Science • Technology • Engineering • Math

POSTER PROCEEDINGS

The 2014 STEM Education Teacher Workshop

February 8, 2014

McAllen Convention Center
700 Convention Center Blvd
McAllen, Texas

Curriculum Posters

Teacher Presenter	Lesson Title	Subject	Grade Level(s)	School District
Abel Zamora	Need for Speed	Physics	12	La Joya ISD
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Need for Speed

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Research Experiences for Teachers Program

Electrical Engineering Department, The University of Texas-Pan American

Summary

Students utilize a model car to find the acceleration of a moving object. In groups of 4, one student releases a model car down a ramp; the other students in the group find the time interval at certain distances. Students will find the position vs. time function using the gathered data. The group will find the first derivative of the function to find velocity and the second derivative to find the acceleration of the car. The goal is for students to be able to find the relationship between the position, acceleration and velocity functions; be able to write an explanation the relationship as well as orally express their findings.

Figure 1. Car speeding down street.

Engineering Connection

Mechanical engineers design and analyze motor vehicles, aircraft, manufacturing plants, medical devices and many other devices we utilize on a daily basis.. A mechanical engineer might design any of these types of products, build the prototype and perform rigorous testing in order to find the most suitable design to fasiciltate the lives of anyone using the device.

Learning Objectives

After this activity, students should be able to:

- determine the relationship between position
- velocity and acceleration vs. time functions/graphs
- calculate the second derivative of a function.

Subject Area(s) Physics

Grade Level 12 (11-12)

Lesson Background & Concepts

Students have a difficult time understanding derivatives due to the abstract nature of the concept. By incorporating this Physics into the Calculus concept, the students are not only solving derivatives, but are kinesthetically conducting an experiment, therefore the students will obtain a greater understanding of the concept. Using a ramp and model cars (figure 2), students will determine the position of a car at certain time intervals, they will then derive the velocity and the acceleration vs. time graphs by finding the derivative

Figure 2. Students performing experiment.

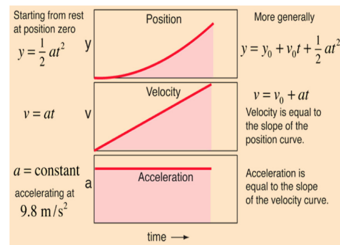

Figure 3. Position, Velocity and Acceleration vs. time graphs.

Associated Activities

1. During the experiment, students will be finding the time intervals using a stopwatch at different positions on the ramp, one student at 1 meter, one student at 2 meters and one student at 3 meters.
2. Once the data has been collected, the students will graph the position vs. time graph on graph paper.
3. Using a graphing calculator, students enter values into stat edit to find the function of the data collected.
4. Once the position vs. time function has been calculated, students determine the first derivative of the function to determine the velocity and the second derivative to find the acceleration.
5. As a group, they must determine which set of tires would be most beneficial for the auto company to use. (The tire with the highest acceleration or the tire that reaches the highest acceleration first)
6. Students will report orally which tires their group chose and why this choice was made.

Assessment

Pre-Activity Assessment

Descriptive Title: Have students What Position which is designed to evaluate students understanding of acceleration of an object.

Activity Embedded Assessment

Descriptive Title: Have students complete Need for Speed. During the activity, check that each student understands what the derivatives of each function signifies. Group orally presents on the findings from the activity. Discuss the finding of each group, similarities and difference between the outcomes.

Post-Activity Assessment

Descriptive Title: Have students complete Understanding Velocity, which is designed to evaluate student's understanding of calculating the velocity and acceleration of a function given a position function. Students find the derivative of a position function to determine the velocity and the second derivative of a position function to find the acceleration.

Conclusions and Future Work

This activity has not been performed by students, further information is pending once the activity is done in the classroom. The expected outcome of the activity is that students will be able to determine the relationship between the position vs. time, velocity vs. time and the acceleration vs. time graphs. Also, students should make a connection between the Physics lesson and Calculus concept that was incorporated in the lesson.

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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Zap, Separate, and Power!

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Summary

Engineering is rarely introduced to middle school students. Hence, exposure to engineering allows students to relate science concepts to real-world applications (Figure 1). In this activity, students build electrolysis of water systems in which they conduct an experiment to learn how water as a compound can be dissociated into its element, namely oxygen and hydrogen.

Figure 1. Hydrogen Fuel Cell Car

This activity will give the student an opportunity to work as engineers by:

- Working in teams to meet specified requirements.
- Collecting, analyzing, and making reasonable conclusions from their data.

Engineering Connection

Electrolysis is a process performed by chemical engineers using direct electrical current to drive a chemical reaction. This chemical reaction yields hydrogen fuel cells which translate to chemical energy from a fuel into electricity through a chemical reaction with oxygen. The International Space Station performs electrolysis to provide the astronauts with oxygen while in space. A related application is hydrogen fuel cell conceptual automobiles, where hydrogen and oxygen are combined to provide “zero emission fuel” (Figure 1).

Learning Objectives

Students will be able to:

- Explain that a chemical reaction needs to occur in order to separate a compound.
- Determine that electrolysis produces hydrogen fuel cells which can power small devices with the electrical power that is being produced.
- Explain that multimeters are utilized in this activity to measure voltage between electrodes.

Subject Area(s)	Chemistry
Grade Level	6th (6-8)

Lesson Background & Concepts

Students will already have had instruction on the differences between elements and compounds prior to the activity.

Introduction to lesson includes:

- The students will be participate in a mini-lab to distinguish the different types of elements and compounds that they are exposed to on a daily basis.
- The students will view a PowerPoint which describes the building blocks of all substances.
- A class discussion will be conducted to explain what energy is, DC (direct current), and the fundamentals of electrolysis (Figure 2).

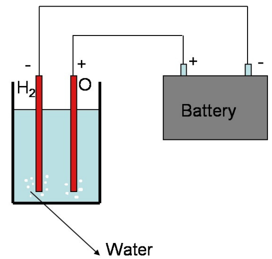

Figure 2. Process of Electrolysis: Two electrodes connected to a battery producing bubbles on the bottom of the electrodes.

Associated Activities

Prior to the Activity: Students watch a video to prompt their minds into thinking:

- What is electrolysis?
- How is does electrolysis work?
- What are the applications of electrolysis?

Note: During the activity the group members need to be discussing amongst each other to draw conclusions and record their findings.

