Contents

Informal STEM Education Activities: Suggested Grades K – 3

Topic: Marble Maze

Suggested Grades: 2nd

Essential Question:
How can you and your team design and construct a structural device that allows a marble to travel the longest distance in time and drop into a paper cup?

Scenario:
You and your teammates are asked to design a new rollercoaster ride for the nearby amusement park! The amusement park wants this ride to be long and speedy fast!

Challenge:
Working as a member of a team, design and construct a structural device that allows a marble to travel the longest distance in time and drop into a paper cup.

Tools & Materials:

Purchases/Rentals	Materials/Tools	Cost
	16” x 16” cardboard	5 credits
	Cutting Tool	2 credits
	12” Masking Tape	1 credit
	3 – Drinking Straws	2 credits
	Hot Glue Gun and Glue	2 credits (rental)
	3” Tube	2 credits

*The cup and marble will be supplied for each team
*****Please return all undamaged materials and all rental tools at the conclusion of the contest

Big Ideas:
Problem Design and Troubleshooting

Limitations:
To complete this design activity successfully, your team must adhere to the following design parameters:
The structure must stand on its own;
Once the marble is in motion, no human interaction is allowed;
Your team must use no more than 15 credits to purchase the materials needed to construct the device;
Two timed attempts (marble runs) will be given upon contest completion. The slowest time will be recorded; and
The design and construction of the structure must be completed in the time allowed.

Assessment:
The team with the structural device that travels the longest distance in time and drops into the cup first will win!

Topic: The Tall Tower

Suggested Grade Level: Grades 2 - 3

Essential Question:
How can you and your team design the tallest tower that will hold five golf balls but weigh no more than 35 grams?

Scenario:
The Tall Tower challenge explores the design of tall structures such as skyscrapers and telecommunication towers.

Challenge:
Given the **materials, rules, and judging criteria** below, design and construct the tallest tower that will hold/support five regulation-size golf balls that does not weigh more than 35 grams.

Tools & Materials:
The following list of materials may be used to construct your tower. However, no other materials may be added to the list.

- 10 pieces of .125 x .125 x 36” balsa wood
- Glue

Big Ideas:
Problem Design and Troubleshooting
Communicating and demonstrating the solution as a team

Limitations:
Your team must complete and submit the following to be considered an eligible competitor in this event:
Finished tower with golf balls (Note: golf balls must not be glued or fastened in any way to the tower)
A portfolio, which includes

- A written description of how your team solved the problem
- A graphic explanation of how your team worked through the design and problem solving process, identifying each step
- Other material your team feels is pertinent to this problem

Assessment:
Each finished solution will be judged using the following point schedule:
15 points for the finished tower
15 points for the portfolio
5 points for aesthetic appeal

Informal STEM Education Activities: Suggested Grades 3 – 5

Topic: The Motorcycle Stunt

Suggested Grade Level: Third Grade

Essential Question:
Can you design a flying vehicle to accomplish the greatest linear distance from the end of a motorcycle?

Scenario:
The teacher will ask the students, "How many of you have ever wanted to drive in a vehicle that will fly?" "Do you think you could design a vehicle that could fly?"

Challenge:
Working as a member of an engineering design team, design a vehicle that will fly (airborne) for the greatest linear distance from the end of a motorcycle ramp.

Tools & Materials:

Purchases/Rentals	Materials/Tools	Cost
	1 – Cutting tool	2 credits (rental fee)
	1 – Scissors	2 credits (rental fee)
	1 – Plastic ruler	2 credits (rental fee)
	4 – Plastic push pins	2 credits
	1 – 24" length masking tape	2 credits
	2 – Axles & 2 wheels	4 credits
	1 – Plastic spoon	3 credits
	1 – Plastic straw	3 credits
	1 – 8.5"x11" card stock paper	3 credits
	1 – 8.5x11" printer paper	3 credits
	1 – Golf ball	3 credits
	4 – Metal paper clips	3 credits
	1 – 24" length of woven string	3 credits

Note: Materials are credited to teams on a first-come, first-served basis. There is no implied guarantee that sufficient amounts of any given material will be available for all teams. Please return all undamaged materials and all rental tools at the conclusion of the challenge so they may be recycled.

