Contents

Technical Procedural STEM Lessons

Rudolph the No Light Reindeer

Title: Rudolph the NO LIGHT Reindeer

Suggested Grade Level: 2 - 3

STEM Content Standards:

Science:
PS3.A Definitions of energy

Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.

Technology & Engineering:
Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.

Benchmark A: Energy comes in many forms

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Benchmark A: Asking questions and making observations helps a person to figure out how things work.

Math:
CCSS.MATH.CONTENT.2.G.A.2

Partition a rectangle into rows and columns of same-size squares and count to find the total number of them.

CCSS.MATH.CONTENT.2.G.A.3

Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.

Big Ideas:
Simple Circuits with switch
Questioning for deeper understanding
Recognition of geometry and simple fractions

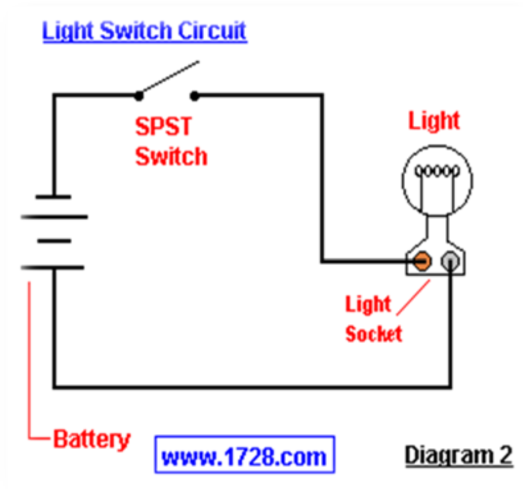
Essential Question:
How can you design a simple switch circuit that will light up Rudolph's nose so that he can guide Santa's sleigh?

Scenario:
Rudolph's nose has lost its glow. He needs you to help design a simple circuit switch to light up his nose for when it gets dark.

Tools, Materials, and Resources:

Tools	Scissors, wire stripper,
Materials	Tape, Crayons, LED red bulb, wire, resister, 9 volt battery, battery/wire connecter, paper plates, pencil
Resources	PowerPoint Presentation

Content information:
Electrical current is the flow of charge. When the switch is connected, electrons flow from the anode (positive/top of battery) to the cathode (negative) at the bottom of the battery and return to the positive pole. The illustration is a diagrammatic form (i.e. circuit diagram or schematic) used to illustrate an electrical circuit.



The battery provides the electromotive force (or e.m.f.) that "pushes" the electrons through the wires of the circuit. Electromotive force is measured in volts. In some ways it is similar to the potential energy stored in an object at the top of a hill. The object might roll down the hill and lose its potential energy and, in an analogous way, the electrons flow down the voltage drop (or potential difference) as they move around the circuit.

As the switch is turned on, the light bulb ignites (lights up). When the circuit is closed, by throwing the switch, the battery forces those electrons to flow around the wire, thereby creating the current.

Standard units used in electricity (in the United States) are:

- **VOLTS (V)**: unit of potential difference, emf, or voltage
- **OHM (Ω)**: unit of resistance
- **AMPS (AMPERES) (A)**: unit of current
- **COULOMBS (C)**: unit of charge (= the charge moved when one amp of current runs for one second).
- **WATTS (W)**: unit of power (power energy per unit time). In electrical circuits, **one watt** is produced when a current of **one amp** flows down a potential difference of **one volt**.
- **JOULE (J)**: unit of energy.

Deliverables:
Student Instruction Sheet
Rudolph circuit project

Parameters or constraints:
Utilize student design sheet
Follow directions precisely

Evaluation – Product based assessment:
Model- Students will demonstrate their circuit project and demonstrate the simple switch mechanism.
The finished product should look similar to model and built according to the given instructions.

Evaluation – Process-Focused Performance-Based Assessment:
Questioning and Discussion- Students will be asked different questions during the construction and presentation of their project. To include but not limited to the following:

1. Why is it important to have a switch?
2. What is the energy source? How does it work?
3. How can you divide a square sheet of paper to get 4 equal parts (legs)?
4. What kind of questions did you ask in order to build your project correctly?
5. What was the most important thing you learned?
6. What was the most fun?

Rudolph the No Light Reindeer

Scenario:

Rudolph's nose has lost its glow. He needs you to help design a simple circuit switch to light up his nose for when it gets dark.

Challenge:

How can you design a simple switch circuit that will light up Rudolph's nose so that he can guide Santa's sleigh?

Answer the following questions before beginning the STEM design challenge.

1) What is in your home or classroom that uses electricity?

2) Electricity has to have __________________ to work.

3) What are some of the ways that electricity gets power?

4) What is an item that you use that requires batteries for electricity?
____

5) A circuit is a _________________ path that electricity can follow.

6) A circuit also needs energy from the ________________ and _______________ terminals for the electricity to travel.

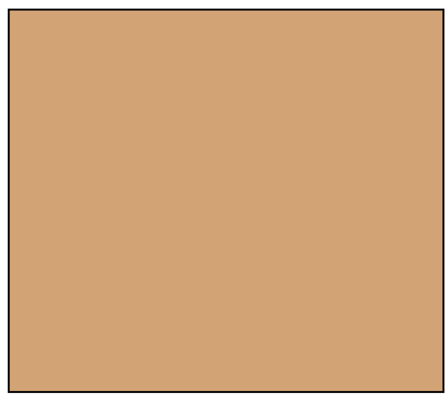
7) You have one plate, but we need to divide it to make Rudolph's body. How can you divide the plate in the picture?

8) What fraction did you make?

9) You have ½ plate, but we need to divide it to make Rudolph's head. How can you divide the plate in the picture?

10) What fraction did you make in this problem?

11) How can you make Rudolph's (4) legs with one square of paper? Show work below.



12) What fraction did you make?

Great Job, let's build Rudolph and light up his nose together!

Assembly Directions (Rudolph):

1. Color your paper plate body and head brown
2. Trace your right hand and left hand on the brown paper and cut out to make the antlers
3. Tape the wiggly eyes on the head
4. Attach the head

Assembly Directions (Circuit):

1. Carefully put the light through the nose and paper plate.
2. Attach the resister to the negative end of the light (shorter prong) and then attach to paperclip to form switch
3. Attach the red wire to the positive end of the light (longer prong)
4. Attach paperclip to the negative (black) wire from battery to complete switch circuit
5. Tape down the battery and wires
6. Attach the antlers and legs to the body

Saber Circuits

Suggested Grade Level: 4-6

STEM Content Standards:

Science: Next Generation Science Standards 4- PS3-4, Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. Arkansas Frameworks PS.7.4.3, Construct simple circuits from circuit diagrams.

Technology and Engineering: Standards for Technological Literacy Standard 12, Students will develop the abilities to use and maintain technological products and systems.
-Follow step-by-step directions to assemble a product.

Big Ideas:
Understanding circuits
Following instructions
General electricity

Essential Question:
How can you construct a light saber that will glow with the use of a switch?

Scenario:
Darth Vader, defender of the dark side, is deep in the heat of battle. With the help of his light saber, he can conquer his enemies. He didn't expect his trusty weapon to break when he needs it most. He is desperate for a quick solution, so he can continue to defend himself. He needs your help to make a temporary light saber to get him through this battle.

Challenge:
Help Darth Vader build a new light saber in time to defend himself against his enemies. Each student will be given the materials needed to build their own light saber, but are encouraged to work with the groups formed at their table. The materials and instructions given will ultimately create a circuit that lights up the saber.

Tools, Materials, and Resources:

9 volt battery	Tape	Lights	Styrofoam	Scissors	Knife
Wires	Glue stick	Paper towel roll		Aluminum Foil	

Content information:
Introduce circuits and electricity to your class by showing this Bill Nye the Science Guy Video.
http://www.youtube.com/watch?v=vK0uAW8usco

It explains circuits and electricity perfectly and appropriately for this age group. He also gives several examples of everyday circuits and uses of electricity.
After watching the video, have a class discussion on how to complete a circuit. Demonstrate a complete circuit with a light bulb and battery. Take questions and ask questions to get them thinking about the importance of checking the path of the electricity. Give your own examples of simple and complex circuits in the world around them. Then introduce the assignment.

Deliverables:
Students will turn in their light sabers to the teacher. They will also be expected to answer questions individually and within their group. They will turn in their worksheet that covers self-evaluation and a review over circuits/electricity.

Saber Circuits

Darth Vader, defender of the dark side, is deep in the heat of battle. With the help of his light saber, he can conquer his enemies. He didn't expect his trusty weapon to break when he needs it most. He is desperate for a quick solution, so he can continue to defend himself. He needs your help to make a temporary light saber to get him through this battle.

Instructions:
Build Darth Vader a light saber he can use to defend himself in battle with the materials given to you.

Including:
9 volt battery Tape Lights Styrofoam Scissors Knife
Wires Glue stick Paper towel roll Aluminum Foil

Saber Circuits: Student Self-Evaluation and Reflection

1.How can you tell if a circuit is complete?

2.What happens if a circuit is not complete?

3.What are some examples of real world circuits?

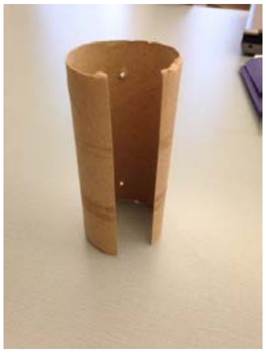
4.Was your light saber successful? Why/Why not?

5.What was the most difficult part of building the saber?

Saber Circuit Assembly:

1. During this project, play the Imperial March while constructing the Circuit Saber.

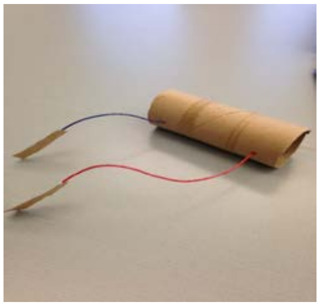
2. Cut a toilet paper roll (or half of a paper towel roll) down the middle, and punch 2 holes on opposite ends.



3. Strip half an inch off both sides of your red and blue wires.

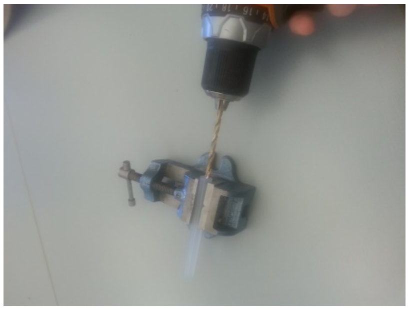
4. Coil one side of the red wire and attach it to the positive side of the 9 volt battery. Coil one side of the blue wire and attach it to the negative side of the battery. Tape them both down so they won't move.

5. Cut 2 small strips of cardboard for your button. Strip half an inch off of the end of a blue wire and attach it to the cardboard by wrapping aluminum foil around it. Tape the foil so that it doesn't move, and so that there is only a "silver face" where the two buttons should meet.

