STEM LESSON: GIZMOS - Growing Plants

***Best For**: 3rd Grade, 4th Grade, 5th Grade Science*

STEM Challenge:

You have decided to enter the county fair contest for the largest plant, measured in mass. You have a budget of $10.00, only enough to submit one trial. Using the price list below, engineer a plant with the greatest mass while staying within the $10.00 budget.

Price List:
- Bean seed $7.00
- Tomato seed $3.00
- Turnip seed $2.00
- 50ml of water is free; $0.50 per 10ml after that
- Light bulbs $2.00 each
- Fertilizer $0.50
- Compost $0.50

Curriculum Addressed

Science: Factors that Affect Plant Growth

Technology: ExploreLearning Gizmo Simulations and devices

Engineering: Engineering a plant with the greatest mass while staying within a budget

Mathematics: Arithmetic of cost and budget

Background Information

Plants in the Gizmo require light and water to gain mass. Without adequate light and water, plants will not be able to gain mass. Fertilizers can greatly accelerate plant growth because they provide large amounts of nutrients to the plant. Compost has a less dramatic effect, but also promotes plant growth by providing smaller amounts of nutrients and improving the structure of the soil.

Possible Solution

Generally, the plant that will end up with the greatest mass while staying within budget is a tomato plant with an approximate mass of 3.9 g. The bean seeds are expensive and therefore prohibit the use of sufficient light. The turnip seeds simply do not grow into plants with greater mass than tomato plants. Best combination for plant with greatest mass is:

Item (s)	Cost

Tomato seed	$3.00
All three lights	$6.00
60mL of water	$0.50
Fertilizer	$0.50
Total cost	**$10.00**

Student Activity

Name____

The Guiding Question…	
The Claim You Will Make	
What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
How Will You Analyze Your Data?	
Show Your Data	
Analyze Your Data, What Was The Solution To The Challenge?	

STEM LESSON: GIZMOS - Force and Fan Carts

Best For: 5th Grade Science

STEM Challenge: Congratulations, you have been hired by Gizmo Inc. to design our newest eco-friendly delivery cart. You must design a cart that can safely deliver packages in 20 sec or less on the 500 cm Gizmo test track. Gizmo Inc. needs to know the maximum mass the new cart can carry on each surface and the length of time for each delivery.

*Remember the cart has its own mass.

Curriculum Addressed
Science: the laws of motion using a simple fan cart.
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images that can be imported into PPTs and/or Word documents, and export button to have numerical data placed into Excel documents.
Engineering: Designing a prototype cart for delivery of goods.
Mathematics: Calculating how force, mass and speed are inter-related and how friction can impact force and speed.

Background Information

Newton's Laws of Motion

Newton, building on the work of Galileo, revolutionized the world of physics by publishing three laws of motion. Prior to Galileo, people thought that force was required to maintain motion. This is one reason to stress that force only accomplishes *change* in motion.

- Newton's First Law states *an outside force is required to change the motion of an object.* This law is often called "the inertia principle." Inertia is the tendency of something not to change without cause. There are several consequences of this law:
    - An object at rest will stay at rest if no force acts on it.
    - A moving object will never slow down if no force acts upon it.
    - The natural motion of any object is a straight line. The only way for an object to change direction is for some force to act on it.
- Newton's Second Law describes how force and mass are related to the speed change. For example, if twice as much force is used, speed will change twice as quickly. Similarly, it takes more force to lift a boulder than a marble.
- Newton's Third Law states *for every action there is an equal and opposite reaction*. This law explains how a fan cart works. The fan pushes air particles backwards, and the air particles push the fan forward.

Friction

Friction is a general term for forces that oppose motion due to contact between surfaces. In general, an object will only roll if there is some friction to "grip" the wheel. This is why the wheels of the Gizmo do not rotate if the **No Friction** surface is used. The cart slides instead.

If an object *slides* on a surface, the roughness of the surfaces is the most important factor in determining the friction. If an object *rolls* across a surface, the hardness of the surface is the most important factor. Rolling a ball on a parking garage floor is easier than rolling it on a wooden table, but the opposite is true if you are sliding the objects.

Speed

Note that the Gizmo displays current (instantaneous) speed of the cart, just like a speedometer in a car does. A common mistake is to confuse *instantaneous* speed with *average* speed. Average speed is calculated by dividing total distance by total elapsed time. This lesson does not use average speed at all, but watch out for this misconception.

Historical Connections

Sir Isaac Newton is given credit for developing three "Laws of Motion" that describe force and its effects. However, Newton's First and Second laws were at least partially formulated by his predecessor, Galileo Galilei.
Galileo noticed that a pendulum always seemed to return to its starting height. Galileo proposed that the pendulum was like a ball rolling back and forth in a frictionless bowl, always reaching to the same height on the rim of the bowl.

What would happen if one side of the bowl were less slanted? Galileo reasoned that the ball would still return to the same height, but would travel farther to do so. If the other side of the bowl were flattened entirely, the ball would never regain its former height but would keep rolling forever! Because of this, Newton's First Law is often referred to as "Galileo's Principle."

Possible Solutions

Students would need to make the assumption that they would be delivering the goods with the fan speed on <u>high</u>.

Students would also need to determine the <u>mass</u> of objects:
Soda- 2kg
Book – 1 kg
Lunch Box- 2kg
Cart- 1kg

	No Friction	Metal	Cement	Wood (no goods can be delivered in less than 20 sec)
Maximum Mass	6 kg	5 kg	3 kg	1 kg
Delivery Time	13.7 sec	17 sec	14.5 sec	
Final Velocity	73.1 cm/sec	58.8 cm/sec	69.8 cm/sec	
Force	32 N	17.3 N	14.4 N	

Students run the Gizmo with different objects on the cart on different surfaces to be delivered to determine which goods result in a delivery time of less than 20 seconds. The mass of those objects and the seconds it takes to go the 500cm is determined through the Gizmo. Those numbers are then inputted into the equations to determine the exact force needed in Newtons.

$F=m*a$
$a= \Delta V/ \Delta t$
$F=m*(\Delta V/ \Delta t)$

No friction surface solution is below:

Time is 13.7sec
Mass is 6 kg
Velocity is 73.1 cm/sec

$F=6 *(73.1/ 13.7)$
$F= 32$ N

The cart will need 32 N in force in order to make the delivery in less than 20 seconds.

Student Activity

Name____

The Guiding Question…	
The Claim You Will Make	
What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
How Will You Analyze Your Data?	
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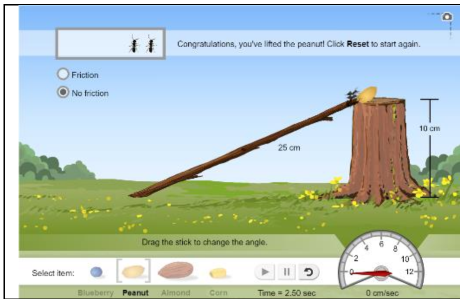
Analyze Your Data, What Was The Solution To The Challenge?	

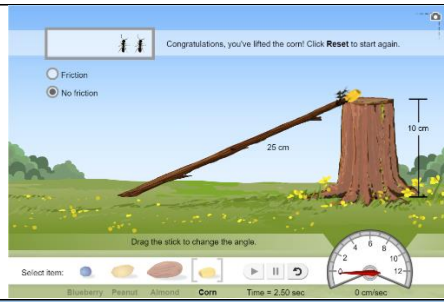
STEM LESSON: GIZMOS - Ants on a Slant (Inclined Plane)

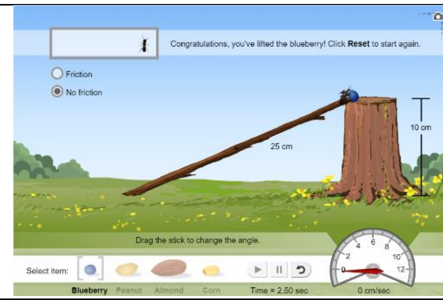
Best For: 3rd Grade, 4th Grade, 5th Grade Science

STEM Challenge: A storm is coming! You and the Atom Ants family need to design a plan to keep their food dry. Design an inclined plane and a suitable team of ants to push a food item up the friction free incline in exactly 2.50 seconds. What food can they save? How many ants need to help? How long should the stick be? Help save the food, take screen shots of all your work.
Curriculum Addressed
Science: *Understand that an inclined plane supports an object by pushing up on it.* *Discover that inclined planes help make lifting an object easier by combining their supportive force with the lifting force applied by whoever is pushing the object.* *Relate the length of the plane to the reduction in required force.* *Discover that friction causes work (energy) to be wasted when sliding objects.*
Technology: *ExploreLearning Gizmo Simulation (Ants on a Slant Gizmo); the screenshot camera icon to generate images which can be imported into PPTs and/or Word documents*
Engineering: *Designing & testing an inclined plane prototype in the Gizmo simulation*
Mathematics: *Understand ratio concepts and use ratio reasoning to solve problems/Analyze proportional relationships and use them to solve real-world and mathematical problems.* *Develop and evaluate inferences and predictions that are based on data.* *Select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels of precision.*
Background Information
The Ants on a Slant Gizmo™ allows students to investigate inclined planes. Inclined planes work by supporting objects and, in doing so, supplying a “pushing up” force. No simple machine is perfectly efficient, meaning that some energy is wasted in their use. Work is the transfer of energy. Some of this work is “wasted” due to friction and becomes heat energy. Shallow ramps waste more heat than steep ones because the item presses more heavily into the surface, increasing friction. The effect of friction can be greatly reduced by using rolling objects. In addition to wasting more energy due to friction, inclined planes require objects to be moved longer distance, and hence more time is needed as well. However, even with these disadvantages, inclined planes have allowed humans to accomplish feats that would be far too difficult without them.
Possible Solution
Possible Solutions: 1. Stick distance = 25 cm, food item = peanut, ants = 4, 5, 6 2. Stick distance = 25 cm, food item = corn, ants = 4, 5, 6. 3. Stick distance = 25 cm, food item = blueberry, ants = 5 or 6.

Peanut	Corn	Blueberry







Extension

Ask students to redo their test with friction, record all results.

Discussion Questions-

1. How does friction effect the results?
2. Friction causes work to be “wasted” as heat (which is why your hands get warm). Does friction waste more work on longer or shorter planes?

Student Activity

Name____

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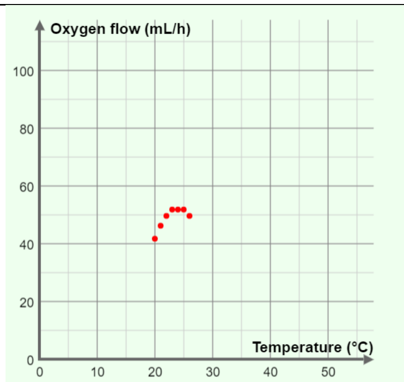
How Will You Analyze Your Data?	
Show Your Data	
Analyze Your Data, What Was The Solution To The Challenge?	