Big Idea:
Communicate and demonstrate the solution with others
Fundamentals concepts of science, technology, engineering, and mathematics

Limitations:
To complete this engineering design challenge successfully, teams must strictly adhere to the following design parameters:

Teams will be allowed 45 minutes to: Brainstorm, conduct ideation, make sketches, test theories, obtain tools/materials, and build a working prototype that solves the design challenge described above;
Teams will select materials and tools identified in Figure 1 below. Additionally:
Teams will begin the challenge with 15 credits. These credits will be used to purchase or rent the tools needed to construct the vehicle (see figure 1 below);
The vehicle must be roll freely down the test ramp without human assistance, must be portable, and must be clearly labeled with the names of team members & school;
The vehicle must be propelled by the forces of gravity alone and must be constructed of materials supplied for the contest;
Vehicles deemed unsafe by the judge will not be tested (judge's decision is final).
Once the completed prototype vehicle is placed into position on the test ramp and released, the vehicle must complete the remainder of the stunt unassisted by human intervention.
Additionally:
Three vehicle jumps will be allowed. The greater distance will be recorded;
Gravity enhancement or flight enhancement devices are allowed.
Teams may reassemble vehicles that disassemble during testing, but additional repairs/modifications will not be allowed between jumps.
Detachable components/elements are also allowed, but the final distance travelled will be measured from the end of the ramp to the primary surface mass of the vehicle.

Assessment:
Students will be evaluated on their participation how well their device works (accuracy).

Topic: Hovercraft

Suggested Grade Level: Grades 3 – 5

Essential Question: How can you design a device that will hover in the air for the longest amount of time over different terrains?

Scenario: Captain America needs a hovercraft to help him travel across the globe. He needs your help to design a device that will keep him airborne for the longest amount of time over different terrains.

Challenge: As part of an engineering design team, you will need to work together to build a suitable structure for Captain America to use in traveling around the globe. This device must keep him hovering in the air for the longest amount of time and be able to move over different forms of terrain.

Tools & Materials:

Old CD's
Styrofoam Bowl
Round Balloons
2-liter bottles with caps
Binder Clips
Hand Saw/Scissors
Hot Glue Gun
Hand Screwdriver
Paper Clips
8 Inches of Tape
1 Sheet of Paper

Big Ideas:
Forces and Balance
Problem Design and Troubleshooting

Limitations:
The students will use only the materials provided; however they do not have to use all the materials.
The hovercraft design must be transportable to different terrains i.e. grass, wood, water
Teams may test their hovercraft as many times they would like during the design and construction phase of the event, however teams will only have three attempts once official testing has begun on each of the different terrains provided.
The hovercraft must be a consistent height of ten inches.

Assessment:
The hovercraft that stays afloat the longest time on all types of terrains will win.
In the case that one single hovercraft does not succeeded on all terrains, the engineering design team whose hovercraft who holds the longest record on each terrain will win.

Topic: Potential and Kinetic Energy

Suggested Grade Level: Grades 3-6

Essential Question:
How can you design a kinetic motion machine that will toss a Ping-Pong ball at least 30 inches into the air, catch the ball at that height, and then release the ball on command?

Scenario:
In an effort to further your understanding of potential and kinetic energy, create a machine that will toss a Ping-Pong ball at least 30 inches into the air, catch the ball at that height, and then release the ball on command.

Challenge:
During this activity, you will be required to work in problems solving teams to design and build a kinetic motion demonstration machine. As you design and build this device, you should take care to follow the design process outlined below:
Read the problem statement and formulate potential solutions.
Consider the steps in the problem solving process: Identification of the problem, Develop several alternative solutions, Evaluate alternatives and decide on prototype, Apply and test your design (IDEA).
Be creative. You have been given general limited materials but you have been given unlimited possibilities to solve the problem.
If at first you don't succeed, don't give up! Remember that almost all inventors experience some type of failure before they finally succeed.

Tools & Materials:
- 2 mousetraps
- 30 inches of masking tape
- 50 inches of string
- 4 large rubber bands
- 1-yard stick
- 2 paper cups
- 2 paper plates
- 1-12" piece off aluminum foil
- 5 sheets of typing paper
- 1 coat hanger
- 1 Ping-Pong ball
- 5 paper clips
- 4 tongue depressors

Big Ideas:
Potential and Kinetic Energy
Problem Design and Troubleshooting

Limitations:
All designers must strictly adhere to the following design parameters to successfully complete this problem:

Designers must not touch the ping pong ball in any way after the device is set in motion;
Designers may only touch the launch device when directly to do so by judges (e.g., when asked to release the ball)

The energy used to move the ball must come from the launch device and not from a human starter
Design teams will have three attempts to accomplish the given task.