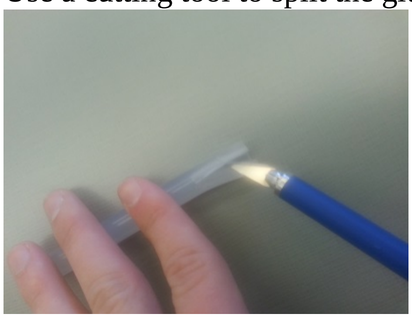


6. Strip the opposite ends of those wires, and insert the paddles through the holes you made at the beginning of the build.

7. Put a glue stick in a vice clamp, and drill a hole through the center of it. **DO NOT HOLD IT IN YOUR HAND TO DRILL THE HOLE**.



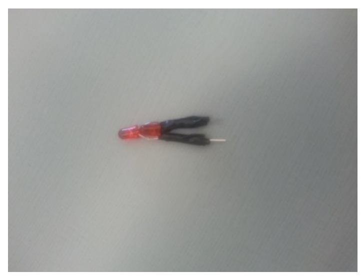
8. Use a cutting tool to split the glue stick, so that we can insert our LEDs.



9. To make our LEDs, identify the long legs of each LED. Twist the two long legs together.

10. Twist the two short legs together.

11. Use electrical tape to insulate your connections.



12. Cut small cylinders out of foam to the diameter of your handle. Push the glue stick through the foam.

13. Connect red wire coming from the battery to the positive lead coming from the LEDs.

14. Connect the blue wire from the battery to the blue wire on the grip.

15. Pull the red wire through the handle, and connect it to the negative lead coming from the LEDs.

16. Push all wires into the handle, and tape the battery to the inside.

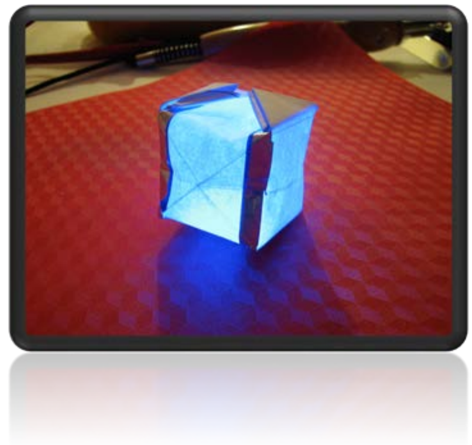
17. Adjust the glue stick fixture so that it is flush with the top, and glue to the inside of the grip.

18. To make the button, simply put the two paddles together, “sandwiching” two pieces cardboard at either end so that only the middle can touch when pressed.

19. Close the grip using tape.

20. Decorate the Circuit Saber as needed!

Origami Night-Light



Suggested Grade Level: 5 - 6
Discipline area: STEM
Unit: Geometry/ Electricity /Simple Circuits

STEM Content Standards

Next Generation Science Standards (Physical Science): Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass.
Standard 7: Energy PS.7.4.2 Classify electrical *conductors* and electrical *insulators*

Technology and Engineering:
STL Standards and Benchmarks

Standard 12. Students will develop the abilities to use and maintain technological products and systems.
D. Follow step-by-step directions to assemble a product.

Mathematics:
Common Core State Standards
CCSS. Math. Content 6.G.A.1: Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.

Big Ideas:
Determine how to construct a cube/ and understand properties of a cube.
Understand what makes a good insulator and conductor of electricity.
Understanding the basic properties of how to make a circuit.
Determine the best way to solve a problem (Design Loop)
Students will understand how electricity circulates through the circuit to make light through the cube.
Electricity flows through using different conductors and insulators

Essential Question:
Can you follow the steps to create a complete circuit to light your own night-light?

Scenario:
Kiko the bat is scared of the dark and doesn't know how to make a light that will stay on all night until the sun comes back up! Help Barry build an origami night-light! Follow the instructions to create a simple origami night-light to keep Kiko's room lit until morning!

Challenge: After being taught about simple circuits by the teacher the students will construct an origami night-light.

Materials: Students will be provided with all the materials needed to create an Origami night-light.
9-Volt Battery
Christmas Light
Foil
Electrical tape/ Duct tape
White 8X8 inches paper
Battery Connecters

Content Information:
A cube is a three-dimensional shape, where all six sides are squares. Every square will be the same dimensions, and all sides will be the same. A cube has six faces, eight vertices, and twelve edges.
We use electricity every day to make our lives easier. Electricity powers the lights we use in our room, electronic devices like computers and telephones, and many other devices. Electricity travels through circuits, a loop of conductors connecting a power source to an object that uses electric currents to work. Electricity cannot flow without a power source. A complete circuit means that a full loop is creates, and there are no holes in the circle. Positive and negative charges are given off and when connected correctly in the circuit, electricity will flow. A circuit can be created through using good conductors like electrical wires, foil, or even graphite from a pencil. See the example of a complete circuit below.

Vocabulary:
Three Dimensional: To have dimension of depth, width and height
Circuit: The act or instance of moving around.
Insulators: A material of such low conductivity that the flow of current through it is negligible.
Conductors: A substance, body, or device that readily conducts electricity.

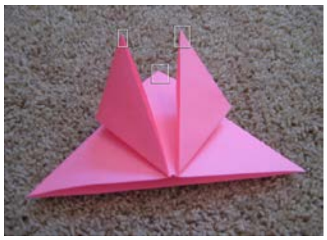
Procedures: (Part 1)
Students will start this assignment by learning about the basics of a circuit. The lesson should be taught first, and then students will begin to create their own circuit using the materials listed below. They will start by creating a cube out of an 8X8 in paper square. These instructions should be given explicitly as the construction might be difficult for students.

Cube Building:

Fold square diagonally on both corners.

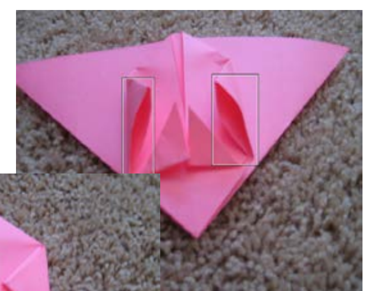
Now fold the sides in as shown in the photo. This is called a mountain fold. Then fold it down as shown.

Fold the two sides in so that the tips touch the center.



Fold the two sides in so that the tips touch the center.

Fold down the two flaps at the top. Also notice that there are two slots that you can open near the center. Tuck the flaps into the slots.



Repeat steps 3-5 on the other side of the shape.

Blow into the end of the shape with the hole.

Crease edges to finish the cube.

Procedures: (Part 2)
Circuit Construction:

Have students unfold their paper cubes to construct their circuit on the inside of the cube.

Students will measure 2 8-inch strips of foil, one positive and one negative.

Have students attach the wires from the bulb to each strip of foil using electrical tape, and attach the foil to the paper cube as well using tape. There will be a few inches of foil that will reach longer than the edge of the paper, which should not be cut off.

Have students reassemble their cubes being careful that the circuit remains intact.

Students will then use the 9-Volt battery and connector to touch the positive end of the battery connector to the positive foil piece, and the same for the negative end. This should cause the bulb to light.

Additional Planning:

This lesson can also be used in a unit to learn about surface area. After the circuit is created, and the cube is complete, a lesson taught about determining surface area can be done. Students can measure the dimensions of each square, find the area of one square, and multiply by six to find the total surface area. The lesson can be expanded even further to find the volume of cube. Students could be given the volume of the light bulb and will need to subtract that measurement from the total volume, etc.

Assessment:
Students will be assessed based upon if their night-light glows and if their circuit is complete. The design loop worksheet attached can also be used to assess if the students are following the appropriate steps of the design loop.

Citations:
"How to Make a Paper Cube." *Instructables*. AutoDesk, 2013. Web. 08 Oct. 2013. <http://www.instructables.com/id/How-to-make-a-paper-cube/step6/Two-more-folds/>.

Origami Night-Light

Student Handout

Scenario:
Kiko the bat is scared of the dark and doesn't know how to make a light that will stay on all night until the sun comes back up! Help Barry build an origami night-light! Follow the instructions to create a simple origami night-light to keep Kiko's room lit until morning!

Materials: Students will be provided with all the materials needed to create an Origami night-light.
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Foil
Electrical tape/ Duct tape
White 8X8 inches paper
Battery Connecters

Content Information:
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Vocabulary:
Three Dimensional: To have dimension of depth, width and height
Circuit: The act or instance of moving around.
Insulators: A material of such low conductivity that the flow of current through it is negligible.
Conductors: A substance, body, or device that readily conducts electricity.

Directions: (Circuit Construction)

Unfold your paper cube to construct your circuit on the inside of the cube.

You will measure 2 8-inch strips of foil, one positive and one negative.

Attach the wires from the bulb to each strip of foil using electrical tape, and attach the foil to the paper cube as well using tape. There will be a few inches of foil that will reach longer than the edge of the paper, which should not be cut off.

Reassemble your cube being careful that the circuit remains intact.

You will then use the 9-Volt battery and connector to touch the positive end of the battery connector to the positive foil piece, and the same for the negative end. This should cause the bulb to light.

Information to Know:
A cube is a three-dimensional shape, where all six sides are squares. Every square will be the same dimensions, and all sides will be the same. A cube has six faces, eight vertices, and twelve edges.
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Engineering Design Loop

Discover the problem.

Understand the problem and develop the solution.

Choose the best solutions, and draw your ideas.

Build you Origami Night light!

Test your Origami night light.

Fire Flies

Unit: STEM - Basic circuits and electricity

Suggested Grade Level: 4 - 6

STEM Standards

SCIENCE:
Next Generation Science Standards 4-PS3-4, Apply scientific ideas to design, test, and refine a device that converts energy from one form to another

TECHNOLOGY/ENGINEERING:
Standards for Technological Literacy Standard 12, Students will develop the abilities to use and maintain technological products and systems
Follow step-by-step directions to assemble a product.

MATH:
Common Core State Standards CCSS.MATH.CONTENT.5.MD.A.1, Convert among different-sized standard measurement units within a given measurement system, and use these conversions in solving multi-step, real world problems

ENGLISH/LANGUAGE ARTS
Common Core State Standards CCSS.ELA-LITERACY.RI.5.1, Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text

Big Ideas:
Understand simple circuits
Understand how a switch works to complete a circuit
Follow detailed instructions to complete an experiment

Essential Question: How can you create a glowing firefly using your knowledge of electricity and simple circuits?

Scenario: Circuit and Volt, best firefly friends, have lost their light. They are very sad, because the thing fireflies like to do most, as you can imagine, is light up. Today you will help restore Circuit and Volt's lights. Follow the instructions to create a simple circuit to put the "fire" back in the firefly.

Challenge: After being introduced to basic circuits by the teacher and watching a short video, students will create a simple circuit firefly with a switch and test it to make sure it works.