Activity

- •Students measure the amount of voltage between electrodes utilizing a multimeter before and after the chemical reaction of electrolysis takes place (Figure 4).
- •Students use batteries to charge electrodes for 10 minutes in the aqueous solution with an electrolyte (baking soda).
- •Students test a LED to verify whether enough electrical energy was produced through electrolysis to power it for a few seconds.
- •Student build the electrolysis set-up. (Figure 3)

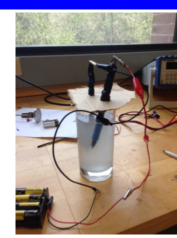

Figure 3. Electrolysis of Water: Example of set-up to be completed by students in this activity.

Figure 4. Multimeter- Used in this set-up to measure voltage between electrodes.

Assessment

Pre- Activity Assessment: Students work in groups of three to answer questions on the Pre-Activity Assessment: Electrolysis of Water Worksheet. They are to complete this prior to the activity individually, then begin a discussion amongst their group to share ideas.

Activity Embedded Assessment: The team member’s work together to record their information on the Electrolysis of Water Worksheet. Once all students have completed the worksheet in their group they are to work together to answer the questions in regards to what is occurring in the beaker when the electrodes are connected to the battery.

Post-Activity Assessment: Once the experiment is completed, students are to answer the questions on the What Do We Know About Electrolysis. Subsequently, students are to also complete the Show and Tell Me What We Learned worksheet. This will allow the teacher to become more informed on the students understanding of the lesson.

Conclusions and Future Work

This activity teaches students the concepts of compounds and elements through a hands-on activity involving electrolysis and hydrogen fuel cells.
Further work is necessary in obtaining equipment and implementing the lesson in the classroom to evaluate if effectiveness is improving students’ learning. Improvements to the lesson might be necessary post implementation and prior to submission for publication.

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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Is this Circuit Function-ing?

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Summary

This activity is designed to teach students the concept of linear functions while using a linear circuit to retrieve data and provide a practical example of such relationships. An academic hands-on activity ties the concept of linear functions to the measurements of voltage across circuits. In this activity, students collect their own data (voltage drop across different number of resistors like demonstrated on figure 1) and are guided through the process of plotting a linear function for each circuit, as well as obtaining an equation for each function. Students are then expected to plot their own gathered data and create their own equations. A sample at the beginning of the activity sheet has all needed directions.

Figure 1. Voltmeter measuring a 10k Ohm resistor's actual resistance. The voltmeter reads 10.09.

Engineering Connection

Students learn about linear functions between two variables. Electrical Engineers analyze and design electric circuits for devices such as cell phones. Their work relies on mathematical models and functions between different variables of the electric circuits, such as the relationship between voltage and current for different components of the circuits. Such components include resistors, capacitors, and inductors. The correct use of these relationships and components is what makes all our electronic devices safe and functional.

Learning Objectives

After this activity, students will be able to:

- Acquire and arrange data from circuits to find the linear relationship between number of resistors and voltage.
- Plot their measurements as a linear function.
- Students are able to calculate equations from the function found in each circuit.

Subject Area(s)	Measurements
Grade Level	7th

Lesson Concepts & Activities

Functions provide mathematical relationships between two or more sets of numbers. Students will measure voltage in a basic electrical circuit (figures 2 & 3) in which the number of resistors will vary. Measurements from this circuit will be utilized in order to plot the function relationship from the circuit. Finally, students will learn to create an equation that describes the relationship from the data they gather.

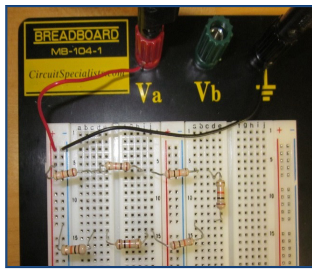

Figure 2. Sample Circuit that was used for developing the activity.

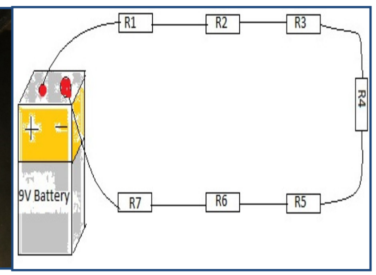

Figure 3. Circuit diagram for the sample circuit.

The data from the circuit above will be collected to form a table (such as table 1) and to produce a graph or plot (such as figure 4). To measure the voltage across zero resistors (0), measure voltage on the wire before the first resistor, or between any two resistors.

Table 1. Function Table.

Battery Voltage= 9.65

# of Resistor	Voltage	Constant Rate
0	0	
1	1.36	1.37/1 = 1.37
2	2.71	2.71/2 = 1.36
3	4.08	4.08/3 = 1.36
4	5.43	5.43/4 = 1.36
5	6.8	6.80/5 = 1.36
6	8.18	8.18/6 = 1.37
7	9.61	9.61/7 = 1.37

To create equations students use the Parent equation: Y = R X, they calculate constant rate
New equation: Y = 1.37X
This equation says that the value of y is equal to the value of X times 1.37. We can
verify that relationship by looking at our data. Verifying is a very important step since it might help you catch any calculation mistakes.

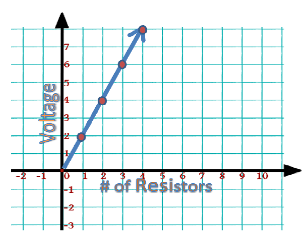

Figure 4. Function plot.

Assessments

Pre-Activity Assessment
Students complete an assessment in order to check for understanding before the main activity. A word splash activity is provided to be used as a vocabulary assessment.

Activity Embedded Assessment
Functions Lab Sheet: Students complete a lab handout with an assessment created into it. This assessment checks for understanding of the linear relationship between number of resistors and voltage. They are also asked to plot the data and to generate and equation from the graph.

Post-Activity Assessment
Students complete the final assessment in order to generate data from different functions, plot the data, and come up with the equations of the linear relationship they just plotted.

Conclusions and Future Work

This activity teaches students the concept of linear functions by using a linear circuit to retrieve data and provide a practical example of such relationships. Students gain understanding of different uses linear functions have in our everyday life.

This lesson's framework can be used to show other type of functions. However, one should be careful to provide the mathematical background for such functions.