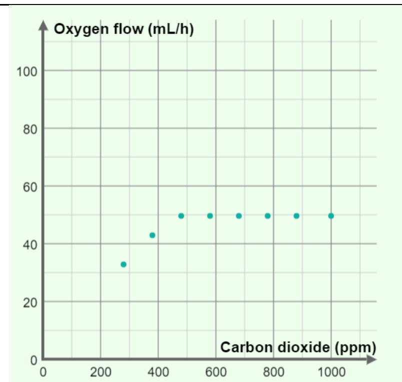
STEM LESSON: GIZMOS - Photosynthesis Lab

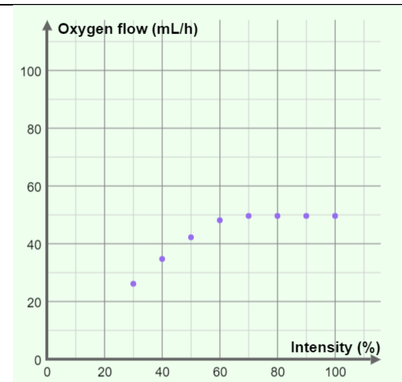
Best For: Middle School Life Science

STEM Challenge: Residents of a large, urban high-rise complex are interested in building a rooftop greenhouse. A committee has requested a feasibility study before beginning greenhouse construction. Your challenge is to design a small-scale greenhouse prototype that will maximize the rate of photosynthesis. Your proposal should recommend the minimal conditions required for light and temperature to yield the maximum rate of photosynthesis.
Curriculum Addressed
Science: NGSS Middle School MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. Review Standards NGSS Middle School MS-ETS1-1, Engineering Design. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. Review Standards NGSS High School HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. Review Standards NGSS High School HS-ETS1-4, Engineering Design. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions with and between systems relevant to the problem. Review Standards
Technology: Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are used for running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet the community's needs. The Photosynthesis Lab Gizmos requires students to maximize the rate of photosynthesis given different conditions for light intensity, temperature and carbon dioxide levels.
Engineering: Both physical models of a greenhouse and computers are used in various ways to aid in the engineering design process. Students will use the simulation for each greenhouse plot however a working knowledge of basic hydroponic gardening may be important background information for student presentations. The following link will help student understanding of one type of growing system: Video
Mathematics: The Gizmos Graph will provide the evidence for the maximum rate of photosynthesis. Using white light, students should analyze the change in oxygen released when light intensity changes, carbon dioxide levels change and temperature changes. Plotting points on the graph will support the numerical values on the Gizmos table. Screenshots of images are used to support student arguments. Slope of the curve and minimum vs. maximum points are used to calculate the change in oxygen level. This evidence demonstrates the rate of photosynthesis.

Photosynthesis rate = Change in Oxygen level/Change in temperature	Photosynthesis rate = Change in Oxygen level/Change in carbon dioxide level	Photosynthesis rate = Change in Oxygen level/Change in light intensity







Background Information

During photosynthesis, plants use light energy to combine carbon dioxide and water to form glucose. A by-product of photosynthesis is oxygen. Therefore, oxygen released measures the rate of photosynthesis. Electricity to power lightning and the ideal conditions for temperature are important factors to consider. Your proposal should recommend the minimal conditions required for light and temperature to yield the maximum rate of photosynthesis.

During photosynthesis, light energy is used to synthesize carbon dioxide (CO_2) and water (H_2O) into glucose ($C_6H_{12}O_6$) and oxygen (O_2). The complex series of chemical reactions is summarized by the following formula:

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

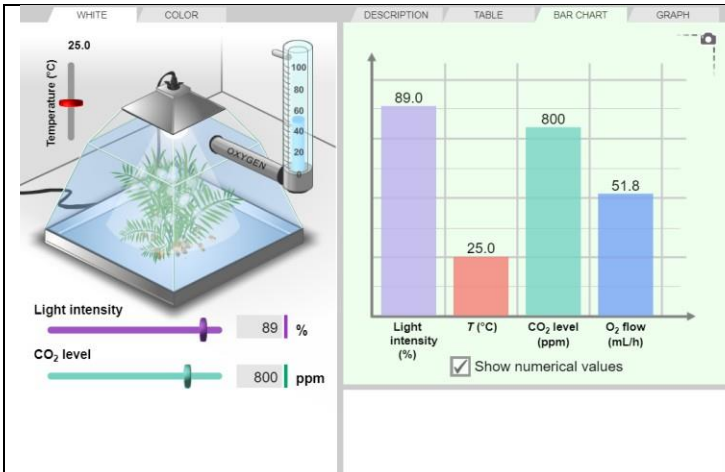
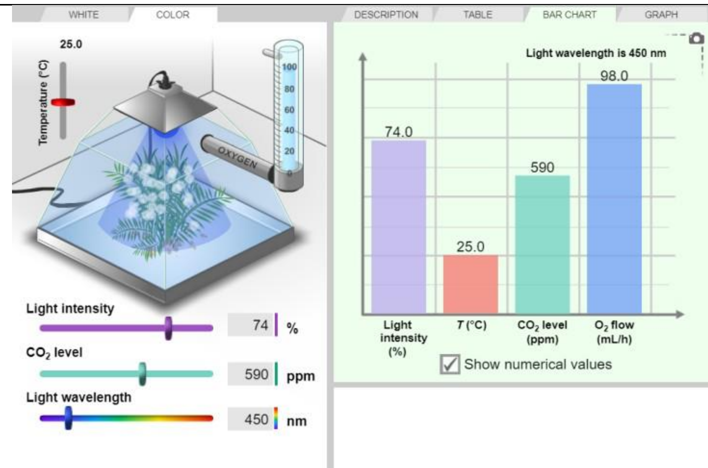
In the Gizmo, what light intensity, temperature, and CO_2 level do you think will maximize the rate of photosynthesis?

In a greenhouse, electricity is required to control temperature and power lightning. Carbon dioxide is a free resource because it is always present in the air. The cost for lightning is also a consideration. The Gizmo compares white light to different colors (wavelengths) of lightning.

Possible Solution

STEM Challenge: Residents of a large, urban high-rise complex are interested in building a rooftop greenhouse. A committee has requested a feasibility study before beginning greenhouse construction. Your challenge is to design a small-scale greenhouse prototype that will maximize the rate of photosynthesis. Your proposal should recommend the minimal conditions required for light and temperature to yield the maximum rate of photosynthesis.

Possible Solution:

 WHITE COLOR DESCRIPTION TABLE BAR CHART GRAPH 25.0 Temperature (°C) OXYGEN Light intensity 89 % CO_2 level 800 ppm 89.0 25.0 800 51.8 Light intensity (%) T (°C) CO_2 level (ppm) O_2 flow (mL/h) Show numerical values	 WHITE COLOR DESCRIPTION TABLE BAR CHART GRAPH 25.0 Temperature (°C) OXYGEN Light intensity 74 % CO_2 level 590 ppm Light wavelength 450 nm Light wavelength is 450 nm 74.0 25.0 590 98.0 Light intensity (%) T (°C) CO_2 level (ppm) O_2 flow (mL/h) Show numerical values

Student Activity

Name____

The Guiding Question…	
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Gizmos

STEM LESSON: GIZMOS - Food Chain

Best For: AP Biology, Biology, Middle School Life Science

STEM Challenge:
Many factors (both biotic and abiotic) can cause major changes in animal populations. However, nature always tries to return to a state of balance (equilibrium).
Change factors in the Gizmo that will cause:

- A significant decrease (no less than 50 percentage points) in at least one population
- A return to equilibrium for all animal populations (100% of balance) within 10 months

Curriculum Addressed

Science: How factors affect animal populations in different levels of the food chain indirectly and directly

Technology: ExploreLearning Gizmo Simulations and devices; the screenshot camera icons to generate images which can be imported into PPTs and/or Word documents, and export button to have numerical data placed into Excel documents.

Engineering: Constructing a scenario to cause a precise decrease and a return to equilibrium within the given timeframe

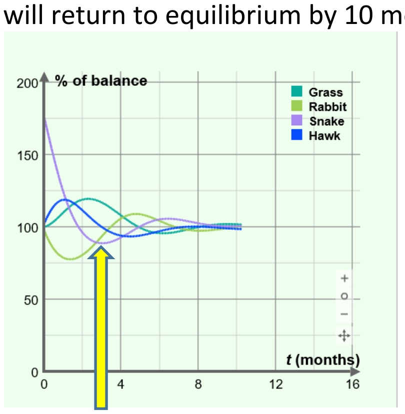
Mathematics: Reading a graph (bar and line), calculating the significant decrease in population.

Background Information

The basic unit of ecology is the ecosystem. An ecosystem consists of the community of interacting organisms living in an area, and the physical environment in which they live. The most common type of interaction between two organisms in a community is one organism feeding on another. The most important point being that the natural balance in an ecosystem is maintained (equilibrium). This balance may be disturbed due to the introduction of new species, the sudden death of some species, natural hazards or man-made causes.
A food chain is a relationship between organisms in which each species higher in the chain derives energy from the species below. The Food Chain Gizmo™ shows a hypothetical food chain in which hawks eat snakes, snakes eat rabbits, and rabbits eat grass. The population of each organism can be manipulated by the student, and the resulting effects on the populations of other organisms can be observed over time.

Possible Solution

Increasing the snake population to close to 500 will cause a drop in snakes over 50% within 2 months and all organisms will return to equilibrium by 10 months.



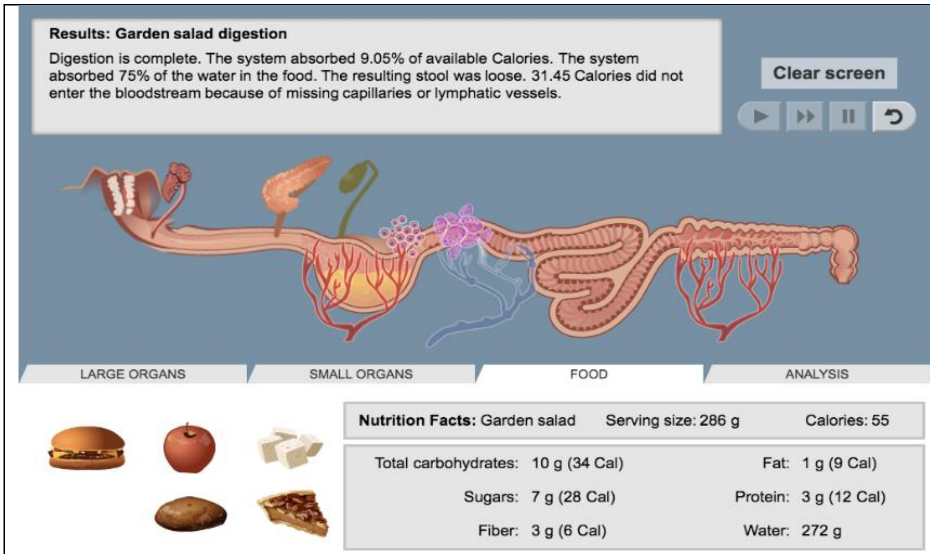
Time	Grass	Rabbits	Snakes (raised to 499)	Hawks
0	27303	2520	492	43
0.5	28229	2180	414	48
1	29947	2018	346	50
1.5	31518	1991	298	49
2	32416	2065	267	47
2.5	32499	2211	251	44
3	31871	2394	246 loss of 50%	42
3.5	30756	2574	249	40