Tools:

Drill Press	Scissors
Thumb Tacks	Erasers
Wood Cutter	Needle Nose Pliers
Single Hole Punch	

Materials (per student):

Plastic Eggs (1)	Wooden Dowel Rod (1)
Pipe Cleaners (3- 2 for legs and 1 for antennas)	Coin Cell Batteries (3V- CR 2025)(1)
LED Light Bulbs (1)	

Materials (Consumables):

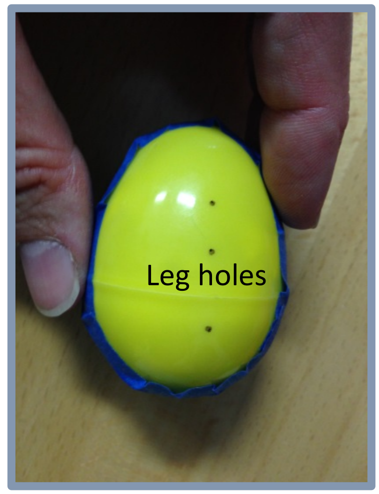
Metallic Duct Tape	Masking Tape
Googly Eyes	Sharpies or Markers
Cardboard box pieces	Tacky Glue

Content Information:
Introduce simple circuits to your class. The video at http://youtu.be/VnnpLaKsqGU is a great starting point! After watching with your class, define and explain the terms included in the *Vocabulary* section of this lesson.
Using a battery and an LED light bulb, demonstrate to your students how touching the electrodes (the wires sticking out of the bulb) to the sides of the battery lights the bulb. Explain that each bulb will have a positive electrode and a negative electrode. Usually, the longer wire will be the positive, but this is not always the case. Because of polarity, the electrodes must be pressed to the correct sides of the battery or the bulb will not light.
Introduce the situation to your students and explain that everyone will be building their own firefly to experience electrical circuits for themselves and cement their learning.
Pass out supplies and facilitate bug making!

Vocabulary:
Circuit- a pathway for the flow of electricity
Current- the flow of electricity through a conductor
Electrons- the negatively charged part of an atom
Filament- the part of a light bulb that gets hot and makes light
Conductor- a substance through which electricity will flow
Insulator- a material that prevents flow of electricity; common insulators are plastic, rubber, glass, and air
Electrode- the negative or positive part of an electric cell
Polarity- the direction of an electric field; it will be either negative or positive
Switch- a device used to interrupt the flow of electrons in a circuit

Circuit and Volt: Electric Fireflies
An Introduction to Circuits
Teacher Instructions

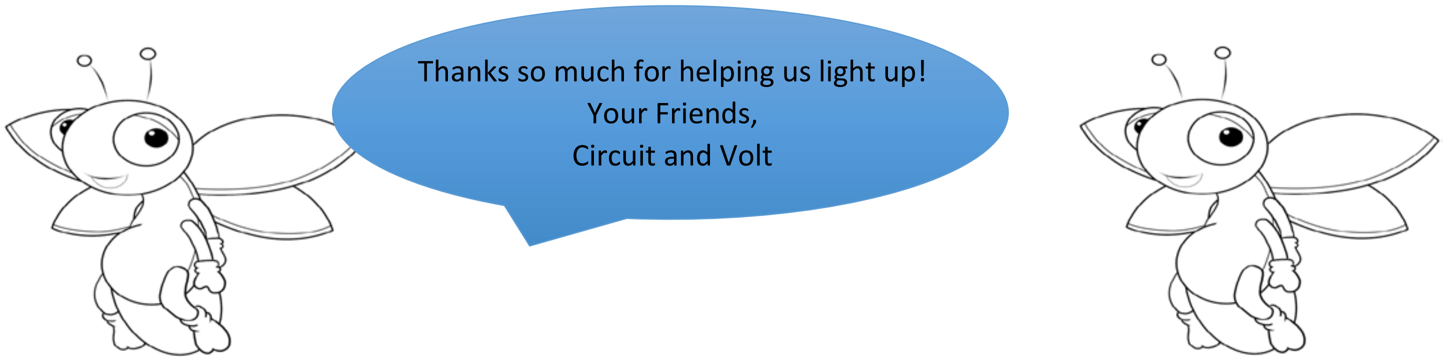
Preparation: Prepare materials for class. An electric drill press will yield the best results, but it is possible to drill the eggs using a hand-operated drill press.



Each egg will need:
6 “leg” holes (3 on each side of the egg)
1 “switch” hole for the dowel rod to stick out of (on the top, slightly behind where the egg snaps together)
2 “antenna holes” (on the top, front of the egg).
It is easier to drill the eggs when they are stuffed with a piece of scrap paper and taped closed.
NOTE: We used a 1/16” drill bit for the pipe cleaner holes (legs and antennas), and a 1/4” drill bit for the dowel rod hole.

Circuit and Volt: Electric Fireflies
An Introduction to Circuits
Student Handout

Circuit and Volt, best firefly friends, have lost their light. They are very sad, because the thing fireflies like to do most, as you can imagine, is light up. Today you will help restore Circuit and Volt's lights. Follow the instructions to create a simple circuit to put the "fire" back in the firefly.

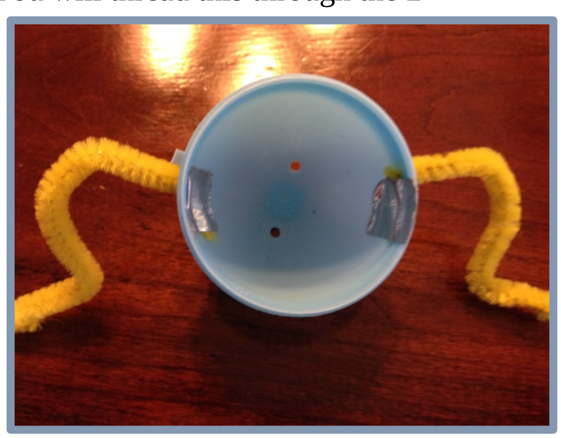


Instructions:
Gather the following supplies from your teacher:

Plastic Eggs (1)	Wooden Dowel Rod (1)
Pipe Cleaners (3- 2 for legs and 1 for antennas)	Coin Cell Batteries (3V- CR 2025)(1)
LED Light Bulbs (1)	Cardboard box pieces
Shiny Silver Duck Tape	Masking Tape
Goggly Eyes	Sharpies or Markers
Tacky Glue	Scissors
Wood Cutters	Pliers
Single Hole Punch	

Cut your pipe cleaners to length (2-3 inches) and put them through the leg holes to give your bug legs. Cut a longer piece for the antenna. You will thread this through the 2 antenna holes and curl the ends.

TIP:
Secure the legs inside the egg with a small piece of tape. This will make your legs more stable.
Fold the "foot" piece under with pliers to keep the sharp edge of the pipe cleaner from hurting someone!



Test your LED light bulb to see which way it needs to go on the battery to light up.

It's time to start building your circuit! In the back half of the egg (the one with the big hole in top for your switch), carefully tape the sides of your battery to the egg. You will then slide the LED in with one wire under the battery, and one on top. You can push down on the top wire to make sure your bulb lights.

TIP:

Make sure you don't tape over too much of the top surface of the battery. You want plenty of surface area for your top wire to make contact and your bug to

Cut a small circle out of your cardboard scraps. It should be about the size of your battery. This is part of your switch!

Cut your dowel rod to 2.5- 3 inches long. Make sure you can insert it in the egg from the inside. If not, it is too long.

Cut strips of tape and use them to tape the dowel rod to your cardboard circle.

Tip: Your switch should look similar to this

Insert the top of the switch through the hole in the top of your egg. It should line up so that it can be easily pressed down and make the light bulb light up. If pressing down on the switch does not easily light the bulb, you might need a small cardboard shim under your battery.

Tape the sides of the switch to the sides of the egg. This will keep your switch from becoming misaligned and not working.

Snap the two pieces of your egg together, making sure your bug legs are lined up.

Attach googly eyes to your bug and draw on a happy face with your markers. You are almost there!

Cut wings out of your shiny tape. First fold the tape over on itself so that the sticky sides stick together. Then cut out your wing shapes.

Hold the egg in the palm of your hand and carefully press down on the switch to light up your firefly!

TIP:

After your wings are cut out, use a single hole punch to make a hole through them- this is where the switch will stick out of your egg. You can attach the wings to your egg with a tiny dab of tacky glue.

Circuit and Volt: Electric Fireflies
An Introduction to Circuits
Student Worksheet

Why does pressing down on the switch cause the bulb to light up?

How can you tell the difference from the positive (+) electrode and the negative (-) electrode on the LED light bulb?

Did you find any errors in your work as you made your bug? If yes, how did you fix them?

Circuit and Volt's Amazing Word Search

CIRCUIT	CONDUCTOR	CURRENT
ELECTRODE	ELECTRONS	FILAMENT
INSULATOR	POLARITY	SWITCH

F	I	L	A	M	E	N	T	S	N
U	A	A	D	E	V	W	C	N	Y
M	X	H	M	M	G	T	T	O	T
V	C	Y	C	N	T	B	J	R	I
C	K	U	T	T	H	H	O	T	R
T	Q	Y	X	S	I	T	C	C	A
N	H	H	J	H	C	W	S	E	L
E	O	A	T	U	Z	V	S	L	O
R	U	X	D	P	D	Z	A	E	P
R	Y	N	I	N	S	U	L	A	T
U	O	P	T	I	U	C	R	I	C
C	J	K	E	D	O	R	T	C	E

Fun Firefly Facts

Fireflies, also called lightning bugs, are neither flies or bugs. They are actually beetles!

Fireflies are the world's most efficient light producers. Have you ever touched a light bulb that's been on for a while? If you did, you probably burned your finger! An average electric light bulb gives off 90% of its energy as heat, and only 10% as light. All 100% of the firefly's energy goes into making light.

Fireflies "talk" to each other using light signals.

Firefly eggs glow.

Not all adult fireflies flash.

Firefly larvae feed on snails.

Some fireflies are cannibals.

Female fireflies sometimes mimic the flashes of other species.

Firefly luciferase (the enzyme that releases their light) is used in all kinds of medical research.

Some fireflies synchronize their flash signals.

Adapted from: http://insects.about.com/od/beetles/a/10-Cool-Facts-About-Fireflies.htm

Circuit and Volt: Electric Fireflies
An Introduction to Circuits

Evaluation and Assessment

Grading Rubric

Objective	Points awarded
Demonstrates knowledge of simple circuits (0-25pts): Student is able to describe how a simple circuit works and implement a switch into a circuit's design.	
Followed procedural instructions to complete experiment (0-25pts): Student is able to follow multi-step instructions to create a simple circuit with switch.	
Effective use of tools (0-25pts): Student is able to use tools recommended in procedural instructions to complete given task.	
Completion of provided handouts for evaluation (0-25pts): Student completed all questions and demonstrate knowledge and comprehension of simple circuits.	

Total Points:
________/100

Classroom STEM Lessons using KEVA Planks

Keva Coaster Design Challenge

Disciplinary Area: STEM
Unit: Energy, Forces, and Motion
Grade Level: 3

Standards:
Next Generation Science Standard (NGSS): Physical Science
PS3.A Definitions of energy & PS3.B Conservation of energy and energy transfer

- Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.

Standards for Technological Literacy (Understanding of Design): The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Common Core Mathematics (Measurement and Data): Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters.

Common Core ELA (Writing): Write opinion pieces on topics or texts, supporting a point of view with reasons.