Acknowledgement

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Plants Hard at Work

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Summary

Students explore the process of photosynthesis which plants, algae and some bacteria perform to convert the sun's energy into chemical energy. Can this process be altered to force the plant to make more oxygen for all living organisms? Teams of students are working together to maximizing the rate of oxygen production in elodea. Students work together to design, build, test and evaluate their aquatic environments in a controlled experiment. Using pH probes to measure acidity and alkaline levels, students will evaluate the rate of photosynthesis in their design.

Figure 1. Plants benefiting all mankind with the production of oxygen.

Engineering Connection

Environmental engineers are experimenting with ways to increase the rate of photosynthesis. Their goal is to maximize the production of oxygen on earth to improve the quality of life for all living organisms. Environmental engineers have calculated that 1 acre of trees will produce the oxygen supply needed for 18 people in 1 year. Students will model the work of environmental engineers by attempting to maximize the oxygen production of an aquatic plant. Designing, building, testing and evaluating will allow students to see if their system has the intended effect.

Learning Objectives

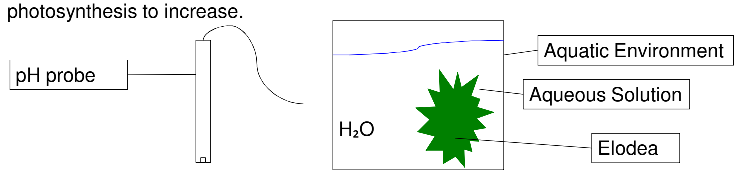
After this lesson students will be able to

- Evaluate the conditions that will increase the rate of photosynthesis.
- Create a graph that compares the pH levels for evaluating the design that yields the most oxygen.
- Describe the engineering design process and understand that engineers must consider economic constraints and meet specific requirements when designing products.

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

Lesson Background & Concepts

Recording and analyzing gases requires expensive equipment which sometimes is not available to us. An accurate and cost effective way to record oxygen (O_2) and carbon dioxide (CO_2) in water is to use pH probes. CO_2 dissolves in water to form carbonic acid (H_2CO_3) which has a pH of 5.7. The pH tends to fall when CO_2 is high and O_2 levels are low. When O_2 levels rise, so does the pH, making the aqueous solution basic. Using the engineering design process students design, build and test an aquatic environment. Performing a controlled experiment will aid in evaluating the effectiveness of their design. This will determine the conditions that allow the rate of photosynthesis to increase.



IMPORTANT: your design should allow the pH probe to enter the aquatic environment to measure the pH of the aqueous solution.

Figure 2. Experimental set up of Aquatic Environment with Elodea.

Associated Activities

Activity lesson is composed of two parts, designing and building of aquatic environment for the elodea followed by testing and evaluating of design in a controlled experiment.

<u>Design and Build (Day 1 Activities)</u>
•Design a product associated with economic constraints and minimum requirements.
•Build an aquatic environment for elodea.

<u>Test and Evaluate (Day 2 Activities)</u>
•Students test their design in a controlled experiment.
•Evaluate the cost effectiveness of their work by comparing data with other groups.

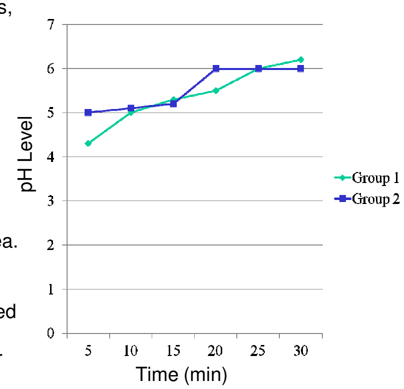


Figure 3. Sample graph showing data collected by two groups.

Assessment

Pre-Activity Assessment
Assesses the student's prior knowledge of photosynthesis, as well as their knowledge of the engineering design process. In addition, students will be asked to construct line graphs, as well as interpret and analyze them.

Activity Embedded Assessment
pH data collection worksheet-Activity assessment-<u>Evaluating your Design and Experimental Set up</u>: Students are asked about the engineering design process that they followed during the activity and are assessed to determine whether or not their design meets cost effective measures.

Post-Activity Assessment
Assess students overall understanding of the engineering design process, the conditions that increased the production of oxygen, their ability to interpret graphs, and describe how engineers work with constraints and specific requirements when designing products.

Conclusions and Future Work

In concluding this activity lesson, students will not only evaluate the conditions that increase the rate of photosynthesis, but will gain experiences that will allow them to think and perform like engineers. Becoming actively engaged in the engineering design process will help students understand how engineers must consider economic constraints and meet specific requirements when designing products that improve our way of living.

Acknowledgement

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Mix It Up!

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Summary

Students are asked to follow the engineering design cycle to design and create a system that will combine three different ingredients automatically, as provided by an investor. They are tested on previous knowledge of the design cycle, use of the engineering notebook, and the six simple machines by the way of this real world challenge. They must consider the trade offs of time, materials and cost as they compete to create the most time efficient, cost effective and overall effective system according to given specifications.

Figure 1. Automobile Engine System

Engineering Connection

This is a highly technological world where there is constant communication between different systems working to meet different objectives as required by current society. Systems are made up of different subsystems that may require the collaboration of different engineers or even different disciplines in order to meet an objective successfully. For example, in the creation of an automobile, there are thousands of different components each doing their job to ensure a quality product. Behind these components are electrical engineers, mechanical engineers, and automotive engineers etc., each doing their part as well. Mechanical engineers focus on the mechanical portion of these different subsystems. As complex as these mechanical systems may get, at the core lie the six simple machines including the wedge, lever, wheel and axle, pulley, screw and inclined plane.

Learning Objectives

After this activity, students should be able to:

• Use the engineering design cycle to design a mechanical system using the six simple machines
•Work collaboratively in a team to design a system that meets given specifications
•Document all their work in an engineering notebook

Subject Area(s)	Science and Technology, Problem Solving, Physical Science
Grade Level	9 (8-10)

Lesson Background & Concepts

For this engineering activity students and the teacher will be familiar with the engineering design cycle and its iterative nature. They will understand how to properly document this as well. Last, specific knowledge of the six simple machines including the wedge, lever, screw, wheel and axle, inclined plane, and pulley will be reinforced.