ExploreLearning

STEM LESSON: GIZMOS - Digestive System

Best For: Biology

STEM Challenge: You have been experiencing some stomach issues for the last 5 days after eating ice cream contaminated with listeria bacteria. You are experiencing some dehydration from the lack of water and nutritional content because of the frequent watery stools. At urgent care, the doctor suggests eating foods that will balance your caloric intake and water absorption to solidify your stool and decrease discomfort. Design (Develop or Create) a digestive system to maximize your digestive process and achieve a healthy digestion with water absorption of 75% and a calorie absorption closest to 100% by feeding it different types of food. *Diagnose how to maximize your digestive process and achieve a healthy digestion with water absorption of 75% and a calorie absorption closest to 100% by feeding it different types of food.* Additional Extension Idea: Researching listeria bacteria and how that spreads using Disease Spread Gizmo; medication needed to address illness and dosage using Drug Dosage Gizmo
Curriculum Addressed
Science: Explore the three functions of the digestive system: digestion, absorption, and elimination. Create a model of the human digestive system using available organs and cells. Determine the importance of mechanical digestion by the mouth, stomach, and bile. Describe the steps of chemical digestion for carbohydrates, proteins, and fats. Explain how nutrients are absorbed into the body.
Technology: ExploreLearning Gizmo Simulation (Digestive System Gizmo); the screenshot camera icons to generate images which can be imported into PPTs and/or Word documents
Engineering: Designing a digestive system prototype in the Gizmo simulation
Mathematics: Calculation of the percentage of calories, water, nutrients absorbed based on structure of digestive system. Analyze results to determine the impact on the system and make changes accordingly.
Background Information
Digestion is an intricate process in which varieties of organs work in sequence to break food down physically and chemically, absorb nutrients, and eliminate waste products. The nutrients in food often are large molecules that must be broken down into smaller components before they can be absorbed and used by the body. The digestive system performs the functions of breaking food down (digestion), absorbing nutrients, and eliminating waste.
Possible Solution


Results: Garden salad digestion
Digestion is complete. The system absorbed 9.05% of available Calories. The system absorbed 75% of the water in the food. The resulting stool was loose. 31.45 Calories did not enter the bloodstream because of missing capillaries or lymphatic vessels.
Clear screen
LARGE ORGANS
SMALL ORGANS
FOOD
ANALYSIS
Nutrition Facts: Garden salad
Serving size: 286 g
Calories: 55
Total carbohydrates: 10 g (34 Cal)
Fat: 1 g (9 Cal)
Sugars: 7 g (28 Cal)
Protein: 3 g (12 Cal)
Fiber: 3 g (6 Cal)
Water: 272 g

STEM LESSON: GIZMOS - Fan Cart Physics

Best for: Middle School Physical Science, Physics

STEM Challenge: A theme park is installing a new, very fast moving eco-safari ride. Park guests will climb into fan carts, similar to an air boat. At the end of the ride, the cart must travel a 10-meter track and reach the end of the disembarkation area, located at 10 meters, at exactly 8.0 seconds. Design a prototype using any/all Gizmo parameters. If each fan used in the prototype supplies a force of 2 N, use Newton's second law and the Gizmo to calculate the cart's mass.
Standards Addressed
Science: Newton's Laws of Motion
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images that can be imported into PPTs and/or Word documents, and export button to have numerical data placed into Excel documents.
Engineering: Design a prototype fan cart that reaches the end of a 10 m track in 8 s.
Mathematics: calculating the mass of the prototype fan cart
Background Information
Newton's second law describes a situation in which there is an unbalanced force on an object. In this case, the object will accelerate in the direction of the force. The acceleration is proportional to the force and inversely proportional to the weight of the object. When mass is measured in kilograms (kg), force in Newtons (N), and acceleration in meters per second per second (m/s^2). Newton's second law is described by the equation F = ma, where F is force, m is mass, and a is acceleration. It is important to understand that acceleration can refer to a change in speed or a change in direction.
Possible Solution
All three fans and all three masses on cart. One fan turned on or all three fans turned on with one blowing in opposite direction. Initial velocity set to 0.6 m/s Force = mass x acceleration F = m x a F = 2 N given a = 0.16 m/s^2 (taken from the Gizmo Bar Chart) Solve for m = F/a m = 12.5 kg Solution

Student Activity

Name____

The Guiding Question…	
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What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
How Will You Analyze Your Data?	
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Analyze Your Data, What Was The Solution To The Challenge?	

STEM LESSON: GIZMOS - Roller Coaster Physics

Best for: ***AP Physics, Middle School Physical Science, Physics***

STEM Challenge:
A toy company is designing a physics game where a toy car can crack an egg in order to put a different spin on the customary egg drop competition. The big difference in the game is that the car is supposed to crack the egg instead of it remaining unbroken.

Design a track that will give your vehicle enough force to crack an egg found at a height of 30 cm in exactly 2.0 seconds, then calculate the amount of kinetic energy the car hits the egg with.

Standards Addressed
Science: Potential and Kinetic Energy
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images which can be imported into PPTs and/or Word documents.
Engineering: Design a roller coaster track that has a car break the egg in exactly in 2.0 seconds.
Mathematics: Calculating the kinetic energy of the cart right before it breaks the egg.

Background Information

An object has several types of energy. Kinetic energy (KE or K), is the energy of motion, and depends on the mass and speed of the object. Gravitational potential energy (U) is energy an object possesses based on its position. Gravitational potential energy depends on mass, height, and the strength of the gravitational field. As an object falls through the air or rolls down a slope, it is accelerated by gravity. During this time, the gravitational potential energy of the object is converted to kinetic energy. This conversion follows the law of conservation of energy, which states that the total energy is constant in a closed system. If there is no friction, the kinetic energy of a freely-rolling car at the bottom of the hill is equal to the gravitational potential energy of the car at the top. If friction is present, some of the potential energy is converted to heat.

The equation for kinetic energy is $K = \frac{1}{2}mv^2.$

Possible Solution

There are multiple solutions. One includes:

<u>Must</u> use the 100g van.
Hill #1 must be at a height of 100 cm and hill #2 must be at a height of 72 cm and a coefficient of friction of 0.03.

$K = \frac{1}{2}mv^2.$

m = 100 g must be converted to kg = 0.1 kg
v = 300.8 cm/s must be converted to 3.008 m/s
KE = ½ (0.1 kg) x $(3.008\ m/s)^2$
KE = 0.45 J Solution

Student Activity

Name____

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STEM LESSON: GIZMOS - Sled Wars

Best For: Middle School Physical Science

STEM Challenge:
Your local park has commissioned you to create a skate park that will provide a safe environment for skateboarding. The mayor wants you to make the best course but safety is his biggest concern. The mayor wants to make sure the average skater will only have enough momentum he needs to knock over exactly three safety cones at the bottom of the biggest ramp. Calculate mass, potential energy and the height needed to destroy exactly three of the five safety cones without damaging the fourth or fifth safety cone. Based on your calculations how high can the ramp be and what is the momentum needed to fully destroy 3 safety cones? Use the Gizmo Sled Wars to model your design. Show all work!

Standards Addressed

Science: Students will explore acceleration, speed, momentum, and energy by sending a sled down a hill into a group of snowmen.

Technology: Students will use ExploreLearning Gizmo simulation to model science and engineering practice.

Engineering: Students will generate possible solutions by building a model using Sled Wars. Students will design a ramp that allows the average skater to safely ride in their park.

Mathematics: Students will calculating the height and momentum needed to destroy exactly 3 safety cones

Background Information

Energy can be defined as the ability of an object to do work. While the term "work" has many real-world meanings, in physics "work" is defined as a force applied over a distance. The units of energy (and work) are newton-meters, or joules (J). One joule is equal to a force of one newton (1 kg•m/s^2) applied over a distance of one meter (m). In other words, 1 J = 1 kg$(m/s)^2$.

Potential energy (*PE*) is energy that is stored. For example, energy is stored in a compressed spring, in the food we eat, or in a book on a high shelf. The energy of the book on the shelf, called gravitational potential energy, is equal to the product of an object's weight (*w*) and height (*h*). Weight is equal to mass (*m*) times gravitational acceleration (*g*), so we have:

$PE = wh$ or $PE = mgh$

Kinetic energy is the energy of motion. The kinetic energy of an object depends on its mass and speed. The formula for kinetic energy is $KE = \frac{1}{2} mv^2$.

This Gizmo will produce multiple answers. Here is one example:
If you the average skater has a mass of 153kg with 59, 976 J of potential energy calculate the height needed to destroy exactly three of the five safety cones without damaging the fourth or fifth safety cone.

Potential Energy: PE = m • g • h.

g stands for acceleration caused by gravity, on Earth's surface, g is 9.8 m/s2

Mass = 153kg given

G = 9.8 given

Height= 40m Solution

PE = 59, 976 J given

Momentum: p = m • v

Mass = 153kg given Speed= 28 m/s given Momentum= 4,284 kg•m/s Solution
Possible Solution
Height = 40 meters Momentum = 4,284 kg•m/s

Student Activity

Name____

The Guiding Question…	
The Claim You Will Make	
What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
How Will You Analyze Your Data?	
Show Your Data	
Analyze Your Data, What Was The Solution To The Challenge?	

STEM LESSON: GIZMOS - Trebuchet

Best For: Middle School Physical Science, Physics

STEM Challenge: Students entering a Science Fair competition are designing a prototype machine demonstrating projectile motion. Students should draw on their understanding of previous devices as well as considering current technological advancements. Using an ancient trebuchet replica designed to breach a castle wall, propel an object that successfully hits the target found on Siege of Acre Castle.
Curriculum Addressed
Science: Investigate the interaction of launch angle, initial speed, potential energy, and kinetic energy of an object's projectile motion. NGSS Middle School MS-PS3-2, Energy. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. NGSS Middle School MS-PS3-5, Energy. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. NGSS High School HS-PS3-, Energy. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
Technology: ExploreLearning Gizmos Simulations and Student Devices - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are used for running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet the community's needs.
Engineering: Design a wooden trebuchet with enough force and precision to breach a wall at a distance of 111 meters. NGSS Middle School MS-ETS1-1, Engineering Design. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/MS%20ETS%20Evidence%20Statements%20June%202015%20asterisks .pdf NGSS High School HS-ETS1-4, Engineering Design. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions with and between systems relevant to the problem. https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-ETS1-4%20Evidence%20Statements%20June%202015%20asterisks.pdf
Mathematics: Utilize the formula for kinetic energy and estimate the opposing force of atmospheric friction.

Gizmos

Student Activity

Name____

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STEM LESSON: GIZMOS - Plants and Snails

***Best For:** Biology, Chemistry, Middle School Life Science, Middle School Physical Science*

STEM Challenge:

Plants require carbon dioxide in order to produce food for themselves and survive. Snails require oxygen in order to survive. If either organism does not receive their respectively required substances in sufficient quantities they can die. Engineer a scenario where the elodea sprigs produce the maximum amount of oxygen they possibly can but require the least amount of carbon dioxide in order to live for 24 hours.

Standards Addressed

Science: Study the production and use of gases by plants and animals. Measure the oxygen and carbon dioxide levels in a test tube containing snails and elodea (a type of plant). Learn about the interdependence of plants and animals.

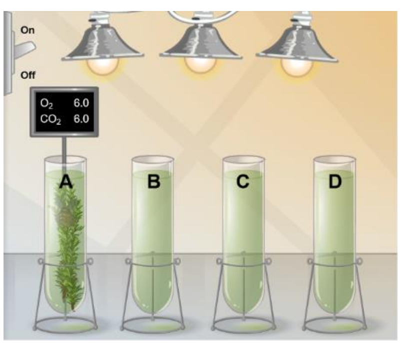
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images which can be imported into PPTs and/or Word documents.

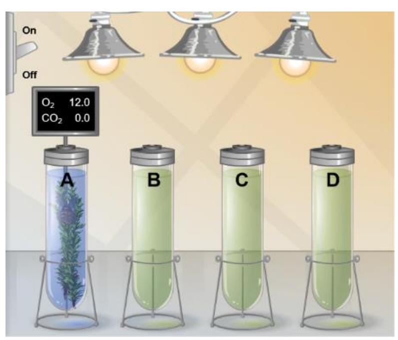
Engineering: Designing a prototype system in the Gizmo simulation that completes the task.