Big Ideas:

- Demonstrate a basic understanding of Newton's first two Laws of Motion and how they apply when designing objects that incorporate movement
- Follow the design loop to build a Keva Coaster

Essential Question: How can you apply your knowledge of Newton's Laws of Motion to design and a build a roller coaster out of Keva blocks that will keep a ball in motion for the longest amount of time possible?

Scenario: You are a roller coaster designer, and your boss wants you to design the biggest, best roller coaster ever- only in a twist, he wants it to be SLOW! Follow the design loop to create a series of contraptions that will keep your cart (a ball) in motion for as long as possible.

Materials: Keva Blocks

Content Information: Introduce the laws of motion to your students. A great way to do this would be to watch *The Magic School Bus* episode titled *The Magic School Plays Ball*, which is available on Vimeo: *http://vimeo.com/50104053*.
The episode will explain that

1. Forces are pushes or pulls that change how things move.
2. Once moving, things keep moving until forces change or stop their motion.
3. How friction, or a lack of it, changes movement.

Sir Isaac Newton lived in the 17th century. He published his ideas on motion and forces, which became knows as Newton's Laws of Motion.

> *1st Law: If no forces (or a combination of forces that is balanced) act on an object then, if it is at rest, it will remain at rest, and if it is in motion, it will continue to move in a straight line path at a constant speed.*

What does this mean? **Objects keep on doing what they are doing**. This is the law of inertia.

> *2nd Law: If a single force (or a combination of forces that is unbalanced) acts on an object, its speed and/or its direction will change. How quickly the speed (and/or direction) changes is directly related to the strength of the net force and inversely related to the object's mass.*

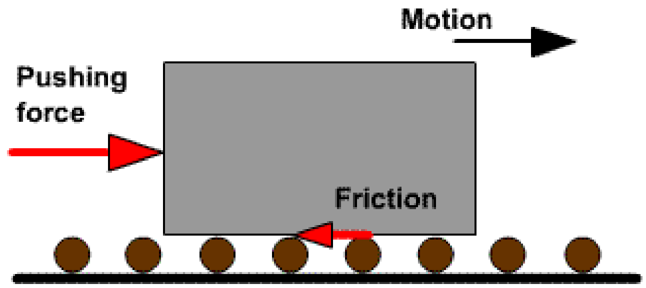
Simplified, this means that a force pushing or pulling on an object will change its direction and/or its speed. When you kick a soccer ball, your kick is the force. Your kick will increase the soccer ball's speed. If the ball was rolling towards you before the kick, it will most likely change direction. The harder you kick, the more drastic and noticeable the change will be. A quick demonstration with a ball and a couple of students would be a great way to introduce this concept! What does it mean when says that changes are inversely related to an object's mass? The easy answer is that the heavier something is, the harder it is to get it moving, keep it moving, and the slower it will go.

What about friction?

Friction is what happens when two things rub together. You might have your students rub their hands together for a minute and feel the heat produced. This is a side effect of friction! Think about the molecules on the surfaces of two materials (even ones we think are smooth) like sandpaper, and then imagine rubbing them together. Just as the individual grains of sand rub against one another, so do the molecules in our smooth surfaces. While we could go in to a lot of detail about friction, it is really just important that you get one thing across to your students at this point. That is: Friction is an opposing force, and it is always at work here on earth, and it slows things down!

To sum up, here are the key points:

- Objects keep doing what they are doing.
- A Force acting on an object will change its speed or direction, or both.
- The heavier something is, the slower it will go. Alternately, the lighter something is, the faster it will go.
    - Friction slows things down.



Keva Coaster: Evaluation and Assessment Grading Rubric

Names:

Demonstrates knowledge of Laws of Motion (25%) ______%

Student is able to describe how the first two laws of motion apply in making a cart go faster or slower.

Followed Design Loop (25%) ______%

Student used design loop to design and build a roller coaster

Effective Collaboration (25%) ______%

Student is able to work in a group to design and build, treating others' ideas with respect.

Completion of provided handouts for evaluation (25%) ______%

Student completed all questions and demonstrated knowledge and comprehension of Laws of Motion, line plots, and creative writing.

Total _____%

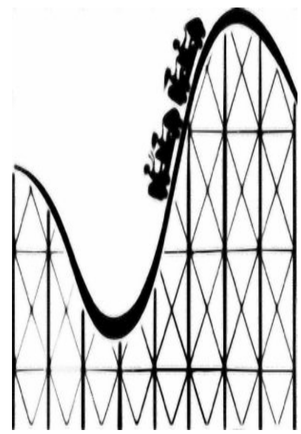
Comments:

Keva Coaster Design Challenge: Student Handout

Scenario: You are a roller coaster designer at the biggest amusement park in the world, and your boss wants you to design the biggest, best roller coaster ever- only in a twist, he wants it to be SLOW! Follow the design loop to create a series of contraptions that will keep your cart (a ball) in motion for as long as possible.

Materials: Keva Blocks

Vocabulary:



Acceleration- the rate at which an object changes its velocity
Balanced- equal
Constant- occurring continuously over a period of time
Force- a push or a pull
Friction- the resistance that one surface encounters when moving over another
Inertia- a tendency to remain unchanged
Inertia- a tendency to remain unchanged
Mass- the quantity of matter that a body or objet contains
Pull- a force drawing something in a particular direction
Rest- not moving
Speed- the rate at which something is able to move
Velocity- the speed of something in a given direction

Instructions:

1. Within your group, follow the design loop to come up with your roller coaster plan. You will need to fill out the design loop worksheet before getting your blocks!
2. Build your roller coaster. Make adjustments as you go!
3. Complete the Student Worksheet
4. Complete timed runs with the entire class, and record data on line plots
5. Write an opinion piece- be creative!

Keva Craze

Title: Keva Maze
Disciplinary Unit: STEM
Unit: Momentum (Motions and Forces)
Grade: 3rd

STEM Content Standards:

Next Generation Science Standard (NGSS): Physical Science

PS2.A Forces and motion & PS2.B Types of interactions

-Pushes and pulls can have different strengths and directions, and can change the speed or direction of its motion or start or stop it.

-The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Technology and Engineering:

STL Standards

Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Common Core ELA Standards

CCSS.ELA-Literacy.SL.2.1. (Comprehension and collaboration) Participate in Collaborative conversations with partners about grade 2 topics with peers and adults in small and larger groups.

Essential Questions: Can you design a Keva in a 75-minute class period that allows a Keva ball to be set in motion and remain in motion for the greatest amount of time?

Scenario: Using the Keva materials given, construct a structural device that allows a Keva ball to be set in motion and remain in motion for the greatest amount of time (changes in direction are allowed) and then finally stop after dropping into a ball holding area.

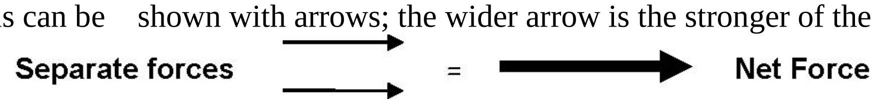
Big Ideas:

- Balance and placement.
- Communicating ideas with others, and bringing them together to create a product.
- Relationship between energy and forces

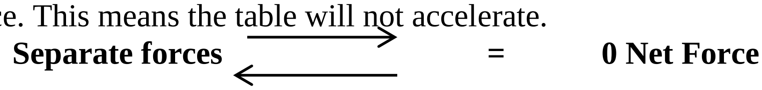
Materials:
Keva planks and Keva ball
Content Information:
Objects store energy as a result of their position. Stored energy is referred to as potential energy. If you think about a bow, in its usual position without an arrow, the bow has no stored energy,

thus it has no potential energy. When the bow is drawn, there is stored energy, as a result of its position. This is potential energy; it is stored in the drawn bow. Gravitational potential energy is the energy stored in an object as a result of its vertical position or height. The energy is stored as the result of the gravitational attraction between the Earth and the object. Kinetic energy is the energy of motion. When an object has motion, it has kinetic energy. Mechanical energy is the energy possessed by an object due to its motion or its stored energy of position. It can be either kinetic or potential energy.

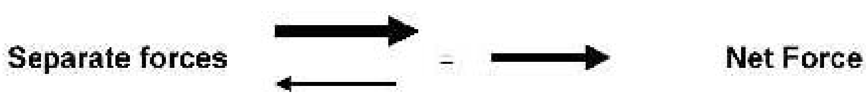
Forces
A force is defined as a push or pull. When you write, for example, you are exerting a force on your pencil because you push or pull it across the paper.
Sometimes there are two forces acting together. If two people are pushing a table across the floor in the same direction, the two forces are added together. Adding these two forces together is called the net force. In the case of the two people pushing the table, the net force is unbalanced. When there is an unbalanced force there is a force that changes an object's motion or causes it to accelerate. This can be shown with arrows; the wider arrow is the stronger of the forces.



Two forces can also act in opposite directions. When the forces are equal and act in opposite directions, they balance each other out. There is no net force in this case. Using the example of two people pushing on a table, if there is a person on each of the opposite ends of the table and they are both pushing on the table with an equal amount of force, they balance each other out to a zero net force. This means the table will not accelerate.



When there are separate forces that are not equal and one force is more powerful than the other, they will not balance out to zero net force. Because there is one force stronger than the other, the weaker force is not strong enough to balance the other end. They are pushing in opposite directions but one of them is pushing with a greater force. The motion will occur in the direction that the stronger force is moving. If two people are pushing on opposite ends of the table and one is pushing with more force, the table will accelerate in the direction that the person with the stronger force is moving.



Newton's Laws of Motion
Newton's First Law
If there is a ball in front of you that is just sitting there, it will stay there until you kick it or until another force acts on it. Why is that? It is inertia. Inertia is the tendency of an object to resist any change in its motion, which means the object does not want to move or if it is moving, it wants to keep moving. Newton's First Law of Motion is also called the Law of Inertia. This law states that an object at rest will remain at rest unless there is unbalanced force acting on it. An object in motion will keep moving until there is an unbalanced forced acting on it.
Newton's Second Law
Newton's Second Law of Motion explains how force, mass, and acceleration are related. The law

states acceleration equals force divided by mass. When something accelerates it gains speed. When someone is driving and putting their foot on the gas pedal to gain speed, they are accelerating. If two people are pushing two tables, one a very heavy table and the other a very light table, the person pushing the light table will move it across the room faster than the one with the heavier table. That is because the lighter table has less mass. Students in fifth grade do not need to work with the formula, but they need to understand the concept of the relationship between force, mass, and acceleration.

Other Forces

Some surfaces, like ice, are so slick it is easy to slip and fall. Others are so rough that it is difficult to slide things across them. All surfaces have irregularities that make up textures on the surface. Some textures you can see and others cannot be seen. Friction is caused by the irregularities getting caught on one another as two surfaces rub against each other.

Friction acts as force acting in the opposite direction of an object's motion. Friction slows things down and can cause them to come to a stop. Friction helps us to move around as well. Without friction it would be difficult to move around on some surfaces. Friction can change its force based on the surfaces of the objects sliding together and how hard the surfaces are being pushed together. Besides slowing things down, friction also creates heat. If you rub your hands together they get warm because of friction.