Assessment:
Your success (or failure) in this activity will be evaluated according to the criteria listed below.
Operation: (30 points) Did the kinetic machine propel the Ping-Pong ball the required 30 inches?
The Catch: (10 points) Did the kinetic machine catch the Ping-Pong ball at the 30-inch mark after it had been launched?
Aesthetics: (10 points) Was the kinetic machine well designed and neat?
Design Planning: (30 points) You will be awarded 30 points for prototype sketches and written descriptions of your solution (use blank sheets provided by the judges).
Summary Questions: (20 points) You will be awarded 20 additional points for successfully answering the summary questions listed below.

Note:
The summary questions and the design planning pages should be submitted as a portfolio or package when the machine is completed and submitted for testing.

Summary Questions:
Please provide answers to each of the questions listed below.

1. What mechanical systems were considered in your solution to the problem?

2. What scientific principles are demonstrated in your solution?

3. Specifically identify the process you used to arrive at your solution?

4. How could you improve your solution to the problem if you had the opportunity to start over?

Topic: Stop the Drop

Suggested Grade Level: 4 - 5

Essential Question: Can you build a device that will slow the decent of a ping pong ball dropped from a height of ten feet?

Scenario:
The teacher will "hook" the students by asking them, "have you ever tried to prolong the time it takes for an object to fall?" "How many of you think you could build a device to help prolong the amount of time it takes for an object to fall?"

Challenge:
Working as a member of a team, construct a device that will slow the decent of a ping pong ball dropped from a height of ten feet. The objective is to build a device that takes the longest period of time to fall from a height of 10 feet (with the ping pong ball). The completed device will be released or launched by a contest official. Therefore, you must make certain that the completed device is not dependent upon your personal assistance.

Tools & Materials:
As teams begin this activity, they will be provided with 10 credits—which can be used to make all necessary purchases. Teams may purchase and use any of the materials listed below to construct a solution to the problem as long as they do not exceed the 10-credit budget limit. Tools (e.g. glue guns and glue, scissors, razors, etc.) may be rented using the same credit system. As teams make decisions to purchase materials or rent tools, they should bring this sheet to the instructor so that all purchases may be recorded. Take care when making purchases and renting tools because once credits are used, ***teams will not be re-credited.***

Purchases/Rentals	Material/Tools	Cost
	1/8" X 1/8" Balsa Strips	2 Credits (per strip)
	Hot Glue Gun & Glue	2 Credits (rental fee)
	Scissors	1 Credit (rental fee)
	4 Large Rubber Bands	2 Credits
	1 Paper Cup	2 Credits
	1 Sheet Flip Chart Paper	4 Credit
	1 Sheet 8-1/2" X 11" Paper	1 Credit
	12" Piece of Masking Tape	1 Credit
	1 Plastic Drinking Straw	1 Credit
	1 Ping Pong Ball	2 Credit
	12" Cotton String	2 Credit

Note: Please return all undamaged materials and all rental tools at the conclusion of the session so that they may be recycled!

Big Idea:
Following the completion of this design activity, the student will be able to:

- Apply knowledge of scientific and technological concepts to the solution of design problems;
- Work cooperatively as a member of a team to solve the given design problem;
- Practice using the problem solving process to solve given problems;
- Describe Newton's Laws of Motion;
- Demonstrate Newton's Laws of Motion using the device constructed in class.

Limitations:
To complete this design activity successfully, your team must adhere to the following design parameters:

- You must work in teams of two or three (as designated by TSA contest rules) to solve the design problem;
- Teams must provide drawings that illustrate the design process undertaken during the problem solving activity;
- Your team must use no more than 10 credits to "purchase" the materials needed to construct the device;
- The design, construction, and testing of the prototype must be completed within the designated contest period;
- The ping pong ball must remain intact and undamaged during the fall;
- During the final testing, you will have three opportunities to test the device. The best (longest) time will be recorded as your final result.