Mathematics:

Suggested math tasks for secondary students that accompany this Gizmos

1) Determine the concentration in moles/L of oxygen and carbon dioxide before and after completing the task. (assuming one liter of solution)
   Calculations:
   Concentration = the moles of the chemical/volume in liters
   Example:





<u>Beginning of the Task:</u>

<u>Initial Concentration of O_2 and CO_2</u>

ppm = 1 mg solute per liter of solution (1000mg in 1g)

ppm = 0.001 g solute per liter of solution

There is 0.006g of O_2 and 0.006g of C O_2 in 1 L of solution. To calculate the moles of each you will need to molar mass of O_2 and CO_2.

Molar mass of O_2 is= O+O= O_2

Molar mass of O_2= 15.999 g/mol+ 15.999 g/mol = 31.998 g/mol

Molar mass of CO_2 is = O+O+C=CO_2
Molar mass of CO_2=15.999 g/mol+ 15.999 g/mol+12.011g/mol=44.009 g/mol
Moles=mass (g)/Molar mass (g/mol)
Moles of O_2 =mass of O_2/ molar mass of O_2
Moles of O_2 =0.0062g / 31.998g/mol
Moles of O_2 = 0.000193 moles

Moles of CO_2=mass of CO_2/ molar mass of CO_2
Moles of CO_2= 0.0062g / 44.009g/mol
Moles of CO_2= 0.000136 moles

Concentration of O_2 is the moles of O_2/volume in liters
Concentration of O_2 =0.000193 mols/ 1L
Concentration of O_2 =0.000193 mols/L

Concentration of CO_2 is the moles of CO_2/volume in liters
Concentration of CO_2= 0.000136 mols/1L
Concentration of CO_2= 0.000136 mols/L

At the beginning of the task there is 0.000136 mols/L of CO_2 and 0.000193 mols/L of O_2 .

End of the Task:
Ending Concentration of O_2 and CO_2
There is 12ppm of O_2 is 0.012g of O_2 but 0ppm of CO_2.

Molar mass of O_2 is= O+O= O_2
Molar mass of O_2= 15.999 g/mol+ 15.999 g/mol = 31.998 g/mol

Moles=mass (g)/Molar mass (g/mol)
Moles of O_2 =mass of O_2/ molar mass of O_2
Moles of O_2 =0.012g / 31.998g/mol
Moles of O_2 = 0.000375 moles

Concentration of O_2 is the moles of O_2/volume in liters
Concentration of O_2 =0.000375 moles/ 1L
Concentration of O_2 =0.000375 moles/L

At the end of the task, the concentration of CO_2 is 0 mols/L and the concentration of O_2 is 0.000375 moles/L.

2) Determine the number of molecules of oxygen and carbon dioxide present in the test tube at the end of the task.
Calculations:
There are 0ppm of CO_2 thus no molecules but since there are is 12ppm of O_2 present in the test tube the number of molecules can be calculated.

There is 12ppm of O_2 is 0.012g of O_2 but 0ppm of CO_2.

Molar mass of O_2 is= O+O= O_2
Molar mass of O_2= 15.999 g/mol+ 15.999 g/mol = 31.998 g/mol

Moles=mass (g)/Molar mass (g/mol)
Moles of O_2 =mass of O_2/ molar mass of O_2
Moles of O_2 =0.012g / 31.998g/mol
Moles of O_2 = 0.000375 moles

Number of molecules of O_2= moles X Avogadro's Constant (6.022140857×10^{23})
Number of molecules of O_2=0.000375 moles X 6.022140857×10^{23}
Number of molecules of O_2=2.2584×10^{20}

There are 2.2584×10^{20} molecules of O_2.

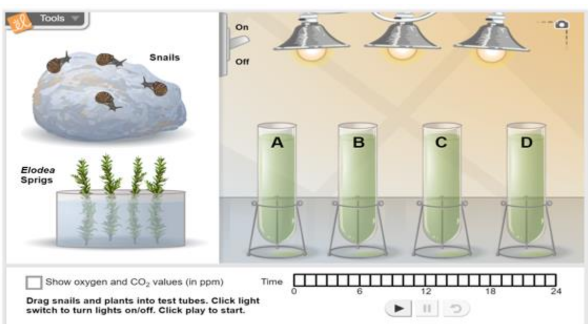
Background Information

Scientific Background
Indicators are important tools used by biologists and chemists. An indicator is a substance that changes color when it comes in contact with some specific chemical. Bromothymol blue (also known as bromthymol blue and as BTB) is a commonly used indicator that indicates whether a solution is an acid, a base, or neutral. In a neutral solution, bromothymol blue is green. In an acid it turns yellow and in a base it turns blue.

When carbon dioxide (CO2) is dissolved in water, the water becomes a mild acid (the acid in soda) and bromothymol blue turns the water yellow. When oxygen (O2) is dissolved in water, the water becomes a base and bromothymol blue turns it blue. This makes BTB particularly useful in studying of respiration and photosynthesis, both of which involve oxygen and carbon dioxide.

Respiration takes place all the time, day and night, in plants and in animals. During respiration the plant or animal takes in oxygen and food and releases carbon dioxide and water. Photosynthesis takes place only in plants and only when light is present. During photosynthesis, plants take in carbon dioxide and they release oxygen.
During the daylight hours, plants are engaged in both processes at the same time. However, the amount of oxygen produced through photosynthesis is usually greater than the amount of oxygen that the plant uses in respiration. In fact, the amount of oxygen produced by plants during the daylight hours is generally greater than the amount that they consume during an entire day/night cycle. As a result plants produce more oxygen than they use, which is critical for the survival of other living creatures (like animals), which require oxygen but don't produce any on their own.

Environmental Connection
A potential environment crisis has recently been receiving a great deal of attention from scientists, the news media, and governments around the world. The concern is global warming – a gradual increase in the temperature of Earth's atmosphere.

Global warming is not an unnatural event. It has occurred many times throughout Earth's history (along with its counterpart, global cooling), but scientists are concerned that the current trend may be more than a natural cycle – that it may be a direct result of human activity. Earth's generally mild climate is due in large part to the greenhouse effect. The greenhouse effect refers to the fact that heat which radiates away from Earth's surface and its oceans is captured by certain "greenhouse gases." These gases hold the heat within the atmosphere rather than letting it escape to outer space. Without these gases, the temperature would fluctuate widely between day and night and the overall average temperature on Earth would be much colder. Carbon dioxide is one of the most common greenhouse gases. Recent human activities, such as the burning of fossil fuels, have greatly increased the amount of carbon dioxide in the atmosphere. (Carbon dioxide is a product of the burning process.) Another factor that may be playing a role in the increase in CO2 is ongoing deforestation – the felling of mature forests to make room for agriculture or urban expansion. Fewer trees means that less photosynthesis takes place. Concern is growing that the current global warming trend may be a direct result of our unnatural addition of greenhouse gases to the atmosphere.
Possible Solution
 In only one test tube, all four elodea sprigs and 2 snails

Student Activity

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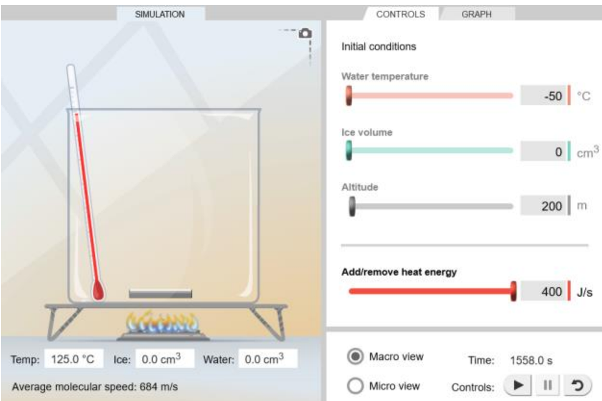
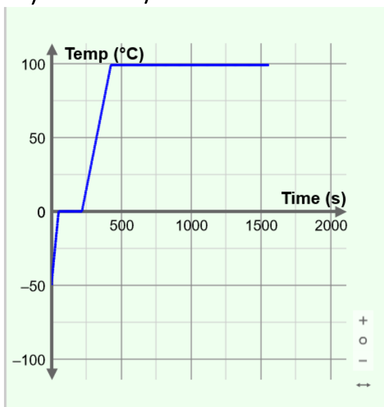
STEM LESSON: GIZMOS - Phase Changes

***Best For:** Chemistry, Middle School Physical Science*

STEM Challenge: Water exists in different phases at different temperatures. Adding heat increases molecular motion and removing heat reduces molecular motion. The amount of molecular motion dictates what phase water exists in. Engineer a 50cc block of ice (representing an iceberg) that melts in less than one minute (take a snapshot of when it happens) and then make water boil at less than 80 degrees Celsius. Consider what you know about Global Warming.
Curriculum Addressed
Science: Explore the relationship between molecular motion, temperature, and phase changes. Compare the molecular structure of solids, liquids, and gases. Explore temperature changes as ice is melted and water is boiled through graphs. Find the effect of altitude on phase changes. The starting temperature, ice volume, altitude, and rate of heating or cooling can be adjusted.
Technology: ExploreLearning Gizmo Simulation (Phase Changes Gizmo); the screenshot camera icons to generate images, which can be imported into PPTs and/or Word documents.
Engineering: Designing a prototype system in the Gizmo simulation that completes the task.
Mathematics: Suggested math tasks for secondary students that accompany this Gizmos 1) Unit conversion from Celsius (°C) to Kelvin (K) Calculation: Temperature in °C + 273.15 = Temperature in K Example: 0 °C +273.15 = 273.15 K (freezing point of water) 100 °C +273.15 = 373.15 K (boiling point of water) 2) Calculating the slope of the line as water transforms from ices to water to gas and making inferences to the molecular motion-taking place. Calculation: Slope =Change in the y-axis/Change in the x-axis Slope =Change in temperature/Change in time Slope= (Y2-Y1)/(X2-X1)

Example: Mount Magazine in Arkansas has an altitude of 200m. Determine what the slope of each portion of line on the graph that will be formed if you heat -50 °C water with zero ice and added heat (you can choose how much heat).
Slope= (Y2-Y1)/(X2-X1)
Slope of the first line in the graph (-50 °C to 0 °C)= (0 - -50)/(52- -0)
Slope of the first line in the graph (-50 °C to 0 °C)= (50)/(52)
Slope of the first line in the graph (-50 °C to 0 °C)= 0.96 °C/s



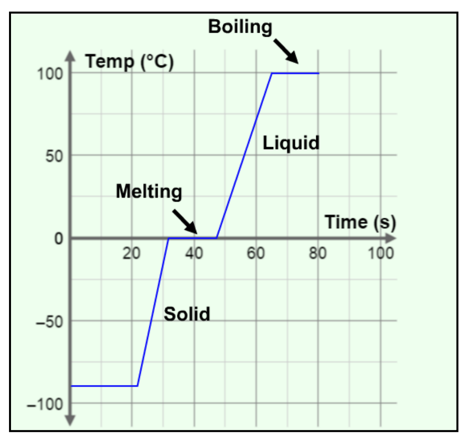


Scientific Background

Matter can exist in several phases, or states. The three states that exist naturally on Earth are solid, liquid, and gas. Plasma is a high-temperature phase that exists on stars. Several other phases have been discovered at temperatures near absolute zero.