When you hold something up and let go, it falls because of gravity. Gravity is the force that pulls things towards Earth. The force of gravity acts between all objects. Gravity is an unbalanced force on a falling object, so when objects are dropping in a free fall, (with no other forces acting on the object), they will accelerate at a rate of 9.8 meters per second per second. So, in theory all objects would fall at the same rate. On Earth however, when something is dropped another force, air resistance is a force that acts upon the object as well. Air resistance is an opposite force acting on the falling object. Air resistance causes an object to fall slower. Air resistance is not the same on all objects because they have different surface areas. Objects with larger surface areas have more air resistance but that doesn't necessarily mean they fall slower, the object's weight also plays a factor. Weight is a measure of the force of gravity on an object. When a falling object's air resistance equals the force of gravity upon that object, the object will still fall, but will stop accelerating. This is called terminal velocity.

Momentum:

Some objects are easier to stop than other. Baseball catchers often catch a baseball that can be moving at very fast speed, or velocity, such as 80 or 90 miles per hour. Can they stop cars moving at the same speed? It is probably not something they want to try. The ball and the car have different masses. Even though moving at the same speed, it is not the same amount of momentum. The reason that these objects do not have the same momentum is because of their masses. The car has a much larger mass than the ball and has more momentum, making it more difficult to stop. Momentum is found by looking at the mass and velocity on a given object. Objects that have a small mass can also have a lot of momentum. Think of a bullet being fired from a gun. Because of its velocity being fired from that gun, it has a very large amount of momentum.

Resources:

http://edhelper.com/Forces_and_Motion.htm
http://library.thinkquest.org/CR0215468/momentum.

htm

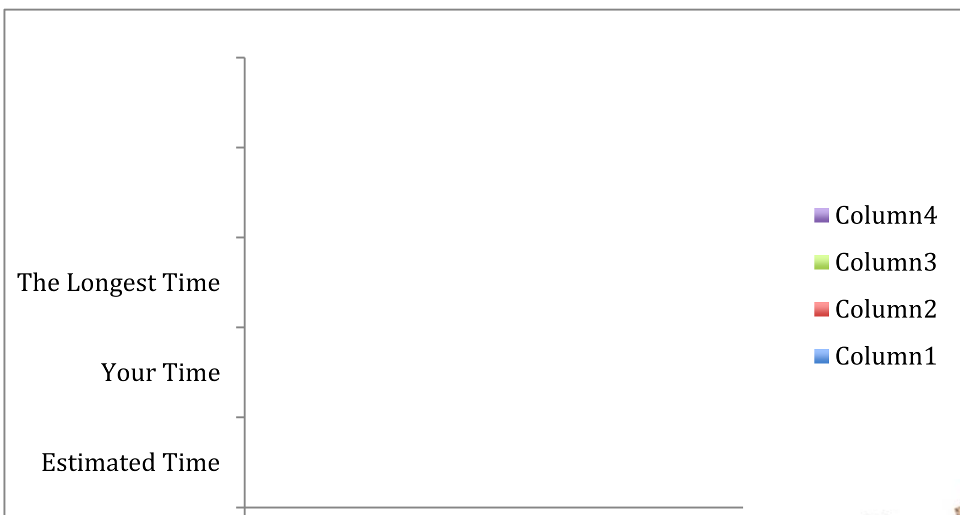
Deliverables: Students will develop a design by following the design loop. The students must first fill out the provided worksheet, where they brainstorm different ideas for the design. Students are only allowed to use the resources that are provided in the materials list. The Keva maze structural device is built in 75-minute class and it will allow the Keva ball to be set in motion and remain in motion for the greatest amount of time before it finally stops. Students record the motion time using a stopwatch.

Parameters: The Keva ball sets in motion for the greatest amount of time before it finally stops.

Keva Craze Evaluation

Directions: Fill in the answers to the questions below. Use the information you learned by building your keva maze!

1. Prior to building your maze, write down your estimation for how high you think your maze will be, how many blocks you will use, and how long your ball will stay in motion.
2. Why did the maze stay up without glue? Do you think it would make a difference if the planks were glued?
3. Would the ball move faster if it were heavier or lighter? Do you think change in direction of the track has an effect on the time?
4. Chart your estimated time, your maze's time, and the longest time of the class



Student Worksheet

Challenge:

With a team (3-4 people) and using the Keva materials given, construct a structural device that allows a Keva ball to be set in motion and remain in motion for the greatest amount of time (changes in direction are allowed) and then finally stop after dropping into a ball holding area. Each team has 75 minutes to finish the device/design. Fill out the worksheet before you begin your design.

Scenario: Using the Keva materials given, construct a structural device that allows a Keva ball to be set in motion and remain in motion for the greatest amount of time (changes in direction are allowed) and then finally stop after dropping into a ball holding area.

Materials:
1. Keva planks
2. Keva ball

Vocabulary:
Gravity- the force of attraction by which terrestrial bodies tend to fall toward the center of earth
Distance- the extent or amount of space between two things, points, lines, etc.
Elevation-the height to which something is elevated or to which it rises
Force- strength or power exerted upon an object
Density- the state or quality of being dense; closely set or crowded condition

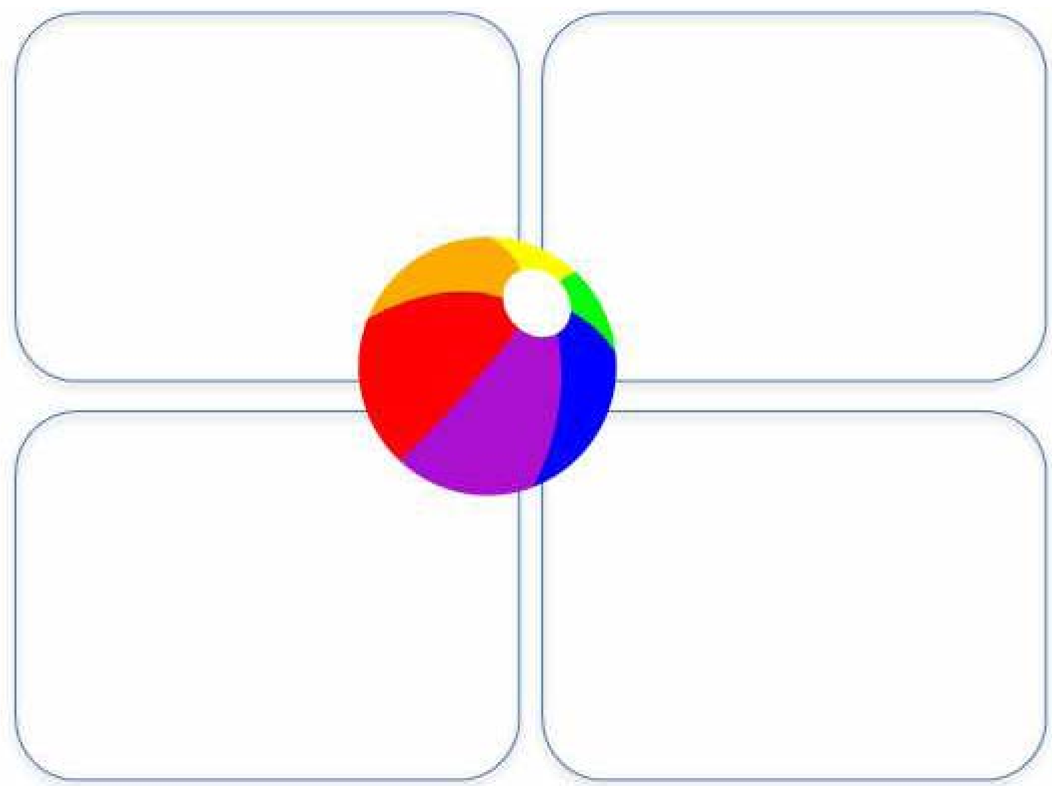
Instructions:
1. Test your ball to your Keva maze design and redesign if needed.
2. Three times attempt (ball runs) and record the times.
3. No human interaction will be allowed once the Keva ball is in motion during testing.
4. Teams will be allowed to troubleshoot the maze between tests.

Name:
Group Members:

KEVA Maze Design Loop

1. **What is the problem**? State the problem in *your own words*.

2. **Brainstorm Solutions**. Draw and describe some possible solutions.



3. **Create the solution you think is best**. *Keep notes below about the problems you have and how you solve them*.

4. **Test your solution**.

- Did you use only the material provided?
- Did you build your Keva maze design in 75 minutes?
- Did you record the times?

5. **Evaluate your solution**.
What is the best solution? Would one of your ideas have been better? Why and why not?

What would you have done differently?

Ready, Set, STOP!

Disciplinary Area: STEM

Unit: Kinetic Energy, Mass, and Speed

Grade Level: 5th

STEM Content Standards:

Next Generation Science Standards

MS.PS3.1—Construct and interpret displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

MS.PS2.4—Construct and present arguments using evidence to support the claim that gravitational interactions depend on the masses of interacting objects.

Technology and Engineering

STL Standards and Benchmarks

Standard 2: Students will develop an understanding of the core concepts of technology

L. Requirements are the limits to designing or making a product or system.

Standard 8: Students will develop an understanding of the attributes of design.

C. The design process is a purposeful method of planning practical solutions to problems.

Mathematics Common Core State Standards:

CCSS.Math.Content.5.MD.A.1: Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

Big Ideas:

- Students will follow steps to construct a racecar from TeacherGeek® materials.
- Students will observe how different masses affect the speed of an object.
- Students will observe how different masses affect the braking time and distance of an object.

Essential Question: How can you design a racecar that will go the furthest distance and redesign it to be able to stop at a certain distance?

Scenario: You are an engineer for NASCAR and have been asked by your boss to construct a non-motorized racecar that can stop at the finish line, but can also outrun all the other racecars. Can you do it??

Vocabulary:

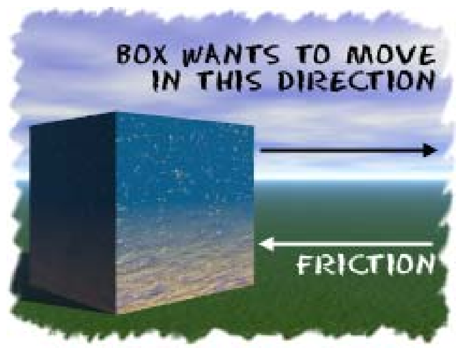
Mass—refers to how much an object weighs
Elastic Potential Energy: Energy stored within an elastic object, such as a rubber band.
Friction: A force that resists motion between two bodies in contact.
Kinetic Energy: The energy that can be seen; the energy of an object in motion.
Potential Energy: Stored energy; derived from condition or position rather than motion.
Speed: The rate of motion. Distance travelled divided by time of travel.
Spring Constant: The stiffness or ability to stretch.
Velocity: The speed of an object moving in a specific direction.
Work: Total applied force multiplied by the total distance travelled

Materials/Resources:

2 Dowels	4 Wheel Hubs
2 Hole Plates	1 -2 Stop Clip
10 #16 Rubber Bands	2 Stretch Tires
16 inches of string	2 Connector Strips
Cutter	Hammer
Wax, Soap, or Crayon	Reamer
Graphing paper	Safety Glasses

Content:

Friction is a force that holds back the movement of a sliding object. That's it. Friction is just that simple.
You will find friction everywhere that objects come into contact with each other. The force acts in the opposite direction to the way an object wants to slide. If a car needs to stop at a stop sign, it slows because of the friction between the brakes and the wheels. If you run down the sidewalk and stop quickly, you can stop because of the friction between your shoes and the cement.



