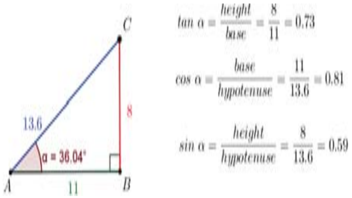

Figure 3. Trigonometric ratios copyright

Activity

Before the Activity

- Gather the materials
- Build and program the robot
- Print materials for each student
- Pre activity quiz

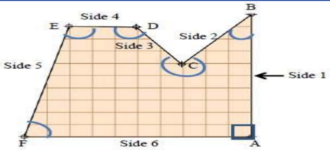

Figure 4. Layout 1 copyright

with the students

1. Provide and assign each group (of 4) a complete set of labeled materials.
2. Use the measuring tape and electrical tape to mark the layout on the floor.
3. Line up the robot and run the program to measure the angles of the layout.
4. View the Lego brick and record the angle measure of the gyroscope at every turn of the robot.
5. Run the program and measure several times. The servos(motors) must be reprogrammed(voltage and time) to achieve accurate results.
6. Calculate the actual measure (using a calculator) of the angles in the layout.(hint:Subdivide the layout into right triangles)
7. Go to a layout of another group and on the back of the activity sheet, draw and label the angle measures of the 2nd layout (Use the robot to confirm).

Assessment

Pre-Activity Assessment

- Pre-Activity Quiz.

Embedded-Activity Assessment

Observe that students are doing the following:

- is every student participating in the activity ?
- are the students communicating using trigonometry and programming vocabulary?
- are students understanding the programming to test the robot?
- are students able to identify techniques to subdivide every layout in small right triangles?

Post-Activity Assessment

- Post-Activity Quiz.

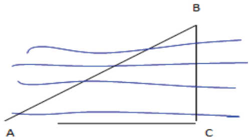

Figure 5. A river nested with rt triangle

Conclusions and Future Work

After students and teacher discuss and review key concepts of the activity, students are able to understand and explain the trigonometry ratios. By highlighting the challenges, students realize that engineers design, develop , and test products such as sensors to measure degrees(radian), voltage, sound, torque, force, temperature, and pressure among others. Yes, measuring is complex. But , with robots, sensors, and fast computers, humanity has no excuse to stop advancing technologically. Now, let's find a way to measure vectors.

Acknowledgement

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