Solids are characterized by atoms or molecules held in a rigid structure. Atoms in the structure may vibrate, but do not move freely. A solid has a definite shape and a definite volume. Liquids are characterized by molecules that are attracted to one another but can still move around so that they take the shape of their container. Liquids thus have a definite volume but an indefinite shape. Gases are characterized by rapidly moving molecules that move and collide freely. A gas will expand to occupy all the space in its container. Gases also can be compressed to a very small volume. Thus gases do not have a definite shape or volume.

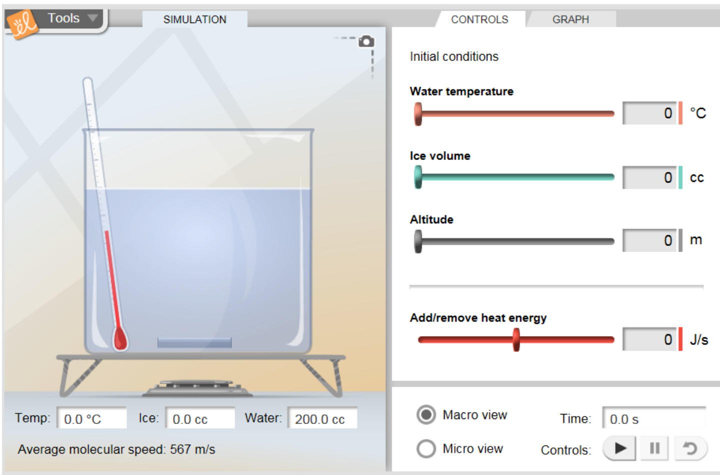
When a solid is heated, the atoms begin to vibrate more and more rapidly. Eventually the vibrations are strong enough to break the rigid bonds holding the atoms together, and the solid melts into a liquid. During the melting process, temperature does not increase because the added heat energy goes into melting the solid rather than heating the liquid.



In a liquid, the molecules move at a variety of speeds. The fastest-moving molecules can escape the surface of the liquid and become a gas. This process is called *evaporation*. As the liquid is heated, the average speed of the molecules increases until large bubbles of gas form within the liquid. This is *boiling*. The temperature remains constant during boiling because the fastest molecules are constantly leaving the liquid and escaping as gas.

Cooling produces the opposite phase changes. As a gas is cooled, the molecules slow down until their mutual attraction causes them to clump together and form droplets of liquid. This is *condensation*. When a liquid is cooled, the molecules move slowly enough that they can begin to form rigid chemical bonds in a crystalline lattice. This is *freezing*.

Possible Solution



Water must be at least 70ºC
Altitude at least 6500m
Add Heat Energy to 400 J/s

Student Activity

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STEM LESSON: GIZMOS - Gravity Pitch

***Best For:** Earth/Space Science*

STEM Challenge: Canada joins NASA-led moon mission, in the 'Lunar Gateway' which will be an outpost that will orbit the moon. It will be a base for human and robotic exploration of the moon and future planets. With the Lunar Gateway (let it be represented in the Gizmo as a baseball pitcher) located at the "north pole" of a new planet that Earth's population would like to inhabit, launch the landing pod (the baseball) to the surface so that it lands at the "equator". Then launch it again so that it lands at the "south pole". https://globalnews.ca/news/5008032/nasa-moon-mission-canada/
Curriculum Addressed
Science: Observe the path of the landing pod when it is launched at different velocities. Launching the landing pod on different planets to see how each planet's gravity affects the pod.
Technology: ExploreLearning Gizmo Simulation (Plants and Snails Gizmo); the screenshot camera icons to generate images, which can be imported into PPTs and/or Word documents.
Engineering: Designing a prototype system in the Gizmo simulation that completes the task.
Mathematics: - Suggested math tasks for secondary students that accompany this Gizmos STEM Activity -Calculate the circumference of the planet $C=2\pi r$ or $C=\pi d$ Based on the information below we know that from the North Pole to the South pole of our custom planet the pod traveled 9,728km. That distance is half the circumference. C=2X Distance from the North Pole to the South Pole C=2 X 9,728km C=19,456 km The circumference of the custom planet is 19,456 km. -Calculate the diameter of the planet $C=\pi d$ 19,456 km=πd 19,456 km/π=d

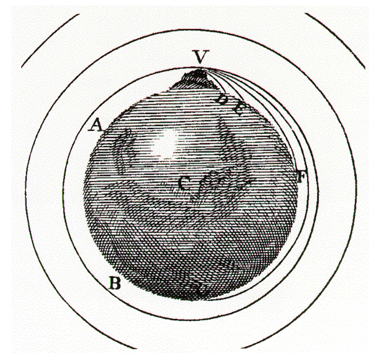
6,193.04 km= d

The diameter of the custom planet is 6,193.04 km

Background Information

Scientific Background
Many people have heard of Newton and the apple, but few know what he actually figured out on that day in 1766. Newton was not the first to see an apple fall from a tree. He was also not the first to notice that the Moon orbits Earth. But Newton *was* the first to make a connection between these phenomena—they are both caused by gravity.

Prior to Newton, scientists such as Johannes Kepler imagined that planet motions were driven by a mysterious force that radiated from the Sun like the spokes of a wheel. Newton realized that a force pulling the planets *in*—gravity—was the only force necessary to keep them in orbit.



Newton's cannon (from *Principia*)

Newton explained his reasoning with a thought experiment. Imagine a horizontal cannon on top of a tall mountain. If the cannon were fired, the cannonball would travel a short distance before Earth's gravity pulled it down to the ground. If the cannonball were launched with a greater velocity, it would travel farther before it finally landed.

At just the right velocity, the cannonball would fall at the same rate as Earth was curving beneath it. In other words, the cannonball would be falling toward Earth, but Earth would be falling *away* from the cannonball. As a result the cannonball would stay at the same height all the way around, eventually crashing into the mountain.

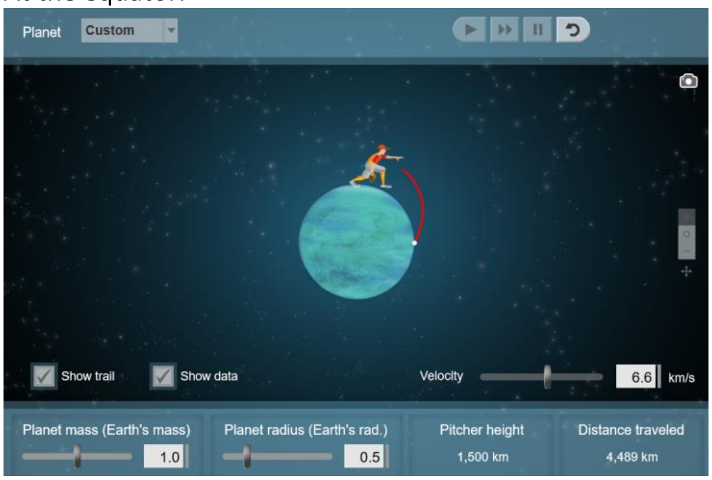
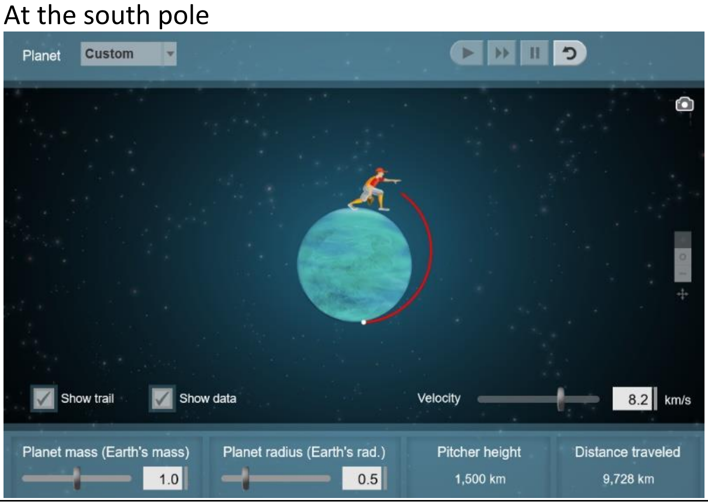
So, orbits result from a balance between the velocity of the projectile and the force of gravity that causes the path to curve. The strength of gravity depends on the mass of each object and the distance between them. Newton summarized this in his *Law of Universal Gravitation*:

$$F_G = Gm_1m_2 / r^2$$

In this equation, m_1 and m_2 are the two masses, r is the distance between them, and G is the gravitational constant. In other words, gravity increases with mass and decreases with distance.

Astronomy Connection
After Uranus was discovered in 1781, scientists noticed that its orbit did not exactly conform to the path predicted by Newton's laws. Astronomers conjectured that the orbit of Uranus was perturbed by the presence of an undiscovered planet. During the 1840s, several teams of mathematicians worked to determine this planet's position. In September of 1846, using these calculations as a guide, the German astronomer Johann Galle located Neptune.

While universal gravitation worked beautifully in the discovery of Neptune, it did not explain the odd orbit of Mercury very well. In 1915, Albert Einstein's *Theory of General Relativity* introduced a new way of thinking

about gravity. Einstein conceived of gravity as a curvature in spacetime. (A large planet could warp space like a bowling ball could warp a sheet of thin rubber.) General relativity accounted for Mercury's orbit and also predicted that the light from distant stars would be bent by the Sun's gravity—something that Newton's laws would not allow as light has no mass. When the predicted bending of starlight was observed during a 1919 eclipse, general relativity was confirmed and Einstein became an international celebrity.
Possible Solution
Customized planet with the same mass as Earth and half the radius. At the equator.  At the south pole 

Student Activity

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STEM LESSON: GIZMOS - Seed Germination

***Best For**: Middle School Life Science*

STEM Challenge: Seed Germination

A newly discovered plant virus has destroyed the entire seedling (sprout) crop for a small remote village. As part of a visiting agricultural research team, your skills are immediately needed to restore the village's seedling inventory in time for the spring planting season. You will lead a team to engineer greenhouse gardens to germinate 3 different seed types using the design parameters below.

Your team will work for one month. The village has an ample water supply.	Work for 31 days in 5-day shifts.
Control electricity to run lights ($1 per % of light intensity).	Budget $600.
Control temperature ($1 per degree Celsius)	Budget $600.
The building used to house the greenhouse plots also has space limitations.	Your team has enough space for 10 greenhouse plots.

Curriculum Addressed

Science: NGSS Elementary K-ESS3-1, Earth and Human Activity. Use a model to represent the relationship between the needs of different plants and animals and the places they live. The Germination Gizmo explores similar topics to this Gizmo but at a more basic level and may be more appropriate for elementary lessons. Review Standard

NGSS Middle School MS-ETS1-1, Engineering Design. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. Review Standard

NGSS High School HS-ETS1-4, Engineering Design. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions with and between systems relevant to the problem. Review Standard

Technology: Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are used for running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client (village leaders and local farmers) about how a given design will meet the community's needs. Using the EL Tools screenshot camera icon, students can generate images used for PPTs and/or Word documents, and the export button to have numerical data placed into Excel documents. The Seed Germination Gizmos requires students to maximize seed production over 5 day intervals given different conditions for water, light and temperature.