FRICTION IS A FORCE THAT ACTS IN AN OPPOSITE DIRECTION TO MOVEMENT.

What the Teacher Needs to Know:
Several Testing Apparatuses should be set up around the room: this involves creating a ramp; ramps should all be same height and length for accurate testing- for example: using classroom desks or tables and some type of flat surface that can form a ramp. This should be a relatively easy task. A scale or scales to weigh the racecar is/are required for the calculations.

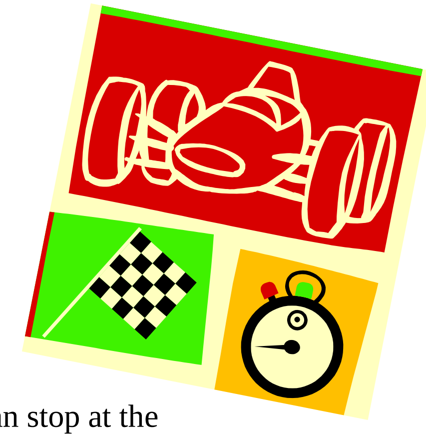
Name:

Teacher Assessment/ Evaluation

Car Model	__/20
Creativity	__/10
Model Test	__/10
Calculations	__/20
Applied Math	__/10
Participation	__/10
Worksheet	__/20
Total	___/100

Comments:

Student Handout



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Materials/Resources:

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10 #16 Rubber Bands	2 Stretch Tires
16 inches of string	2 Connector Strips
Cutter	Hammer
Wax, Soap, or Crayon	Reamer
Graphing paper	Safety Glasses

Rubber Band Racer Distance Challenge

Directions:

1. Make a basic rubber band racer using the "How To" worksheet.
2. Set up racer at the starting line of the racetrack. Pull racer back to send down the track.
3. On the Data Chart (below) record the distance and time of the racer.
4. Add 2 large rubber bands to the front wheels of your racer to create friction like tires.
5. Repeat steps 2 and 3.
6. Remove the "friction" rubber bands and add the series to your racer. (Use "How To" worksheet)
7. Repeat steps 2 and 3.
8. Remove the series and add a lever to the racer. (Use "How To" worksheet)
9. Repeat steps 2 and 3.
10. Leave the lever attached. Place a rubber band around the front two wheels to create friction and replace the rubber band series.
11. Repeat steps 2 and 3.
12. Remove the lever, rubber band series, and rubber band around the wheels. This is your chance to add what you want to make your racer go as far as you possibly can.
13. Repeat steps 2 and 3.
14. On the data sheet, finish the other calculations to determine the velocity, acceleration, mass, and elastic potential energy.
15. Use graph paper to graph the data you have collected in your Data Chart.

Rubber Band Racer Data Chart

Rubber Band Racer	**Basic**	**With friction**	**With series**	**With lever**	**With all three**	**Design of your choice**
Distance:						
Time:						
Velocity:						
Acceleration:						
Mass:						
Elastic Potential:						

Ready, Set, STOP!

Worksheet

1. Build a rubber band race car from the steps given. Do not add extra weight to your car yet. Ask the teacher if help is needed.

2. Weigh your car on a classroom scale. What is the **mass** in **grams**?

3. Test your race car with a ramp three times. Do not push the car. Simply place it on the ramp and allow it to move on its own. Be ready with a stopwatch to time your car.

   What is the car's **distance** in **centimeters** the first time?
   What is the car's distance in centimeters the second time?
   What is the car's distance in centimeters the third time?
   How many **seconds** was your car in motion the first time?
   How many seconds was your car in motion the second time?
   How many seconds was your car in motion the third time?

4. Calculate the **speed** of your car for each trial run by **dividing distance by time**.

   What is the speed in **cm/sec** for the first trial?
   What is the speed in cm/sec for the second trial?
   What is the speed in cm/sec for the second trial?

5. Now add weight to your car. Weight your car on a classroom scale. What is the **mass** in **grams**? How many grams did the mass increase by?

6. Do you think it will take shorter or longer for the car to stop with the added mass? Why?

7. Test your race car with a ramp three times. Do not push the car. Simply place it on the ramp and allow it to move on its own. Be ready with a stopwatch to time your car.

   What is the car's **distance** in **centimeters** the first time?
   What is the car's distance in centimeters the second time?
   What is the car's distance in centimeters the third time?
   How many **seconds** was your car in motion the first time?
   How many seconds was your car in motion the second time?
   How many seconds was your car in motion the third time?

8. Calculate the **speed** of your car for each trial run by **dividing distance by time**.

   What is the speed in **cm/sec** for the first trial?
   What is the speed in cm/sec for the second trial?
   What is the speed in cm/sec for the second trial?

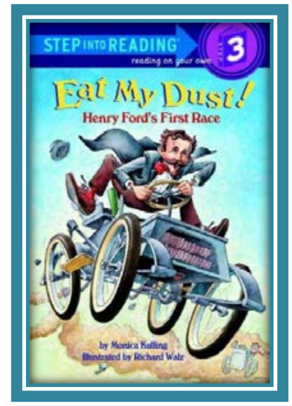
9. Did your hypothesis math your results? How or how not?

10. Create a table with all your information in one place. Think of how you would explain what you just learned to a friend or family member.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Distance (cm)						
Time (sec)						
Speed (cm/sec)						

Classroom STEM Lessons using Teacher Geek Products

Race for the Future



Disciplinary Area: STEM
Grade Level: 3
Unit: Newton's Laws of Motion
Literacy: *Eat My Dust! Henry Ford's First Race* by Monica Kulling

Standards:

- National Science Education Standards (Physical Science): Position and motion of objects.
- Standards for Technological Literacy (Understanding of Technology and Society): The influence of technology on history.
- Common Core Math Standards (Measurement and Data): Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters.
- Common Core ELA Standards (Presentation of Knowledge and Ideas): Report on a story, or recount an experience with appropriate facts and relevant descriptive details, speaking clearly at an understandable pace.
- National Standards in Economics: Standard 14: Entrepreneurship- Entrepreneurs are individuals who are willing to take risks, to develop new products, and start new businesses. They recognize opportunities, like working for themselves, and accept challenges.

Big Ideas:

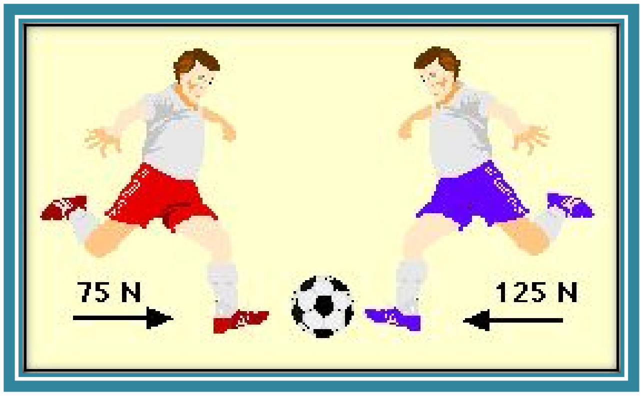
- Follow detailed instructions using Engineering Design Loop processes
- Demonstrate an understanding of Newton's first two Laws of Motion
- Document results with proper measurements

Essential Question:
After building a racecar following detailed instructions, can you apply your knowledge of Newton's Laws of Motion to modify it to go faster and farther?

Scenario:
Henry Ford wants to build a car that is affordable for everyone, but he needs money to start his factory. He sees that a race is being held with a prize of $8,000, and he just knows he can win. Unfortunately, his car is just a regular car- not a racecar! Using the design loop and what you have learned about Newton's Laws of Motion, can you modify his original car design so that he can beat The Daredevil?

Vocabulary:
Acceleration- the rate at which an object changes its velocity
Balanced- equal
Constant- occurring continuously over a period of time
Entrepreneur- a person who starts a business and is willing to risk loss in order to make money
Force- a push or a pull

Friction- the resistance that one surface encounters when moving over another
Inertia- a tendency to remain unchanged
Mass- the quantity of matter that a body or objet contains
Net Force- the overall force acting on an object. In the diagram of the soccer players, the player in red is kicking with a force of 75 N, while the blue player is kicking with a force of 125 N. 125 - 75=50, so there is a net force of 50 N moving the ball from right to left.
Newton (N)- the standard metric unit for measuring force
Pull- a force drawing something in a particular direction
Rest- not moving
Speed- the rate at which something is able to move
Velocity- the speed of something in a given direction



Tools:

Reamer	**Wood Cutter**
Wax, Soap or Crayon	Mallet or Hammer
Pliers	Screwdriver
Scissors	Rulers
Measuring Tape	Board to roll cars down
Stop Watch	

Materials/Resources (Teacher Provided):

String	**Rubber Bands**
Dowel Rods	Screws and Bolts (optional- #10)

Materials/Resources (TeacherGeek, per group) (1st number for basic racer, 2nd optional for advanced):

Connector Strip- 4,6	**Hole Plate- 2**
Wheel Hub- 4	Stop Clip- 2,4
50 Tooth Gear- 0,1	40 Tooth Gear- 0,1
20 Tooth Gear- 0,1	10 Tooth Gear- 0.1

Content: Introduce the unit by showing the following YouTube videos, which explain the first two laws of motion, to your students:

- http://www.youtube.com/watch?v=pxWHWOYVov4#t=111
- http://www.youtube.com/watch?v=iwP4heWDhvw#t=24

This site has many resources on Newton's Laws of Motion that may be helpful to you as a teacher:

- http://www.neok12.com/Laws-of-Motion.htm

TIP: There is a Magic School Bus episode titled The Magic School Bus Plays Ball that would be perfect to show a day or so before this project, if time allows! It is available to watch on Vimeo.

In the late 17th century, Sir Isaac Newton published his ideas on motion and forces, which became known as Newton's Laws of Motion.

1st Law: If no forces (or a combination of forces that is balanced) act on an object then it is at rest, and it will remain at rest. If an object is manipulated with force, it is in motion; it will continue to move in a straight line path at a constant speed.

What does this mean? **Objects in motion stay in motion**. This is the law of inertia.

2nd Law: If a single force (or a combination of forces that is unbalanced) acts on an object, its speed and/or its direction will change. How quickly the speed (and/or direction) changes is directly related to the strength of the net force and inversely related to the object's mass.

Simplified, this means that a force pushing or pulling on an object will change its direction and/or its speed. When you kick a soccer ball, your kick is the force which will increase the soccer ball's speed. If the ball was rolling towards you before you kick it, it will most likely change direction once you do. The harder you kick the more drastic and noticeable the change will be. A quick demonstration with a ball and a couple of students would be a great way to introduce this concept! What does it mean when Newton says that changes are inversely related to an object's mass? The answer is easy! The heavier something is, the harder it is to get it moving, keep it moving, and the slower it will go.