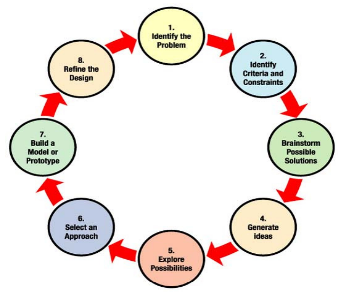

Figure 2. The Engineering Design Cycle

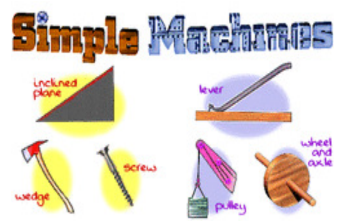

Figure 3. The Six Simple Machines

Associated Activities

Day 1 and 2:

1. Students will be divided into groups and introduced to the challenge.
2. Once they have understood and done research they will be supplied with materials that they may use as shown by Figure 4.
3. Students will then be asked to show a complete design which will go through a check list to complete understanding and good planning. Figure 5 shows a sample design drawing.

Day 3 and 4:

4. Students will have time to build there prototype according to their design drawing.
5. An outside person will judge their design according to a rubric and award the best design a certificate.

Figure 4. Materials

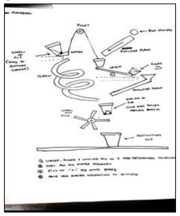

Figure 5. Design drawing

Assessment

Pre-Activity Assessment
Review of Simple Machines: Have students do the Simple Machines Assessment in order to make sure that there is no confusion as to the difference between the six. This will also allow them to then decide how they will use them in their design.
Activity Embedded Assessment
Complete Design: Have students go through the Design Drawing Checklist before they demonstrate their actual drawn out design to you. Students need to understand that it is necessarily to have a well thought out plan of attack before diving into any sort of build session. They will reinforce their knowledge of proper documentation in an engineering notebook.
Post-Activity Assessment
Final Demonstration: You and the investor will go around the room having students present and demonstrate their finished system such as shown by Figure 6. They will be evaluated according to the Challenge Rubric. Students must understand that there needs to be a way to evaluate any innovation, and it should not be abstract. They will see how their collaborative work led to the ultimate success of their product.

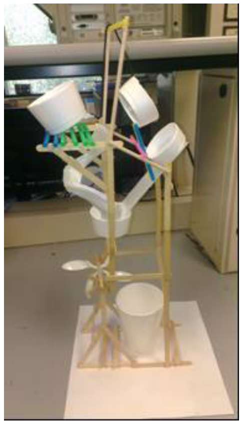

Figure 6. Prototype of a mixer

Conclusions and Future Work

Students will have learned how simple machines can be used to build more complex systems.

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Let Me Breathe!

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Summary

In this lesson, students use scientific and engineering principles to investigate the effects of Dissolved Oxygen (DO) in aquatic life. DO is the most essential and dynamic critical environmental variable that has to be monitored and maintained. Students perform an experiment that entails them to measure DO in set-ups with different degrees of temperature, aeration, and salinity. They then predict the effect of varying DO concentrations in bodies of water to the sustainability of certain aquatic environments. Students also analyze and evaluate the impact of low DO on aquatic ecosystems and consider measures to limit or prevent such impacts.

Figure 1. Experimental set-up measuring Dissolved Oxygen at high temperature in an aquarium with fish.

Engineering Connection

Environmental engineers employ aquaculture engineering systems utilizing water treatment operations to ensure good quality environment for aquatic life . Water pollution control engineers monitor and review processes from the environment to assess problems affecting aquatic organisms and work on measures that prevent such problems. Students act as environmental engineers as they take measurements of critical environmental factors affecting water quality and predict the effect of varying DO concentrations to the sustainability of aquatic environments. Students also evaluate the adverse impacts of low DO to the environment and consider measures to prevent such impacts.

Learning Objectives

After this activity, students will be able to:

1. Measure the amount of D O in water environments with different degrees of temperature, aeration, and salinity;
2. Observe how fish respond to DO levels in their environment;
3. Analyze and evaluate the impact of low DO on the sustainability of the aquatic environment to support life and consider measures to limit or prevent such impacts.

Subject Area(s) Life Science
Grade Level 7(6-9)

Lesson Background & Concepts

Students learn that water pollution has been a cause of concern for decades. With urbanization, it has increased to such enormous levels that it now poses a threat to the existence of aquatic life and human health. Water pollution is the contamination of the water bodies when pollutants are released into the water without thorough treatment and removal of harmful components. It causes drastic changes in temperature, aeration, and salinity of water which deplete dissolved oxygen that is vital to the survival of aquatic organisms. It does not only affect the environment and human well-being, but also disrupts the balance of the ecosystem.

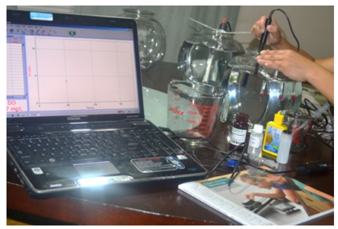

Figure 2. Collecting data using DO sensor attached to a computer .

Figure 3. Recording observations of the fish's response to DO levels.

Activity Timeline

This activity requires two class periods. Students in four groups of six perform the experimentation on Day 1. They prepare three set-ups using same size aquarium glass jars filled with 1 gallon of dechlorinated water in each jar. Below is the experimental set-up:

Set-up #1	Set-up # 2	Set-up # 3
A-Warm water at 79ºF	A-Water at Room Temperature	A-Cold water at 55ºF
B-Water with High Aeration	B- Water with Moderate Aeration	B-Non-aerated Water
C-Water with High Salinity	C-Water with Minimal Salinity	C-Water without Salt

As soon as the temperature, aeration, and salinity settings are established, students measure and record the DO using DO sensor in each of the set-up. They then place a goldfish in each set-up and observe the response of fish to the different levels of DO. Analysis of data follows on Day 2 where students report their findings to the class and evaluate the impact of low DO to aquatic life and ecosystem. Students subsequently reflect on measures to help solve water pollution problems.

Assessment

Pre-Activity Assessment
Students answer some safety review questions about handling glassware and hot objects.
Example: What are some safety precautions when working with hot objects? What about handling glassware in the laboratory?

Activity Embedded Assessment
Students gather and record their data using their data analysis sheet. They answer analysis questions to evaluate their data.

Post-Activity Assessment
Students present the results of their investigation to the class by group. Students also answer teacher-generated practical application questions about dissolved oxygen and the environment.