Assessment:
This design activity will be evaluated according to individual team solutions. Team grades will be based on the score achieved and points accumulated in the evaluation criteria listed below:
Design Creativity (30 points): Did the team provide evidence of design and problem solving creativity (see item #2 above)?
Descent Score (10 points): Teams will receive ten (10) points for each additional second that the device remained afloat.
Quality (10 points): Points will also be assessed according to overall aesthetic quality (How it looks) of the completed device.
Teacher Overview: During the completion of this activity, students will be working in groups of two or three to solve the stated design problem. You should prepare students for this activity by discussing appropriate problem solving strategies (see "design loop" listed above). After discussing this (or other) problem solving method(s), spend a few minutes of class time preparing the students for the activity. During this time, you should: (1) State the evaluation criteria; (2) Discuss appropriate team work strategies; (3) Provide each team with a written copy of the problem and state the problem; (4) Provide each team with a materials purchase list; and, (5) Provide each team with time limits for completing this activity. After the students have begun the activity, you will need to layout a section of the class as a testing space. You will need a step ladder for testing purposes. Make certain that you are present at all times when students are using the step ladder. Allow each team the opportunity to test their device several times before the actual test (this will involve your assistance). Much can be learned through the test and evaluation process.

Topic: Transportation

Suggested Grade Level: Grades 3-6

Essential Question: How can you design a vehicle that will quickly carry a clothespin a distance of twenty feet in a relatively straight line?

Scenario: Your school is interested in developing a new transportation system to move students rapidly between their homes and the school.

Challenge:
Using the materials you were given, you and a partner will design and construct a prototype vehicle that will travel under its own power or under a self-contained power source. The vehicle must carry a payload (clothes pin) a distance of twenty feet in a relatively straight line from the starting point.

Estimated Project Time: 1-½ hours of construction - 1 hour for testing

Tools & Materials:

- 2 soda straws
- 2 straight pins
- 12" of tape
- 1 clothespin
- 3 balloons
- 4 rubber bands
- Fishing line
- 1 sheet 9 x 12" construction paper
- Glue
- 2 paper clips

Cost of Materials:
Approximately $5.00 for 10 sets of materials

Big Ideas:
Propulsion and Guidance System
Problem Design and Troubleshooting

Limitations: You may use only the materials contained in the packet. Materials may be modified by combining, forming, or separating.

Assessment: The vehicle reaching its destination in the shortest possible time will determine success.

Activity Procedures:
Read the problem statement and formulate in your own mind what is necessary to construct a solution.
Consider the steps in the problem solving process: Identification of the problem, Develop several alternative solutions, Evaluate alternatives and decide on prototype, Apply and test your

design (IDEA). There are many other models of problem solving but this one is short, contains the essential elements, and is easy to remember.
Be creative. You have been given general limited materials but you have been given unlimited possibilities to solve the problem.
Consider various ways to propel and guide your vehicle.
If at first you don't succeed, don't give up! Remember that almost all inventors experience some type of failure before they finally succeed.
Keep your ideas to yourself. You don't want to "leak" corporate secrets.
Be prepared to discuss your solution with the class. (Student reporting may contain working drawings, description of problem solution, graphing speed/time of vehicles, etc.)

Activity Analysis and Follow-up Discussion:

1) What two mechanical systems must be considered in order to solve the problem?

2) What scientific principles are demonstrated in your solution?

3) How did you arrive at your solution? Did you consciously apply the problem solving process? Why or why not?

4) What worked and what didn't? Why do you think so?

5) How did your vehicle fit the transportation taxonomy? On a sketch, identify the relationship between your vehicle and the transportation taxonomy.

6) How could this activity be part of a larger Math/Sc/Tech unit?

7) What propulsion systems are used for other LAWS transportation vehicles (land, air, water, and space)?

8) What guidance systems are used for other LAWS transportation vehicles?

Topic: Fix the Leak

Suggested Grade Level: Fourth Grade

Essential Question: Can you identify where and why the valve is leaking?

Scenario: The teacher will ask the students, "How many of you have had a bad leak at your house?" "Do you think you could fix the leak?"

Challenge: Work in groups of 3, to brainstorm ideas as to why the valve is leaking. First, identify where the leak is on the mechanism. You will be given 4 valves that are not in operable condition, meaning that they all have leaks. It is up to your team to think critically and justify your reasoning as to what should be done or which piece(s) need to be repaired. Record all symptoms, and after testing, your team will be required to create guide listing several symptoms as well as their corresponding remedies. After your team has agreed that the appropriate troubleshooting measures have been taken, test the unit at the sink area. Continue until all valves have been diagnosed properly.