Engineering: Both physical models of a greenhouse and computers can be used in various ways to aid in the engineering design process. Students will use the simulation for each greenhouse plot however a working knowledge of basic hydroponic gardening may be important background information for student presentations. The following link will help student understanding of one type of growing system: [Video]
Mathematics: 1. Students will need to understand how to calculate seedling yield; the total number of sprouts/total number of seeds. 2. Students will need to understand how to calculate the mean (average) for data collected through multiple trials. 3. Students will need to know to how to calculate cost of electricity to power lightning and controlling temperature.
Background Information
1. Ask students to start listing some of the environmental conditions they think seeds need in order to germinate. The Gizmos scaffolds students' prior knowledge by listing Water, Light and Temperature as the variables which can be manipulated. The greenhouse plots are pre-seeded therefore students cannot manipulate the soil conditions. Elementary students should be questioned on seasons and if they think that gardens are planted in the fall or spring. Temperatures are typically warmer when moving from spring to summer. 2. Demonstrate the importance of gathering baseline yield data for each seed type (A, B, & C) at default conditions; Water- 50 drops/hr, Light at 50% intensity and Temperature at 18 degrees Celsius. Students will notice that each trial will yield different results therefore multiple trials are necessary to determine average results. Initial testing will provide students with enough evidence to establish how to begin their 31-day seed germination project. 3. Discuss the selection of the independent variable and controlling all other variables when conducting a controlled scientific investigation. For example, in order to determine the impact of an increase or decrease in temperature; water drops/hour and light intensity must remain constant. 4. Prompt students to think about any additional information that would be useful which has not been provided by the village. In other words, nutritional information on each seed type and the final amount of food product (beans versus grains versus potatoes, etc.).

Possible Solution
Ideal conditions for Seed A – (1) Water at 75-80 drops/hr. (2) Temperature range 24-29 degrees Celsius (3) Light intensity has not effect. Six 5-day growth cycles produced 493 sprouts for an 82.1% yield with ~ $150 total cost. Ideal conditions for Seed B – (1) Water at 68-75 drops/hr. (2) Temperature range 21-23 degrees Celsius (3) Light intensity 25-100%. Six 5-day growth cycles produced 548 sprouts for a 91.3% yield with $300 total cost. Ideal conditions for Seed C – (1) Water at 49-52 drops/hr. (2) Temperature range 15-17 degrees Celsius (3) Light intensity has not effect. Six 5-day growth cycles produced 582 sprouts for a 97.0% yield with ~ $90 total cost. Therefore, Seed C has the highest seedling yield for the least cost. Student results will vary but total cost of 2 plots for Seed A, 1 plot for Seed B, and 5 plots for Seed C would be $1,060 or less than budgeted.

Student Activity

Name____

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STEM LESSON: GIZMOS - Free Fall Tower

Best For: Middle School Physical Science

STEM Challenge:

Your class has collected enough box tops to win a trip to Italy. On your tour of the Tower of Pisa, you come up with the brightest idea – being so science savvy – to recreate Galileo's experiment but with a twist. You challenge your classmates to drop different objects from different heights so that there is a difference of no more than 0.1 seconds between the drop times. Once you identify the objects, calculate the amount of force each one hits the ground with using the force of gravity equaling 9.8 m/s^2 and the chart below:

Object	Mass (in kg)
Watermelon	8
Soccer ball	0.43
Golf ball	0.046
Ping pong ball	0.00247

Curriculum Addressed

Science: Gravity; Air Resistance; Newton's Second Law of Motion

Technology: ExploreLearning Gizmo Simulations and devices; the screenshot camera icons to generate images which can be imported into PPTs and/or Word documents

Engineering: Design a scenario where two objects of different mass fall and reach the ground with a time difference no greater than 1/10th of a second

Mathematics: Calculating the amount of force that each object hits the ground with

Background Information

The force of gravity is not the same on all objects. The force of gravity on an object, also called its weight, is proportional to the object's mass. Therefore, the rock is being pulled by 100 times as much force as the pebble, and they will fall at the same rate. In air, the motion of falling objects is opposed by the frictional force of air resistance. Air resistance depends on the surface area of the falling object. If two objects have the same mass, air resistance will slow the object with larger surface area more.

Possible Solution

Solution (without parachute):

	Golf ball	Soccer Ball
Time (seconds)	3.03	3.04
Height (meters)	40	30
Force (Newtons)	0.45	4.21

Student Activity

Name____

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	↓
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	↓
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	↓
How Will You Analyze Your Data?	
	↓
Show Your Data	
	↓
Analyze Your Data, What Was The Solution To The Challenge?	

STEM LESSON: GIZMOS - Golf Range

Best For: Middle School Physical Science

STEM Challenge: The Top Gizmos golf design team must create game bays from several floors of their building. Golfers tee off from the game bays and try to score a hole in one. The target hole is 200 meters from each bay. The bays are on the ground floor, the first floor at 25 meters, and the top floor at 50 meters. Design a solution with all available parameters to help a test golfer get a hole in one. Be sure to share velocity of ball and maximum height of the ball. The Advanced Features of the Gizmos are used to elevate the tee bay to 25 meters and 50 meters.
Curriculum Addressed
Science: Experiment with different combinations of initial velocity and launch angle of a projectile. Observe the differences between an object traveling through air and one traveling through a vacuum. Learn about velocity vectors and gravity's effect on vertical velocity. Calculate the hang time and distance of a projectile based on its initial velocity and launch angle.
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images that can be imported into PPTs and/or Word documents, and export button to have numerical data placed into Excel documents.
Engineering: Designing & testing a golfing range.
Mathematics: Graph linear and quadratic functions and show intercepts, maxima, and minima. Understand that numerical information can be represented in multiple ways: arithmetically, algebraically, and graphically. Solve problems involving velocity and other quantities that can be represented by vectors.
Background Information
In the Golf Range Gizmo, students observe an example of projectile motion: an object following a path subject only to the influence of Earth's gravitational field. Some of the greatest minds in the history of science—among them Johannes Kepler, Galileo Galilei, and Isaac Newton—have contributed to the development and understanding of this central concept in physics.
Possible Solution
This challenge will have many different solutions. Possible solution A) Golfer at a height of 0m, an initial velocity of 50 m/s and a launch angle of 44 degrees. Possible solution B) Golfer at a height of 25m, an initial velocity of 47 m/s and a launch angle of 44 degrees. Possible solution C) Golfer at a height of 50m, an initial velocity of 44 m/s and a launch angle of 44 degrees.

Gizmos

Student Activity

Name____

The Guiding Question…	
The Claim You Will Make	
What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
How Will You Analyze Your Data?	
Show Your Data	
Analyze Your Data, What Was The Solution To The Challenge?	

STEM LESSON: GIZMOS - Genetic Engineering

Best For: AP Biology, Biology

STEM Challenge:

You are a farmer who sells genetically engineered corn to supermarkets and farmers markets. One particular customer is interested in purchasing double headed corn kernels for use as interesting pips, bubble blowers and other assorted knick-knacks. Your farm has had problems in the past with Coleoptera sp. larvae (immature beetles) so your corn has been genetically modified to be resistant to them.

Engineer corn that will result in double headed cobs but with a sufficient yield that will be profitable (70 units or greater). Then construct an argument as to why you need to charge this customer a higher price for these cobs as opposed to standard cobs.

Curriculum Addressed
Science: Genetic Engineering
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images that can be imported into PPTs and/or Word documents, and export button to have numerical data placed into Excel documents.
Engineering: Engineering double headed corn cobs that will still turn a profit.
Mathematics: Construct an argument explaining why the farmer has to charge a higher price for the double headed cobs as opposed to normal cobs.
Background Information

Genetic engineering is the manipulation of an organism's genome using biotechnology. The first step in creating a genetically modified organism (GMO) is finding a trait of interest. To create a crop that is resistant to a specific insect, for example, a researcher may look for other organisms in the environment that are able to kill that pest. In this Gizmo, students screen a few strains of bacteria, but in reality, scientists may screen hundreds or thousands of bacterial strains before they find one with the trait they want.

The second step in creating a GM crop is isolating the gene that is responsible for creating the desirable trait from the bacteria. Scientists will often compare the genomes of the bacteria containing the desirable trait to the genome of a similar species that does not contain the trait. They then transfer genes that were only in the organism with the desirable trait to the organism without the desirable trait to determine which gene (or genes) created the desirable phenotype.

Next, the new gene will be prepared for expression in the crop of interest. Genes from bacteria contain bacterial promoters, regions of DNA that initiate transcription of a gene. Bacterial promoters may not work in other organisms, so the bacterial promoter will be replaced with a promoter from the target organism. Different promoters may be active in different parts of the organism, so with the right promoter, a researcher may be able to express their gene of interest in a plant's leaves only, or roots only, or in the entire plant.

After the promoter is chosen, the new gene is inserted into the organism of interest. This can be done in many ways, depending on the organism. In plants, a bacteria called Agrobacterium tumefaciens naturally infects plant cells and inserts pieces of its own DNA into the plant's genome. If the new gene is inserted into the Agrobacterium tumefaciens genome, that bacteria can be used to insert the new gene into the plant's genome. Care is taken to make sure that the new gene is not inserted into an essential part of the genome or disrupting the normal function of other genetic material.

Finally, after the new gene is successfully inserted into the plant's geonome, the modified organism is grown. The organism is checked to make sure that it is now exhibiting the new trait and that the new genetic material does not disrupt the normal function of the organism.

Possible Solutions

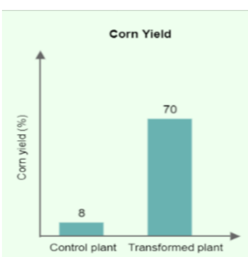
First Possible Solution:

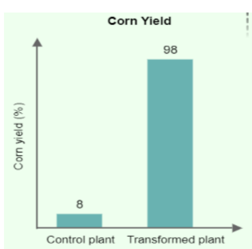
1) Choose Petri dish #6
2) Gene F is inserted
3) Choose Promoter 1 or 3
4) Choose a callus where the new promoter-gene (blue) is surrounded by exon, intron or promoter (green)
5) Add Coleoptera sp. larvae and press play
6) If the resulting mutation is brown kernels or small sized cobs, go back and try a different callus which results in double headed cobs

Second Possible Solution:

1) Choose Petri dish #11
2) Gene H is inserted
3) Choose Promoter 1 or 3
4) Choose a callus where the new promoter-gene (blue) is surrounded by exon, intron or promoter (green)
5) Add Coleoptera sp. larvae and press play
6) If the resulting mutation is brown kernels or small sized cobs, go back and try a different callus which results in double headed cobs

Why farmer must charge higher price for double headed cobs:





Double headed cobs   Normal cobs

Double headed cobs: 70y

Normal cobs: 98x

70y = 98x
y= (98/70)x
y= 1.4x

Example:

The farmer charges \$0.35 per normal corn cob. x= 0.35 The amount charged for double headed corn cobs will be 1.4 x 0.35 = 0.49 in order for profit to be the same as normal corn. 70 x 0.49 = 98 x 0.35 \$34.30 = \$34.30

Student Activity

Name____

The Guiding Question...	
The Claim You Will Make	
What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
How Will You Analyze Your Data?	
Show Your Data	
Analyze Your Data, What Was The Solution To The Challenge?	