Conclusions and Future Work

Students discovered how dissolved oxygen can be affected by changes in temperature, aeration, and salinity of the water. They learned how pollution caused these changes. Like environmental engineers, students considered measures to prevent adverse impacts of low DO to the environment and help solve pollution problems. The idea about dissolved oxygen depletion in natural waters posed concerns about the effects of water pollution on aquatic life. In the future, many specific questions may be developed for investigations as students explore the interplay of the different biotic and abiotic factors that affect the sustainability of an aquatic environment. Pollution in water may range from thermal to chemical; aquatic organisms may be freshwater, estuarine or marine, and there are limitless types of organisms to investigate. Effects of pollution may be any form of measurable or observable responses: behavioral, physiological or ecological.

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Gentle Touch

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Electrical Engineering Department, The University of Texas-Pan American

Summary

Students build a force sensor circuit composed of a force sensor, whose resistance changes based on the applied force, and some electric components. Experiments are conducted to find the mathematical relationship between the force applied to the sensor and the output voltages of the circuit. Student will take several measurements; force vs. resistance, force vs. voltage, and use measurements to find the best fit curve models for the sensor. Students will design and build their own "Robo-Glove X2", a tactile feedback system using a cloth glove and the force sensor circuit. Students will use glove to answer: what is the minimum force required to crack an egg.

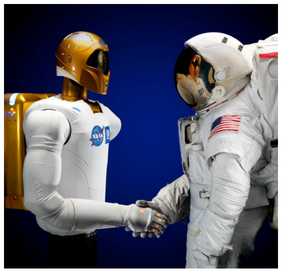

Figure 1. NASA's Robonaut 2, a dexterous humanoid robot, shaking hands with a suited NASA astronaut.

Engineering Connection

Models made from curve fitting plays an important role in all engineering, mathematics, science and technology fields. The studying of these models gives us a better understanding of the behavior and relationships among variables. In most cases, models are an effective and efficient method to simulate solutions to real world problems.

Learning Objectives

After this activity, students should be able to:

1. Identify and use simple engineering curve models.
2. Collect and plot data using two variables.
3. Graph linear functions on the coordinate plane.
4. Write, with and without technology, linear functions that provide a reasonable fit to data to estimate solutions.

Subject Area(s)	Algebra 1
Grade Level	9

Lesson Background & Concepts

Biomedical engineers along with electrical engineers working with robots closely look at curve models that relate voltages, resistance, and forces applied on load sensor. All devices that output resistance need a circuit to convert the resistance to voltage range. The curve models used to calibrate the sensors serve as a tool to improve robotic tactile feedback systems in surgical and manufacturing applications. In this lesson, students act as NASA/GM engineers to discover the correct model that best fits voltage data collected from applied force to a sensor.

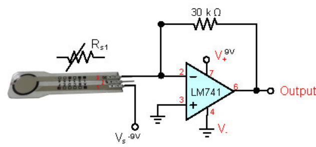

Figure 2. A circuit used to convert sensor resistance to voltage using an op amp and 30 K ohm resistor.

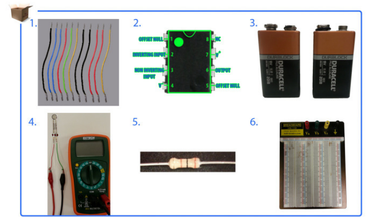

Figure 3. Robo-Glove X2 Kit used to convert resistance to voltage.

Associated Activities

The activity will conducted over four different days. Students will work in groups of three to follow a partial design cycle of the engineering design process. Day 1: Establish a connection between curve fitting and activity/real world application. Day 2: Conduct research on flexiforce sensor using multimeter and weight set. Day 3: Build a force sensor circuit. Day 4: Design/Build Robo-Glove X2 and test it by applying pressure to an egg.

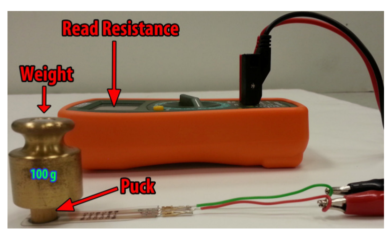

Figure 4. Experimental resistance reading from flexiforce sensor .

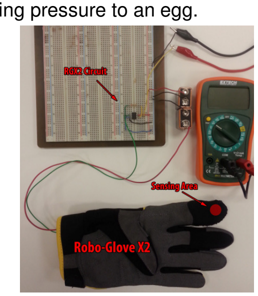

Figure 5. Robo-Glove X2 circuit setup.

Assessment

Student will be asked to produce a table and graph from data collected using force vs. resistance, force vs. voltage, and use measurements to find the best fit curve models for the sensor. Students will test their gloves and use the best fit line to answer the question: what is the minimum force required to crack an egg.

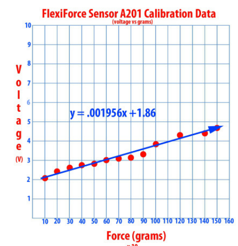

Figure 6. Voltage vs. Force graph from data collected

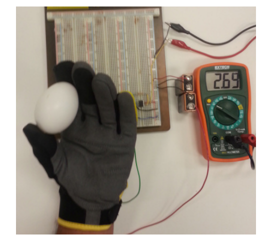

Figure 7. Robo-Glove X2 applying pressure to an egg.

Conclusions and Future Work

With this activity, students will learn the importance of curve fitting in Math, Science, and Engineering as it applies to load sensors. Students will build a tactile feedback system using a cloth glove and the force sensor circuit and use it to solve a problem. In the future, this activity can be extended to use the Robo-Glove X2 to gather data on human handshaking. Students may produce their own scatter plots and best fit equation from voltage vs. height or voltage vs. age.

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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Up We Go!

Marco Alcantar (McAllen ISD)
Research Experiences for Teachers Program (Summer 2013)
Electrical Engineering Department, The University of Texas-Pan American

Summary

In this activity, students build a hoist system using a DC motor and a pulley to lift an action figure (emulating a person to be rescued). Students then conduct experiments by running the DC motor for a specified amount of time and measuring the corresponding vertical distance traveled by the figure. Students calculate the lifting rates (distance (cm)/duration(sec)) and unit rates (distance (cm)/1 sec). Using the unit rates, students generates a linear graph to represent distance vs. time. To assess their learning, students are asked to use the calculate unit rates to estimate the amount of time it would take to lift the the figure by a specific distance.