Before we get started building, let's take a moment to talk about friction. Friction is what happens when two things rub together. You might have your students rub their hands together for a minute and feel the heat produced. This is a side effect of friction! Think about the molecules on the surfaces of two materials (even ones we think are smooth) like sandpaper, and then imagine rubbing them together. Just as the individual grains of sand rub against one another, so do the molecules in our smooth surfaces. While we could go in to a lot of detail about friction, it is really just important that you get one thing across to your students at this point. That is that this opposing force, friction, is always at work here on earth, and it slows things down!

So, how do we use this information to build a better racecar? Here are the key points:

- Objects in motion will stay in motion.
- Force acting on an object will change its speed or direction, or both.
- The heavier something is, the slower it will go. Alternately, the lighter something is, the faster it will go.

- Friction is bad. It will slow you down. While we cannot entirely escape it here on Earth, we do want to mitigate its effects as much as we can.

Teacher Instructions:

- After introducing the concepts to your students, have them build their basic racers. They will most likely be working in groups for this, so now is the time to assign them to their respective teams!
- After each group has built their basic racer following the instruction sheet, they will need to test the speed on the "test track" you have set up. For our experiment, we used a 6' long board angled on a 27" stool, lined the back wheels up with the back (top) of the board, and let the racer go. Students will need to time exactly how long it takes the racer to roll down the board and come to a stop, as well as measure the distance travelled. They will then record this information on their handouts.
- After each group has conducted their initial experiment, read the book *Eat My Dust! Henry Ford's First Race* by Monica Kulling to your students. This is based a true story and details how Henry Ford obtained the money to start building cars that everyone could afford to own!
- After reading, introduce the design problem to your students. They will then return to their groups to work through the design loop in the student packet to come up with a way to modify their cars and win the race you will be having later!
    - TIP: To be sure your students are using the design loop; have them draw out three ideas before allowing them to collect more materials for their cars!
- Once everyone has completed their new, improved racer, the students will need to return to the "race track" to complete their worksheets with the data found by averaging their three tries.
- After everyone has filled out their worksheets, hold a race and time each car to see whose car will travel the farthest distance in the shortest amount of time.
    - Optional: Have a prize for the team that wins first place!
    - Optional: As a class, figure out how fast the winning car was going.
        - $\text{average speed} = \dfrac{\text{total distance traveled}}{\text{travel time}}$

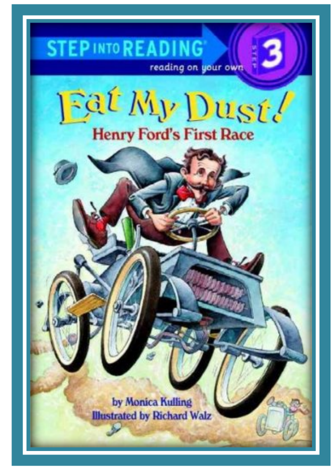
Racing For The Future - Evaluation and Assessment

Objective	***Points Possible***	***Points Given***
Demonstrates knowledge of Laws of Motion: *Student is able to describe how the first two laws of motion apply in making their car go faster and farther.*	25	
Followed procedural directions to complete challenge: *Student is able to follow multi-step instructions to create a basic racecar.*	25	
Effective use of tools: *Student is able to use tools recommended in procedural instructions to complete the given task.*	25	
Completion of provided handouts and Measurements: *Student completed all questions and demonstrated knowledge by using correct measurements and line plots.*	25	
		Total Points / 100

Word Search Key:

T	D	J	I	N	E	R	T	I	A	F	Z	E	F	A
N	C	E	D	N	L	L	U	P	M	Y	N	E	O	C
A	S	G	C	I	V	C	B	W	X	T	D	Y	R	C
T	Q	S	A	N	S	E	T	X	R	N	T	X	C	E
S	W	U	A	P	A	R	R	E	J	I	S	C	E	L
N	I	O	E	M	T	L	P	S	C	C	E	A	N	E
O	W	E	B	R	I	R	A	O	E	F	R	X	R	R
C	D	Z	O	X	E	O	L	B	W	T	H	Z	Y	A
N	E	Y	M	N	A	E	V	A	S	D	Z	B	D	T
K	U	D	E	R	V	W	O	P	G	M	A	O	R	I
O	U	U	N	O	I	T	C	I	R	F	K	U	N	O
D	R	U	Q	A	T	V	E	B	E	G	Z	P	C	N
I	L	G	D	P	B	K	R	Z	A	L	G	I	X	F

ACCELERATION, BALANCED, CONSTANT, ENTREPRENEUR, FORCE, FRICTION, INERTIA, INVERSE, MASS, PULL, REST, SPEED, VELOCITY



Racing For The Future
An Introduction to Newton's Laws of Motion
Student Handout

Situation: Henry Ford wants to build a car that is affordable for everyone, but he needs money to start his factory. He sees that a race is being held with a prize of $8,000, and he just knows he can win. Unfortunately, his car is just a regular car- not a racecar!

Challenge: Using the Engineering design process and what you have learned about Newton's Laws of Motion, can you modify his original car design so that he can beat The Daredevil and win the prize?

Instructions:

- Build a basic rubber band racer following the instructions included with this handout.
- After your car is built, test it on the "test track" your instructor has set up. Start with the back wheels lined up with the back (top) of the board, and let the racer go. Using a stopwatch, time exactly how long it takes the racer to roll down the board and come to a stop. Then measure the distance your car travelled. Record this information on the line plots on your student worksheet. You will need to conduct this experiment three times, recording the data each time.
- STOP! After you have completed your line plots, wait for your instructor to share a book with the class.
- Now that you have heard the story, are you ready to help Henry win the race? Use the design loop to decide to how to make your car fast enough to win the race! After you have drawn three designs on your design loop worksheet, you may collect materials from your teacher to implement your best idea!
- You may use ideas for your modifications given in the handout, but be creative! After you modify your racecar, test it on the test track again. Start with the back wheels lined up with the back (top) of the board, and let the racer go. Using a stopwatch, time exactly how long it takes the racer to roll down the board and come to a stop. Then measure the distance your car travelled. Record this information on the line plots on your student worksheet. You will need to conduct this experiment three times, recording the data each time.
- Complete the student handouts.
- Compare your results with the rest of the class. Was yours the fastest car?

Tools:

Reamer	Wood Cutter
Wax, Soap or Crayon	Mallet or Hammer
Pliers	Screwdriver
Scissors	Rulers
Measuring Tape	Stop Watch

Materials/Resources (TeacherGeek, per student or group)(1st number for basic racer, 2nd for advanced):

Connector Strip- 4,6	**Hole Plate- 2**
Wheel Hub- 4	Stop Clip- 2,4
50 Tooth Gear- 0,1	40 Tooth Gear- 0,1
20 Tooth Gear- 0,1	10 Tooth Gear- 0.1
String	Rubber Bands
Dowel Rods	Screws and Bolts

Racing For The Future
An Introduction to Newton's Laws of Motion
Student Worksheet

1. Draw a line plot to show how long it took your basic racer to complete the test track.
2. Draw a line plot to show the distance your basic racer traveled on the test track.
3. Draw a line plot to show how long it took your advanced racer to complete the test track.
4. Draw a line plot to show the distance your advanced racer traveled on the test track.
5. After you modified your car, did it perform as you expected? If not, why do you think this was?
6. In your own words, explain the 1st and 2nd Laws of Motion.

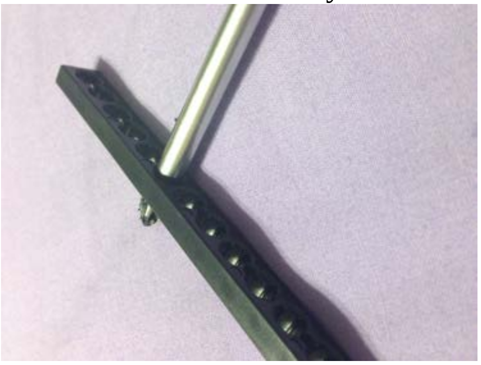
Fun With Physics Word Search

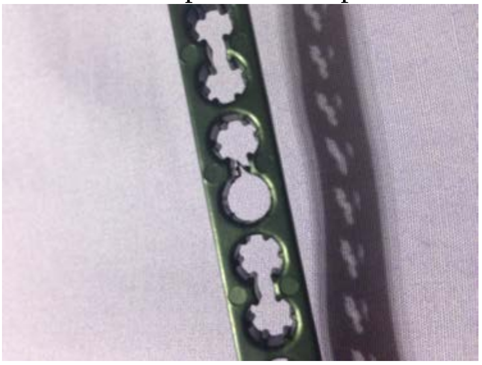
T	D	J	I	N	E	R	T	I	A	F	Z	E	F	A
N	C	E	D	N	L	L	U	P	M	Y	N	E	O	C
A	S	G	C	I	V	C	B	W	X	T	D	Y	R	C
T	Q	S	A	N	S	E	T	X	R	N	T	X	C	E
S	W	U	A	P	A	R	R	E	J	I	S	C	E	L
N	I	O	E	M	T	L	P	S	C	C	E	A	N	E
O	W	E	B	R	I	R	A	O	E	F	R	X	R	R
C	D	Z	O	X	E	O	L	B	W	T	H	Z	Y	A
N	E	Y	M	N	A	E	V	A	S	D	Z	B	D	T
K	U	D	E	R	V	W	O	P	G	M	A	O	R	I
O	U	U	N	O	I	T	C	I	R	F	K	U	N	O
D	R	U	Q	A	T	V	E	B	E	G	Z	P	C	N
I	L	G	D	P	B	K	R	Z	A	L	G	I	X	F

ACCELERATION, *BALANCED*, *CONSTANT*, *ENTREPRENEUR*, *FORCE*, *FRICTION*, *INERTIA*, *INVERSE*, *MASS*, *PULL*, *REST*, *SPEED*, *VELOCITY*

Racing For The Future
An Introduction to Newton's Laws of Motion
Basic Racer Instructions

Holes and Reaming: Use a Reamer or a screwdriver to create holes that will allow the dowel rods to move freely. The holes that have not been reamed will securely hold onto the dowel rods! Be careful not to ream too many holes! Most holes are needed to keep dowels in place!



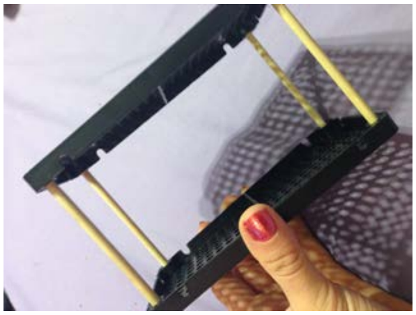


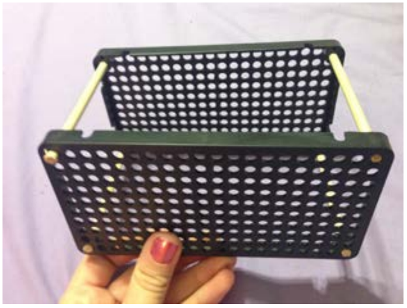
Push dowels into place by wiggling and pressing them with your hands or tapping them with a hammer.
Here's a tip! You can use soap, crayon or wax on a dowel to allow it to slide in and out of holes easier!