STEM LESSON: GIZMOS - Radiation

Best For: 5th Grade Science

STEM Challenge: You are opening a movie theater in a part of town that is bustling with activity. You need a popcorn maker that can produce a high amount of popcorn in a very short amount of time. Design a prototype popcorn making machine that can pop kernels in exactly 28.0 seconds.
Curriculum Addressed
Science: Heat transfer by radiation
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images that can be imported into PPTs and/or Word documents, and export button to have numerical data placed into Excel documents.
Engineering: Designing a prototype popcorn maker
Mathematics: Unit conversion of Kelvin temperature to Celsius. Unit conversion of cm into meters and inches
Background Information
Almost all objects radiate light naturally as the very small particles that comprise them jostle around. This is known as blackbody radiation. The greater the jostling of particles, the greater the quantity and energy of radiation. This means that hotter objects not only radiate different kinds of light than colder objects, but they generally radiate more light of all kinds than colder objects. This is why temperature makes a huge difference in how much heat an object radiates. For example, a 1000 K filament radiates mostly infrared light and a little red light. We perceive faint red light. A 3600 K filament radiates more infrared light, more red light, green light, and a bit of blue light as well. Our eyes perceive yellow light (red light + green light = yellow light), but this yellow light contains more red than the red light emitted from the 1000 K filament. The blackbody radiation given off by an object is a wide spectrum of light that includes many colors blended together. For example, a prism shows us that sunlight contains different colors (types of light) that our eyes perceive as a single color. Most blackbody radiation is imperceptible to humans, either being ultraviolet light or infrared light. If an object does not glow, it is not hot enough to emit visible light. This is not always the case for other sources of radiation. Microwave ovens create radiation of a particular kind, designed to be easily absorbed by water and other molecules inside food. Fluorescent lighting also creates light of a particular kind, which is why certain clothes can look very different inside a building with fluorescent light compared to outside under the Sun. Because radiation travels as light, it allows transfer of heat without matter. This is why we receive heat from the Sun even though there is almost no matter in space to ferry the heat to us. The heat of the Sun is converted to light, travels through space, and is absorbed by Earth.
Possible Solution

Distance to lens: 54cm
Temperature: 1900K
Red glass

Temperature conversion:
Temperature in K – 273 = Temperature in Celsius
1900 – 273 = 1627 C

54 cm = 0.54m
54cm/2.54 = 21.26 inches

Student Activity

Name____

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What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
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Show Your Data	
Analyze Your Data, What Was The Solution To The Challenge?	

STEM LESSON: GIZMOS - GMOs and the Environment

Best For: AP Biology, Biology

STEM Challenge: You are a farmer whose farm has been in your family for four generations. Over the decades your farm has used pesticides and herbicides with varying amounts of effectiveness. These chemicals have also had deleterious effects on the organism found in the stream near your crops. Thanks to awareness and experience you are a very environmentally conscious farmer who needs to maximize the corn yield over the long term while having the least amount of environmental impact on the stream near your farm. Design a long term (30 year) solution where your farm produces the highest possible yield of corn while having the least amount of negative impacts on the animal populations (50 or more species still exist) that live in the stream. Once the solution is designed, use the Export button to export the data into an excel sheet. Use this data to construct a graph of corn yield per year. Now repeat the experiment with all the same variables except with the herbicide increased to 250 L/ha. Consider your first solution to be the control and your new results to be the experiment group. Export the data from the second experiment and construct a second graph of corn yield per year. By what percentage does the corn yield change? Using the data from both graphs, defend whether the increase in herbicide is worth it. Explains in terms of profit from corn yield differential and environmental impact.
Curriculum Addressed
Science: GMOs, Human Impact on the Environment
Technology: ExploreLearning Gizmo Simulations, the screenshot camera icons to generate images that can be imported into PPTs and/or Word documents, and export button to have numerical data placed into Excel documents.
Engineering: Designing a solution where the maximum yield of corn is produced over 30 years while having the least amount of negative impact on the aquatic wildlife in the stream
Mathematics: Construction a viable argument using mathematics.
Background Information
Two factors that can affect the yield of a corn field are the presence of corn-damaging insects and weeds that compete for resources. Farmers can use chemical herbicides and insecticides to combat weeds and insects, but herbicides can damage sensitive corn plants and both chemicals can harm the environment. One solution to these issues is to use genetically modified crops, or GMOs. GMOs resistant to insects and tolerant of herbicides have been developed.

Genetic engineering is the manipulation of an organism's genome using biotechnology. How this is done is described in the Genetic Engineering Gizmo and Teacher Guide. In this Gizmo, students can experiment with unmodified corn, insect-resistant corn, herbicide-tolerant corn, and corn that is both resistant to insects and tolerant of herbicides.

Besides helping to increase yields, a major advantage of insect-resistant corn is that it reduces or eliminates the need for chemical insecticides. This reduces costs to the farmer and harm to the environment. A potential negative consequence of the use of insect-killing corn is the development of insects that are resistant to the toxin the corn produces. Through natural selection, most of the insects exposed to the toxin would die and a few insects that were naturally immune to the toxin would remain alive. The immune insects would reproduce, eventually creating a population of toxin-resistant insects.

A refuge field, a field with crops that do not produce any toxins and is not treated with insecticide, can be used to combat immunity development. A refuge field gives the insects a place to feed and multiply without being subjected to the selection pressure in the GMO field. Non-mutant insects from the refuge field mate with toxin-resistant insects from the GMO field, keeping the population of toxin-resistant insects low.

The use of herbicide-resistant corn may promote an increase in chemical herbicide use on farms. Chemical herbicides and insecticides can harm the environment. Insecticides may kill invertebrate species that are environmentally beneficial, including spiders that control other insect populations. Pesticides can leach into nearby streams and rivers, killing insects that feed aquatic wildlife and water plants that supply oxygen to those aquatic organisms.

Possible Solution

Resistance Type: Caterpillars and Herbicide
Check box to Add Refuge Field
Herbicide: 80 L/Ha
Insecticide: 0 L/Ha

Corn yield will be ~ 65 tons/Ha
There will be more than 50 species found in the stream

Math component:

Increase of herbicide from 80 L/Ha to 250 L/Ha results in a 32.4% increase in corn yield which will bring in significantly higher revenue. However, the increased herbicide now results in the number of species dropping to around 35 versus over 50 before the fields are sprayed with the increased amount of herbicide over 30 years.

Student Activity

Name____

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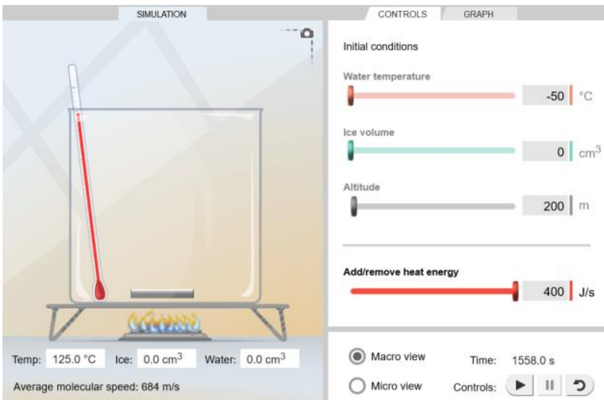
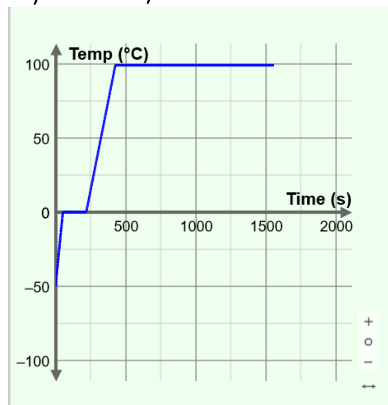
STEM LESSON: GIZMOS - Phase Changes

Best For: Chemistry, Middle School Physical Science

STEM Challenge: Water exists in different phases at different temperatures. Adding heat increases molecular motion and removing heat reduces molecular motion. The amount of molecular motion dictates what phase water exists in. Engineer a 50cc block of ice (representing an iceberg) that melts in less than one minute (take a snapshot of when it happens) and then make water boil at less than 80 degrees Celsius. Consider what you know about Global Warming.
Curriculum Addressed
Science: Explore the relationship between molecular motion, temperature, and phase changes. Compare the molecular structure of solids, liquids, and gases. Explore temperature changes as ice is melted and water is boiled through graphs. Find the effect of altitude on phase changes. The starting temperature, ice volume, altitude, and rate of heating or cooling can be adjusted.
Technology: ExploreLearning Gizmo Simulation (Phase Changes Gizmo); the screenshot camera icons to generate images, which can be imported into PPTs and/or Word documents.
Engineering: Designing a prototype system in the Gizmo simulation that completes the task.
Mathematics: Suggested math tasks for secondary students that accompany this Gizmos 1) Unit conversion from Celsius (^{o}C) to Kelvin (K) Calculation: Temperature in ^{o}C + 273.15 = Temperature in K Example: 0 ^{o}C +273.15 = 273.15 K (freezing point of water) 100 ^{o}C +273.15 = 373.15 K (boiling point of water) 2) Calculating the slope of the line as water transforms from ices to water to gas and making inferences to the molecular motion-taking place. Calculation: Slope =Change in the y-axis/Change in the x-axis Slope =Change in temperature/Change in time Slope= (Y2-Y1)/(X2-X1)

Example: Mount Magazine in Arkansas has an altitude of 200m. Determine what the slope of each portion of line on the graph that will be formed if you heat -50 °C water with zero ice and added heat (you can choose how much heat).
Slope= (Y2-Y1)/(X2-X1)
Slope of the first line in the graph (-50 °C to 0 °C)= (0 - -50)/(52- -0)
Slope of the first line in the graph (-50 °C to 0 °C)= (50)/(52)
Slope of the first line in the graph (-50 °C to 0 °C)= 0.96 °C/s

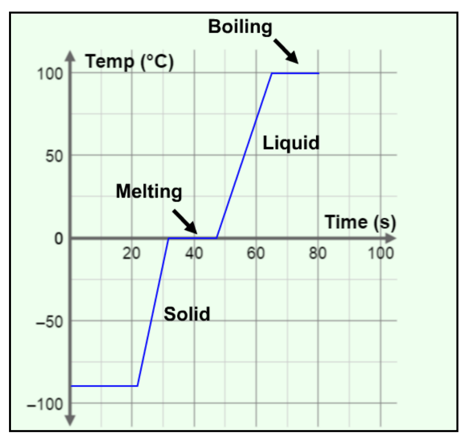




Scientific Background

Matter can exist in several phases, or states. The three states that exist naturally on Earth are solid, liquid, and gas. Plasma is a high-temperature phase that exists on stars. Several other phases have been discovered at temperatures near absolute zero.

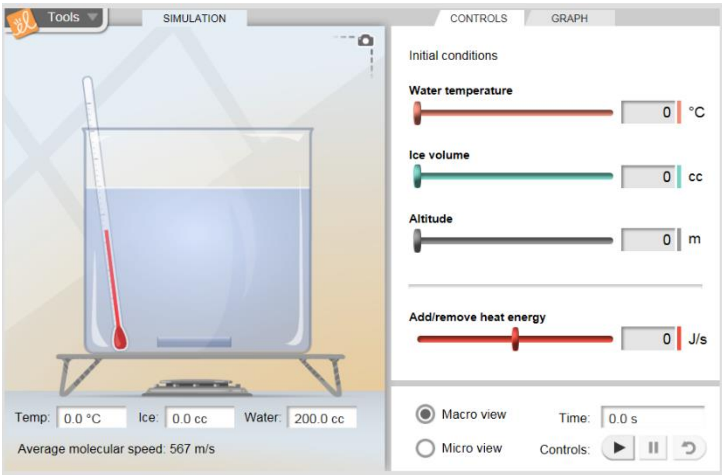
Solids are characterized by atoms or molecules held in a rigid structure. Atoms in the structure may vibrate, but do not move freely. A solid has a definite shape and a definite volume. Liquids are characterized by molecules that are attracted to one another but can still move around so that they take the shape of their container. Liquids thus have a definite volume but an indefinite shape. Gases are characterized by rapidly moving molecules that move and collide freely. A gas will expand to occupy all the space in its container. Gases also can be compressed to a very small volume. Thus gases do not have a definite shape or volume.