Figure 1. United States Coastal Guard Hoist Helicopter demonstrating the hoist with individuals

Engineering Connection

Hoist systems are used to lift and move heavy objects from one location to another. They can be seen on trucks, boats and even on helicopters to lift up heavy construction equipment or rescue humans from catastrophes. Mechanical engineers have to test lifting rates of hoist systems for different object weights and applications. In this activity, students play the roles of mechanical engineers by assembling a hoist system and collecting measurements to evaluate its lifting rate.

Learning Objectives

With these activity, students will be able to

1. Define ratios & rates
2. Calculate unit rates (unit of distance/unit of time) by using a measurement of ratios
3. Graph measured ratios on a distance vs. time set of axes

Subject Area(s) Math
Grade Level 6th (6-8)

Lesson Background & Concepts

Any rescue organizations such as the United States National Guard or local law enforcement have been using mechanical hoist systems to elevate humans or animals from danger. These hoist pulleys are attached to helicopters and are controlled by a motor. It takes a lot of planning and preparation to perform this rescue effectively and in a timely manner. Students will assemble a "hoist" prototype with provided limited resources. They will use the hoist to lift up a weight and calculate the unit rate between unit of distance and unit of time. Using their calculated unit rate students will be able to graph and estimate the amount of time it took to lift the weight.

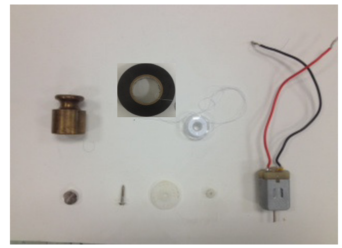


Figure 2. "Hoist Device prototype Unit kit

Associated Activities

The duration of the activity is 3 class periods. Day 1: Vocabulary and Presentation: teacher assigns three Frayer models to students and present a power point presentation on the a hoist system. Day 2: Hoist Prototype Assembly: students assemble a hoist system using a Hoist Kit prepared by the teacher. Students conduct experiments to calculate lifting ratios. Day 3: Students calculate unit rates using the lifting ratios and generate a graph of distance vs. time. Students then apply unit rates to predict the amount of time it will take to lift an object by a certain distance.

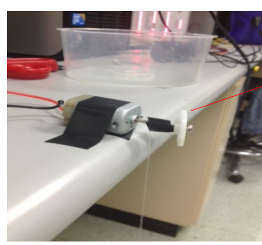


Figure 4. "Hoist" Device prototype Unit Kit

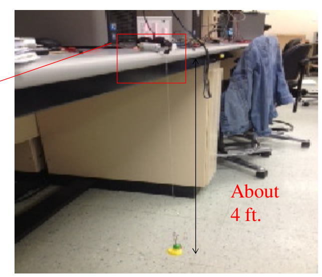
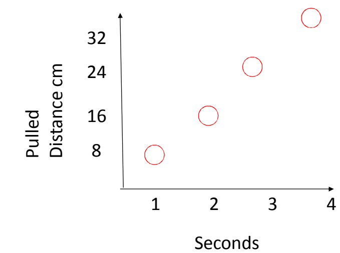


Figure 5. Sample Set up

Assessment

Pre-Activity Assessment
Students will define rates, ratios and a hoist device by using a Frayer model diagram.
Activity Embedded Assessment
" Operation Rescue Data Collection" is a lab activity where students conduct experiments to measure lifting ratios and apply unit rates to graph distance vs. time characteristic of their hoist systems..
Post-Activity Assessment
"Mr. Lopez Trip" quiz assesses students' learning of ratios and rates.

Time (Sec)	Pulled dist. cm
1	8
2	16
3	24
4	32



Conclusions and Future Work

This hands-on activity engages students to learn the concepts of ratios and rates. Using the hoist systems, students can relate mathematical concepts to real-world engineering applications. Some improvements to the activity will be considered post implementation.

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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From Ideas to Reality!

Roy Perez (La Joya ISD)

Research Experiences for Teachers Program (Summer 2013)

Electrical Engineering Department, The University of Texas-Pan American

Summary

Students are given designs challenges where they have to build 3D prototypes given some volume and surface area specifications. To design such prototypes, students need to apply a number of geometric concepts such as volume and surface area calculations for different shapes. Some of the challenges include a cost constraint on the construction paper used to build the prototype. Students follow the engineering design cycle to complete the geometric challenges. (Figure 1)

Figure 1. From prototype to production

Engineering Connection

Math and engineering play an immense role in the creation of 3D prototypes. In this lesson, students will be challenged to play the role of manufacturing engineers. Manufacturing engineers are responsible for designing products as well as deciding how to build a prototype after the design specifications are determined. They must consider not only the most efficient and cost effective designs, but how accurate calculations were made. Students will develop an understanding of how prototypes are designed by following the engineering process: Brainstorm ideas, sketch designs, think about materials to use, build a design, test it, and build it again.

Learning Objectives

Students will be able to:

- Calculate volume, surface area, and dimensions of 3D models to build a prototype.
- Design and construct a 3D prototype with given volume, surface area, dimensions, and constraints such as cost effectiveness.
- Demonstrate a basic understanding on prototyping.

Subject Area(s)	Geometry
Grade Level	10th

Lesson Background & Concepts

Students will have already been exposed to geometric models in prior grade levels. To review prior knowledge students will view a PowerPoint on how the world revolves around geometric models including:

- 3D Models, Nets, Dimensions,
- Bases, Perimeter of Bases, Area of Bases,
- Surface Area, Volume,
- The Engineering Design Process.(Figure 2)

The activity allows the students to determine what unknown dimensions need to be calculated. They are given the opportunity to evaluate their prototypes to determine if it satisfies the given specifications and if they meet the design constraints.

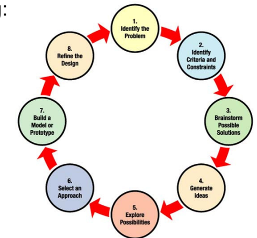
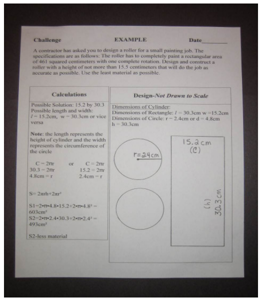
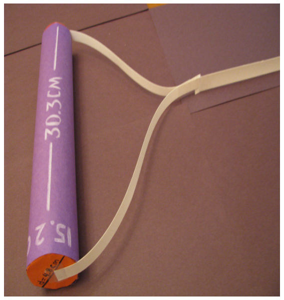


Figure 2. Engineering design process

Associated Activities





Day 1: Each group will receive a different prototype challenge problem.