Consider the following:
Are we thinking critically about the problem, or just guessing until we get it right? Remember, in the "real world", time and materials cost $$$.
What tools and equipment would I need to repair this and/or inspect the valve?

Tools & Materials:
Safety approved eyewear
Leaky water valves (4)
Tools- Adjustable wrenches, screwdrivers
Durable work surface
Rubber O-Rings, Misc. Replacement hardware, etc
Thread tape
Wire brush
Hose attached to water source (sink)

Big Idea:
- Communicate and demonstrate the solution with others
- Fundamentals concepts of science, technology, engineering, and mathematics

Limitations:
Must be completed in 3 class periods, working as a group.
Do not simply guess at the problem, but use deductive reasoning skills to come to conclusions and perform experiments.
Each group will submit a word processed chart detailing typical symptoms of the leaking valve, and ways to remedy them.
Each group will create a sketch of the components involved in a fully operable valve system, with proper labeling.

Each individual will turn in a minimum of one paragraph observation of this activity, answering follow-up questions.

Assessment:

1. Completed all work neatly, including details in a technical manner

   5 4 3 2 1

2. Observed safe behaviors and cooperated with group

   5 4 3 2 1

3. Submitted all requirements found in the GUIDELINES on time and complete

   5 4 3 2 1

4. Use of scientific reasoning skills instead of "blind guessing"

   5 4 3 2 1

Total ______/20pts

Topic: That Blows!

Suggested Grade Level: Fourth Grade

Essential Question: Can you design and build a wing-powered vehicle composed of miscellaneous recycled materials?

Scenario: In this lab activity, students will experience concepts related to wind powered transportation systems. These concepts include propulsion (moving the vehicle forward) and guidance systems (directional control). Students will also have the opportunity to creatively solve a transportation problem by creating an experimental vehicle out of miscellaneous recycled materials. This activity should take approximately four class periods. Prior to vehicle testing, you should procure a 3-speed box fan, a steel carpenter's tape measure, and mark a track on the floor. The track should include a starting point, a required distance point, and a center line.

Challenge: During this activity, you will be required to work in teams (assigned by your instructor) to design and build a wind-powered vehicle. As you design and build this vehicle, you should take care to follow the design procedures and parameters listed in the following paragraphs. When designing and constructing your vehicle, you should consider the each of the design procedures listed below:

- Read the problem statement and formulate potential solutions.
- Consider the steps in the problem solving process: Identification of the problem, Develop several alternative solutions, Evaluate alternatives and decide on prototype, Apply and test your design (IDEA). There are many other models of problem solving but this one is short, contains the essential elements, and is easy to remember.
- Be creative. You have been given general limited materials but you have been given unlimited possibilities to solve the problem.
- Consider various ways to propel and guide your vehicle.
- If at first you don't succeed, don't give up! Remember that almost all inventors experience some type of failure before they finally succeed.
- Keep your ideas to yourself. You don't want to "leak" team secrets.
- Be prepared to present and describe your solution in class.

Tools & Materials:
Recycled Materials (students can bring them from home)
3-speed box fan
steel carpenter's tape measure
marker to mark the track

Big Idea: Upon completion of this activity, the student will have developed a wind powered vehicle that is capable of traveling at least 24 inches (or farther) in a straight line.

Limitations: The vehicle can be designed and constructed from any "post-consumer" recyclable materials (have been previously used). For example, you could use an empty soft drink can however, you could not use a full soft drink can. You may use materials available in the classroom, the school, or materials that you bring from home. However, your instructor must approve of all materials prior to their usage. You may use only hand or power tools supplied by your instructor. The vehicle must be no larger than 2’x2’x2’ (designed to fit within a 2 foot cube). The vehicle must be designed to be solely powered and controlled by wind power. For example, you may not use rubber bands, mouse traps, electric motors or any other means of steering or locomotion. During vehicle testing, the vehicle will be placed one foot in front of a box fan and released. After the vehicle is released, it cannot be touched or disturbed until the testing is complete.

Assessment: Your success (or failure) in this activity will be evaluated according to the criteria listed below.

- Operation: Did the wind-powered vehicle travel the required distance?
- Speed: Did the wind-powered vehicle achieve an acceptable performance rating?
- Aesthetics: Was your wind-powered vehicle well designed and neat?
- Planning: You will be awarded 30 points for prototype sketches and written descriptions of your solution (use worksheets provided by your instructor).
- Summary Questions: You will be awarded 20 additional points for successfully answering the summary questions listed below.