When a solid is heated, the atoms begin to vibrate more and more rapidly. Eventually the vibrations are strong enough to break the rigid bonds holding the atoms together, and the solid melts into a liquid. During the melting process, temperature does not increase because the added heat energy goes into melting the solid rather than heating the liquid.

In a liquid, the molecules move at a variety of speeds. The fastest-moving molecules can escape the surface of the liquid and become a gas. This process is called *evaporation*. As the liquid is heated, the average speed of the molecules increases until large bubbles of gas form within the liquid. This is *boiling*. The temperature remains constant during boiling because the fastest molecules are constantly leaving the liquid and escaping as gas.

Cooling produces the opposite phase changes. As a gas is cooled, the molecules slow down until their mutual attraction causes them to clump together and form droplets of liquid. This is *condensation*. When a liquid is cooled, the molecules move slowly enough that they can begin to form rigid chemical bonds in a crystalline lattice. This is *freezing*.
Possible Solution



Water must be at least 70ºC
Altitude at least 6500m
Add Heat Energy to 400 J/s

Student Activity

Name____

The Guiding Question…	
The Claim You Will Make	
What Data Will You Collect?	
How Will You Collect Your Data?	Your Procedure
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SHORE EROSION
BEST FOR: Grades 6-12

Additional forms of erosion:
Erosion Rat:

River Erosion:

Overview

In this activity for grades 6-12, students design a seawall to protect a major coastal highway from erosion by ocean waves and address these questions: Erosion–can you fight it? How much energy is involved with waves and erosion? Can humans stop erosion of the shoreline? Should we? Is it cost effective?

Procedure

Problem Statement
Your engineering team has been charged to submit a bid for a design for a 600 meter seawall to protect a major coastal highway. Your team must design the wall right at the edge of the water. The structure must be able to withstand the impact of the ocean waves. You cannot spend any more money on the project than is necessary, so it is crucial that the team know what materials can be used in construction and how much each material will cost. It is also important to know that there will be no funding available for beach nourishment (replenishment) in the future. Your team will have to give a 10 minute presentation on the seawall design and submit the bid to the Project Manager (teacher).

1. To determine the amount of wave energy, use an equation to calculate the amount of energy based on the height of a wave. First, determine the amount of energy for every square meter of wave, the energy (joules) is equal to 1260.6 times the square of the wave height.

Wave Energy = 1260.6 (Wave Height)2

2. To determine the Total Energy in a wave, calculate the total surface area of the wave and multiply that by the wave energy.

Total Energy = Wave Energy (surface area of wave)

For example, calculate the energy for an average open water wave that is 2 meters high, 7 meters wide and 500 meters long:

Wave Energy = 1260.6 (Wave Height)2
Wave Energy = 1260.6 (2)m2
Wave Energy = 1260.6 (4)m2
Wave Energy = 5042.4 Joules/m2

Total Energy = Wave Energy (surface area of wave)
Total Energy = Wave Energy (7 meters x 500 meters)

Total Energy = 5042.4 Joules/m2 (3,500m2)
Total Energy = 17,648,400 Joules or 1.76484 x 107 Joules

3. For this activity, the waves will be 8 meters wide, and the section of the seawall that the waves will hit is 300 meters long. Determine the highest water height for this month for this location.

4. Calculate the Total Energy of the wave.

5. Using the table of materials below, your team must design a wall to withstand the wave energy calculated above.

Material	Strength	Cost/cubic meter	Amount needed	Total Cost
Natural Rock	30 million joules	$50/cubic meter	900 cubic meters	
Masonry	40 million joules	$150/cubic meter	300 cubic meters	
Wood	4 million joules	$25/cubic meter	2000 cubic meters	
Steel	90 million joules	$225/cubic meter	300 cubic meters	
Concrete	50 million joules	$180/cubic meter	800 cubic meters	

Note: The strength represents how much energy the material can absorb PER WAVE before it structurally fails. The Amount Needed column represents how much material needed to supply the stated strength. For example, a wall of 2,000 cubic meters of wood can absorb a maximum of 4 million joules from each wave that hits it.

6. One of the highest waves in recorded history for this site was 5 meters high. This wave occurred during an exceptionally large storm. Would this information change your design? If so, explain.

7. The following links may be of assistance for research: NOAA pictures of shoreline types; NOAA Beach Nourishment.

8. Using all of this information, create a bid for a design for the seawall project described in the Problem Statement.

Your team must create a 10 minute presentation on the seawall design and submit the bid to the Project Manager (teacher).

When preparing your project, your group might also want to consider if the project will be cost effective, possible alternatives, tourism dollars, etc.

Any mix of materials is allowable, but remember that your bid and presentation will be judged according to:

- calculations
- structural integrity
- projected longevity

- aesthetics
- environmental concerns
- cost

Stopping apple oxidization
BEST FOR: Grades– Prek-KG

Support Resource: Changes in Matter in Science4Us (Matter can change in many ways; some changes alter the appearance, while others create new and different matter. In this module, students explore chemical changes and physical changes, including phase changes, of matter.) Additional activities available for other grades as well.

Supplies Needed:

- apple
- lemon
- knife {for adult use}
- pastry brush
- paper plate
- science journal (see example at the end of activity)
- set of colored pencils or crayons
- pencil

Instructions:
With your child, talk about the apple – **what does it look like? feel like? smell like? is it all one color or are there several different colors on the skin?** – and have her draw what she observes in her science journal.

Then…

- Ask her to **predict** how many seeds there will be inside the apple and have her write the number in her journal or on the preschool science lab sheet.
- Cut the apple in half across the middle so the seed "star" shows inside to make it easier for your preschooler to count seeds.
- Have your preschooler **count** the seeds and record the actual number of seeds.
- Place the apple halves on the paper plate, and **label** them #1 and #2.
- Cut the lemon and let your preschooler squeeze it into a cup and brush juice all over the top of apple half number one with the pastry brush.
- Leave apple half number two plain – this is the **control** apple. Explain to your preschooler that when scientists are trying to figure out the answer to a question, they have one set of materials that they leave alone so they know that the **results** are because of what they did.

- Ask your Student to draw and color what the apple halves look like at the start of the **experiment**, label her drawings #1 and #2.

- Put the apple halves in the center of the table and leave them there for several hours.
- Later, bring your preschooler back to the table with her preschool science journal, and have her **observe** what she sees when she looks at the apple halves and draw and color her observations.
- Then talk to her. Explain that there is oxygen in the air, and when the inside of the apple is exposed to the air, the oxygen causes a reaction, turning the apple brown. The apple skin protects the inside of the apple from oxidizing, so it's important to leave the skin on as long as possible.
- So why didn't the half brushed with lemon juice oxidize? Lemon juice contains citric acid, which is an anti-oxidant. It slows the process of oxidation. So, you can explain to your preschooler that the lemon juice can protect her apple if it's been cut, just like its skin would have.

This is a great experiment to help your student hone her observation skills, learn to make predictions, and to evaluate results.

Draw your apple — what does it look like? Make sure you add a blend of colors.

Prediction	Actual Number

Think about what happens to apples when they are left out. Tell your grown up what you know, and what you think might happen.

Put your two apple halves on a paper plate. Label them #1 and #2. Brush #1 with lemon juice. Leave #2 alone.

Draw what your apple halves look like in the top box in the apple to the right.

Go play for 3-4 hours and then come back and check your apples and draw what they look like after the time has passed.

Predict how many seeds your apple will have and ask your grown-up helper to cut it in half across the middle. Then count them

#1	#2
#1	#2

Take a Note with STEM: Motion **"Measuring Motion"**
BEST FOR GRADE 2

Objective
Students will be able to demonstrate understanding of how the shape of a path can affect the distance it takes to reach a destination.

Curriculum Addressed

Science
- Exploring distance and time

Technology
- Tools for marking and measuring

Engineering
- Creating path designs in different shapes and patterns

Mathematics
- Relate addition and subtraction to length. Use the numbers from students' steps and/or time measurements as data to write class addition and subtraction word problems within 100.
- Use number lines to compare numbers within 100. Have students practice doing addition or subtraction on the number line using the data of number of steps or number of seconds for each path.

Real Connections
- Scientists learn through observation. Direct observation and manipulation of paths, motion, and time will support understanding of the concept.
- Scientists compare and contrast what they observe. Conducting follow-up with all students provides a valuable extension of the observation activity as students will learn from peers' findings/reflections as well as their own. Ask, "What did you learn from the class' results?"
- Collecting and recording data are important science process skills. Organizing data in charts helps illustrate concept understanding. Models can be used to demonstrate scientific concepts.

Essential STEM Skills Include
- Working with peers
- Discussing and exchanging ideas
- Recording and communicating results and findings
- Summarizing experiences and drawing conclusions

Take a Note with STEM: Sound Energy "Piping Up Some Sound Vibrations" BEST FOR GRADE 2

Objective

Students will be able to explain, and demonstrate, how sound energy is matter in motion, and how sounds differ in pitch and volume.

Curriculum Addressed

Science
- Moving matter and the connection to sound energy

Technology
- PVC piping, tuning forks, measuring tools

Engineering
- Designing PVC instruments

Mathematics
- Estimate Length - Have students estimate the length of the different PVC pipes in centimeters.
- Select Appropriate Measuring Tools - Have students choose the appropriate measuring tools (ruler, meter stick, tape measure) to check the length of each PVC pipe in their set.
- Measure to Determine and Compare Lengths - Have students measure and record in centimeters the length of each PVC pipe in their set. Students can then compare the difference in length in any two of their PVC pipes.

Real Connections
- Scientists learn through observation. Direct observation and manipulation of paths, motion, and time will support understanding of the concept.
- Scientists compare and contrast what they observe. Conducting follow-up with all students provides a valuable extension of the observation activity as students will learn from peers' findings/reflections as well as their own. Ask, "What did you learn from the class' results?"
- Collecting and recording data are important science process skills. Organizing data in charts helps illustrate concept understanding. Models can be used to demonstrate scientific concepts.

Essential STEM Skills Include
- Working with peers
- Discussing and exchanging ideas
- Recording and communicating results and findings
- Summarizing experiences and drawing conclusions

Take a Note with STEM: States of Matter **"Matter Collages"**
BEST FOR GRADE 2

Objective
Students will be able to demonstrate that matter is found in three common states or phases and can be modeled, observed, identified, and classified by these states or phases.

Curriculum Addressed

Science
- Classifying matter into the various states (solid, liquid and gas)

Technology
- Digital presentation tools or scissors and glue

Engineering
- Create a model of a particle viewer for all three states of matter

Mathematics
- Add up to four numbers. As posters are being assembled, compare the number of examples of each state of matter found by each group. Have students add up to four numbers using strategies of place value and properties of operations.
- Practice addition and subtraction within 100 using the number of pictures per poster. To solve equations, students may use strategies that include place value, properties of operations, and the relationship between addition and subtraction.

Real Connections
- Scientists learn through observation. Direct observation and manipulation of paths, motion, and time will support understanding of the concept.
- Scientists compare and contrast what they observe. Conducting follow-up with all students provides a valuable extension of the observation activity as students will learn from peers' findings/reflections as well as their own. Ask, "What did you learn from the class' results?"
- Collecting and recording data are important science process skills. Organizing data in charts helps illustrate concept understanding. Models can be used to demonstrate scientific concepts.

Essential STEM Skills Include
- Working with peers
- Discussing and exchanging ideas
- Recording and communicating results and findings
- Summarizing experiences and drawing conclusions