- Groups will receive materials based on challenge question.
- Students are to design and construct a 3D model prototype with given specifications.
- Students design, test, analyze, improve and re-design as necessary.

Day 2: Groups will meet individually with teacher for feedback.

- After given feedback from teacher, groups will make adjustments if needed and then design a prototype based on their calculations.

Day 3:

- Groups meet with teacher individually again to test prototype and to demonstrate that the requirements have been met.
- Groups make adjustments if needed to finalize prototype.
- Groups will present final product to the class.
- Groups will turn in calculations and final product.

Assessment

Pre-Activity Assessment

Understanding Surface Area, Volume, and Prototypes Worksheet: Students complete the Understanding Surface Area, Volume, and Prototypes Worksheet, which is designed to reinforce surface area, volume, and prototypes as it relates to engineering.

Activity Embedded Assessment

Prototype Challenge Worksheet: Students complete the Prototype Challenge Worksheet, in which students record calculations and design a prototype.

Post-Activity Assessment

Prototype Evaluation Worksheet: Students complete the Prototype Evaluation Worksheet which is designed to evaluate students' knowledge of surface area and volume.

Conclusions and Future Work

This hands-on activity reinforces and extends the concepts of volume and surface by allowing students to design and construct real life prototypes. The students will get first hand experience in the field of manufacturing and design engineering throughout the entire activity because the processes they are conducting is what is done in actual businesses. Future work is necessary in obtaining materials and implementing the lesson in the classroom to evaluate the effectiveness and in improving students learning. Improvements to the lesson might be necessary post implementation and prior to submission for publication.

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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Power Wheels!

Carlos Rivera (PSJA ISD)
Research Experiences for Teachers Program
Electrical Engineering Department, The University of Texas-Pan American

Summary

In this activity students will learn how electrical energy is used to put mechanical energy in motion. Students will work in groups to and learn this by assembling their own pulley system that will produce enough torque to spin the wheel of their pulley by applying sufficient current. In order to understand this, students are to calculate how much current is needed to produce enough torque to spin wheels consisting of different weights.

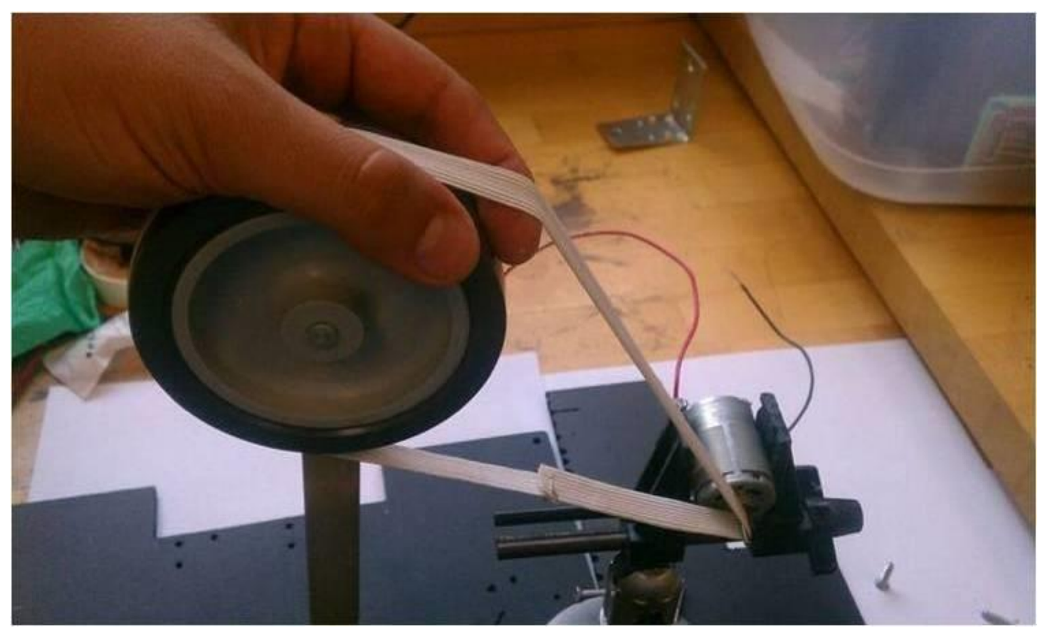


Figure 1. Image of a pulley system with an integrated motor and a voltage supply.

Engineering Connection

Production of energy is essential in the field of engineering. All engineers use some sort of energy to produce work. Mechanical engineers learn how to construct machines that produce work by using mechanical energy. Electrical engineers learn how to create and implement electric systems by using electric energy. Chemical engineers learn how to turn raw materials into useful, every day products by using chemical energy.

Learning Objectives

After this activity, students should be able to:
- Explain how electric energy is able to set mechanical energy in motion
- Calculate electric current and voltage
- Explain what torque is
- Explain why more electric current is required to produce more torque
- Produce a graph using the current/torque results

Subject Area(s)	Science
Grade Level	8 (6-8)

Lesson Background & Concepts

Students will be working in groups in order to better understand all concepts of transformation of energy and answer questions they may encounter during their state assessments. Figure 3 is a released state assessment question. Students will be following a specific process called engineering design process. Students will be able to *Ask* what problem they would like to solve, *Imagine* how it can be solved, *Plan* as a group in order to achieve it, Experiment with their ideas and *Improve* these ideas in order to acquire better results. These series of steps were created by NASA and illustrated on Figure 2.