<u>Let's Start Building!</u>

Build the frame:

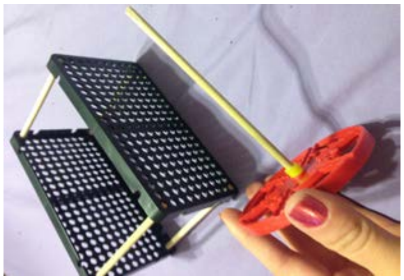
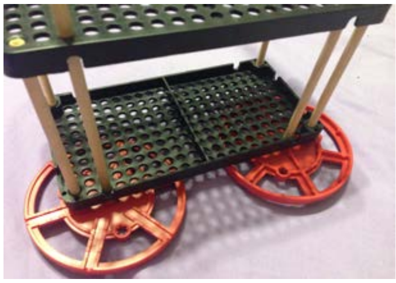
Step 1: Cut four 4 inch dowels and insert them into the four corners. Don't ream these holes! They need to be secure.





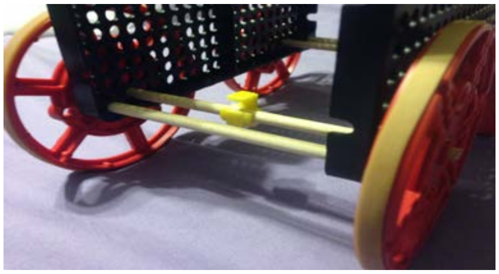
Wheels:

Step 1: Cut two 5 inch dowels.
Step 2: Press the wheels onto dowels. These will become axles! Do not ream holes.
Step 3: Insert the wheels through the frame where you think they will work the best.
Tip! The wheels should not be tight against the frame.
You can provide traction to the wheels by stretching a rubber band around them. Secure with glue if needed!

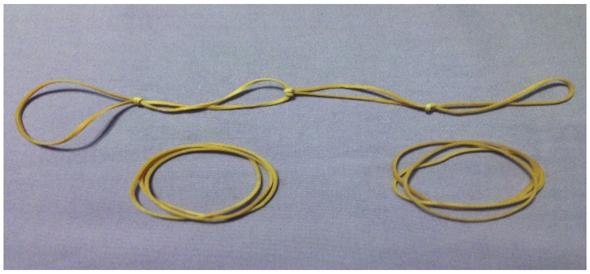




Clip and Bands:

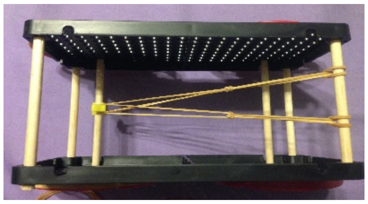
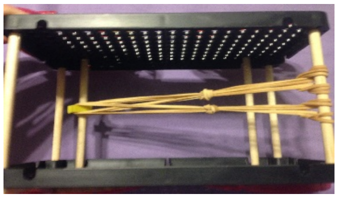
Step 1: Attach the stop clip on the front wheel axle. The hook should be facing forwards so the rubber band will slip over it. You may need to use a drop of glue to hold it in place!



Step 2: Rubber bands may be linked in a series. They store and release less force over a greater distance or be linked in a parallel form these release greater force over a less distance! Find out which option will make your racer go faster and/or farther!



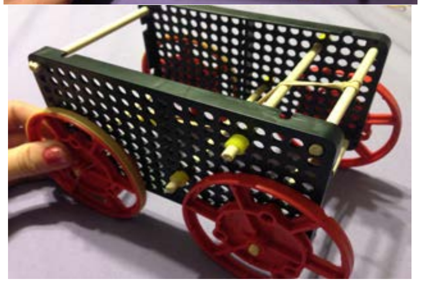
Step 3: Attach two sets of rubber band links, (either linked in a series or parallel) to the back top dowel rod and around the stop clip.
Hold in place and wind backwards. The rubber bands will wrap around the axle. Let it Go!!

Mechanical Advantages:
Here are some examples of how you can modify your racer!
Routing: Pulleys can be used to change the direction of a rubber band, or string, and the force it applies. Dowels allowed to spin in lose fit holes (reamed holes), can be used as pulleys!

Add extra dowels to have the rubber band stretch over to change the force!

Use these slide stops to keep the dowels from slipping out of the holes!

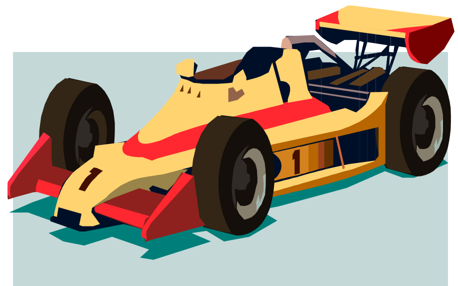


Gears:

A gear is a wheel with evenly spaced teeth around its perimeter. The teeth on multiple gears can mesh to form a gear train. Gear trains can transmit force, create a mechanical advantage and change the direction of force!

Step 1: Connect gears by dowel rods. Do not ream holes.
This gear train uses multiple gears to create a mechanical advantage greater than a 2 gear train. It is called a compound gear train.

Reaching the Target



Disciplinary Area: STEM
Unit: Physics, Motion, Friction, and Measuring
Grade Level: First or Second

Standards:

- *Standards for Mathematical Practice*: CCSS.Math.Content.2.MD.A.1 Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.
- *Standards for Mathematical Practice:* CCSS.Math.Content.2.MD.A.4 Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit.
- *National Science Education Content Standards (*Physical Science Standards): Properties of objects and materials; Position and motion of objects

Big Ideas:

- The utilization of measurement tools such as rulers and tape measures to determine distances
- Determining what factors of a track provide more or less friction on an object moving on the surface
- Determining what factors of a rubber band powered car make it move faster or slower

Essential Questions:

- How far, in a concrete way, does this measurement require my car to travel?
- What can factors can I alter in my car to change its speed?
- What factors can I alter on my track to change my car's speed?

Scenario:
After learning about the physical science concepts of velocity, speed, and energy, have students construct the rubber band powered car, following the directions provided below. After all of your students have successfully constructed the car, place a target on the floor of your classroom. Your students will work towards getting their car to land on the target. Each student will draw from a bowl of papers, each paper having a different measurement written on it (ex: 1 ft., 13 cm, ½ of a meter, etc.). The goal is that the students will have to start their car however far away from the target that the measurement they chose portrays. In order to do this, they will need to determine how to make their car travel a longer distance, or a shorter distance, depending on how far away they are from the target. In order to do this, they will get the opportunity to use a variety of materials to alter their car or the track that the car is traveling on in order to make their car travel the desired distance, and land on the target. The goal is for each car to land on the target, or as close to the target as possible.

Materials/Resources:

- Rulers
- Tape Measures
- Meter Sticks
- Washers (or small weights)
- Felt
- Foil
- Ramps of various inclines
- Tape or some material to create the target
- Teacher Geek materials to build the car (preferably enough for one car per student)
- Extra rubber bands, of varying sizes

Content Information:

In this lesson, you will first be able to use simple materials, such as wheels and small rods, and rubber bands to build and power a car. After following the directions given here and the materials to build the car, you will use it to complete challenges regarding distance, velocity, and friction. You will also use different measuring tools to determine how far your rubber band car must travel.

Distance	The extent of space between to objects or places. This can be measured in feet, inches, meters, centimeters, miles, kilometers, and many other measurements.
Velocity	The rate of speed of action or occurrence Equation: Velocity=Distance/Time
Friction	A resistance encountered when one body moves relative to another body with which it is in contact
Motion	The process of continual change in the physical position of an object
Acceleration	The rate of change of velocity or speed with respect to time

Feel free to do research on what you can do to your car or the track to increase or decrease the distance that your car will travel. Some ideas would be increasing or decreasing the weight of the car, creating a rubber band motor that is longer or shorter, or thicker or thinner, or increasing or decreasing the friction between the wheels and the track.

Here are some websites that might be helpful while researching:

- http://teachergeek.org/rubber_band_racer.pdf
- http://pbskids.org/designsquad/build/rubber-band-car/
- http://www.physics4kids.com

Deliverables/Student Instructions:

Using the instructions provided below, you will build the rubber band powered car. Then, you will pick, at random, a measurement. This measurement will be how far your rubber band car must travel in order to reach the target on the ground. You will need to determine which measuring tool will best find that measurement, and then use it to see how far away your car will start from the target. The goal is for your car to start however far away from the target your measurement says and for it to land on the target. You can alter your car, or the track that your car is on, in order to make your car travel a longer or a shorter distance. You are also able to wind your car as many or as few times as you would like, in order to change the distance the car travels.

Building the Rubber Band Car

Materials Needed:

- 10 rubber bands
- 4 Connector Strips
- 4 Basic Dowels
- 2 Hole Plates
- 4 Wheel Hubs
- 4 Machine Screws
- 4Nuts
- 2 Stop Clips

How to Build the Car:

1) Cut dowel rods into 4 pieces, each 4 inches long
2) Insert these dowels into the hole plates, connecting the plates at each of the 4 corners
3) Cut dowel rods into 2 pieces, each 5 inches long (These become the axels for the wheels)
4) Insert the axels, one in two wheel hubs
5) Place the wheel and axel through the hole that you constructed in step 2. Place one wheel axel on opposite sides of the frame, wherever you think they will function best.
6) Press the two wheel hubs left over onto the axels, one on each axel. Wheels should be tight against the frame, and there should be one wheel on each corner of the frame, so it begins to look like a car. Practice rolling the car, and make sure the wheels turn
7) Attach a rubber band onto one of the connecting dowel rods between the two hole plates
8) On the opposite side, attach the stop clip on the wheel axel. (Snap the clip by pushing downward, and ensure that the "hook" side is facing away from the racer when up
9) Hook the rubber band around the stop clip.
10) In order to wind the car up, pull the racer backward with the wheels on the ground, and then let go! You have officially built a rubber band racer. ☺

Parameters:
You must only use the materials provided to alter your car or the track. You may utilize as many or as few of these resources as you like. In order to get your car to reach the target, you must use the design loop worksheet provided to alter your car and determine what the best solution for your problem is.

Assessment:
Teacher will assess how successful the students were in reaching their target. Then, have a discussion with each student about why they altered their car or the track in the way that they did, and what concepts they used about physics in order to make these changes. The teacher will also collect the design loop worksheet attached to ensure that each student followed the design loop.

Design Loop Worksheet

1. What is the problem? Include how far your car must start from the target.
2. What did you learn from your research that could help you solve this problem?
3. What are some possible solutions?
4. Which solution worked the best to solve your problem?
5. Test this solution, and evaluate whether or not it worked (did your car land on the target?)
6. What, if any, changes need to be made?
7. Draw your final solution to the problem in the space provided below.