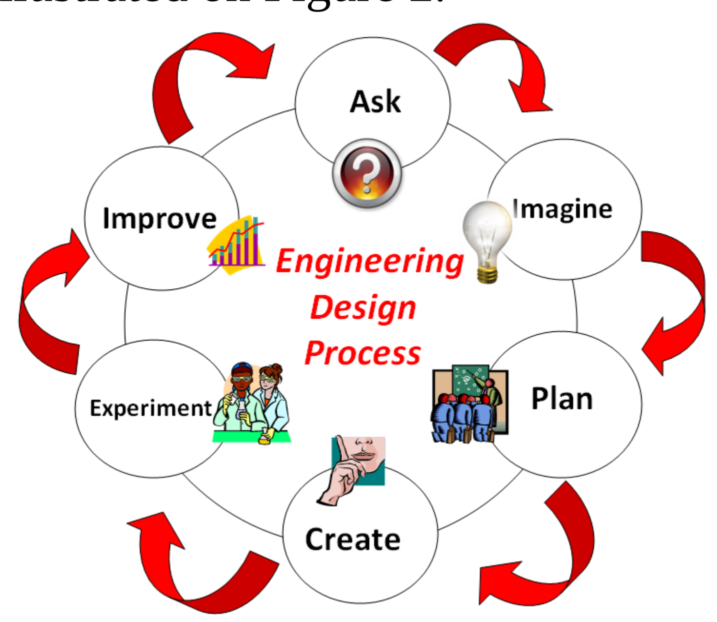
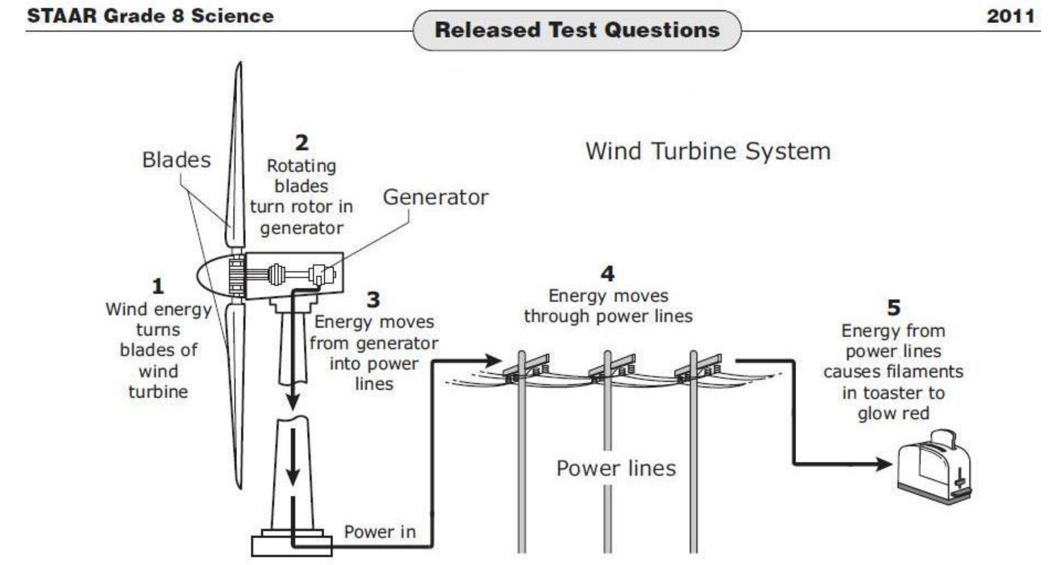


Figure 2. Steps of the engineering design process created by NASA.


STAAR Grade 8 Science
Released Test Questions
2011

In the diagram above, a wind turbine is transforming energy from the wind. Between which two steps in the diagram is mechanical energy being converted into electrical energy?

Figure 3. STAAR released question associated with energy transformation.

Associated Activities

Voltage &Current
The Voltage & Current.pptx presentation allows teacher to **f**amiliarize themselves with the concepts of voltage, energy and electrical current. It provides all the information needed inorder to better explain to students how we are able to efficientlyuse electricity to provide kinetic energy.

Multimeter Use
Teacher should go over the Multimeter Use.pdf presentation with the students. This presentation will guide the students during the introduction of the multimeter and assist in explaining what the purpose of using a multimeter is and how to correctly adjust the meter dial to measure the desired units.

Motivation Handout
Motivation**:** In this activity students will be presented a problem with a fun story and they will have to overcome this problem by completing this activity.

Pre-Activity Assessment
Calculating Units! : In this activity, the students will be able to calculate units of electrical power, voltage and current of their mechanisms in order to understand how electricity is transformed and converted into useful, kinetic energy.

Assessment

Activity Embedded Assessment
Calculating Current : During the pulley system activity, students will be recording their data on this handout. This handout provides cells to enter electrical current, voltage and torque values.
Graphing Data : In this worksheet, students will plug in the data gathered on the *calculating current* handout and use it to create a line graph. Students will also identify the points in which enough torque was produced to spin the wheel.
Post-Activity Assessment
Essay Discussions*:* Students are to write an essay in their laboratory notebooks explaining the following topics:
How do electrical energy and mechanical energy benefit us?
How do we transfer electrical to mechanical energy every day?

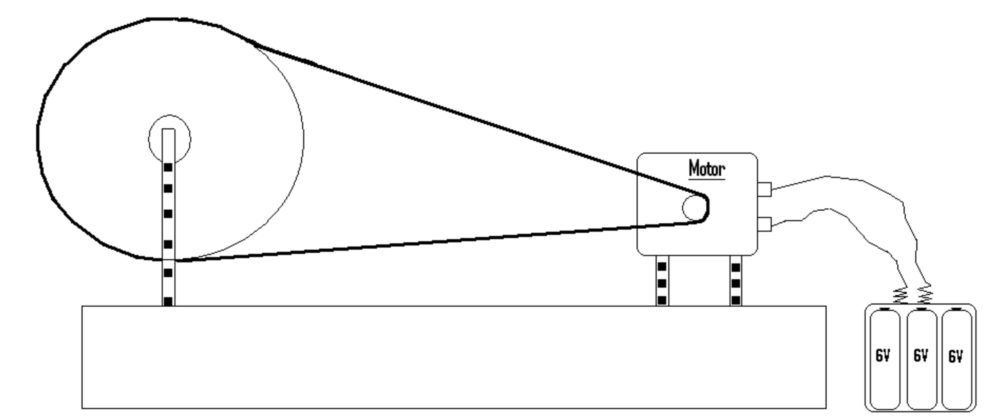


Figure 4. Illustration of the pulley system assembly with a voltage supply.

Conclusions and Future Work

As students complete this activity, they will be able to understand how energy plays a huge role in our daily and many professions such as engineering where energy is used to produce work. Students will be able to understand energy applications in common house appliances and the lesson may also spark an interest in student minds for the field of engineering.

Acknowledgement

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