Summary Questions: Please provide answers to each of the questions listed below.

- What mechanical systems were considered in your solution to the problem?
- What scientific principles are demonstrated in your solution?
- Specifically identify the process you used to arrive at your solution?
- How could you improve your solution to the problem if you had the opportunity to start over?
- What ideas did your classmates use that could have been beneficial in your design?

Prototype Testing: The wind power will be created through the use of a box fan provided by your instructor. After the vehicle is placed at the starting point (one foot in front of the fan), the fan will be switched to the “low” speed position for a period of five seconds. After the initial five second period, the fan will be switched to the “medium” position for an additional five seconds. Finally, the fan will be switched to the “high” position for the duration of the trial (until the vehicle comes to a complete stop and sits without motion for 10 seconds). The vehicle must travel at least 24 inches however, you should attempt to design a vehicle that will travel much further. The “performance rating” of your vehicle will be evaluated according to the distance the vehicle travels subtracted from the distance the vehicle strays from the center line. Distance will be measured from the starting point (tape on the floor) to the point where the vehicle came to rest. Additionally, one inch will be subtracted from the total distance traveled for every inch that the vehicle strayed from the center line of the test track. This final figure will result in the vehicles “performance rating”. For example, if the vehicle traveled 48 inches but, strayed from the center line 12 inches, the performance rating would be calculated to be 36 inches.

Topic: Simple Machines

Suggested Grade Level: Fourth Grade

Essential Question: Can you build a device using the six simple machines using the least possible force to lift a 25 pound weight from the floor to a height of six inches?

Scenario: Almost every task performed by humans is accomplished by using various combinations of the six simple machines. The six simple machines include: The lever, pulley, wheel and axle, inclined plane, wedge, and screw. Recently, your technology teacher has mentioned that it is difficult to demonstrate these machines to students and you would like to help.

Challenge: Using as many of the six simple machines outlined above and described on the following page, build a device that will (using the least possible force) lift a 25 pound weight from the floor to a height of six inches. Additional points may be earned by the team for successfully lifting additional weight.

Tools & Materials:

Miscellaneous wood
Screws/nails
Paper and cardboard stock
String/Twine
Pulleys
Bolts/nuts
Glue guns and glue

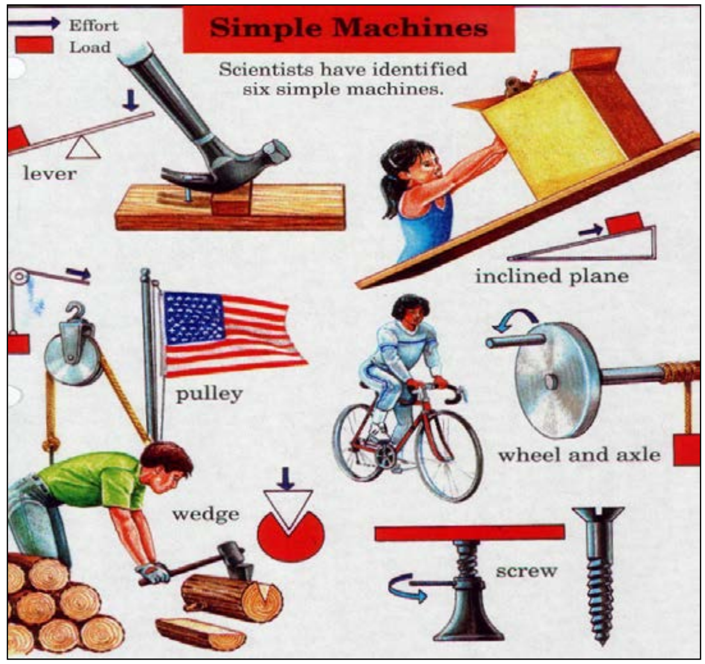
Big Idea:

- Understanding of the six simple machines
- Communicate and demonstrate the solution with others
- Fundamental concepts of science, technology, engineering, and mathematics

Simple Machines

The six simple machines are the primary machines that can be found in even the most complex machines. The 6 simple machines are:
Pulley: This simple machine reverses the direction of a force, and when multiple pulleys are utilized in conjunction with each other, less force is required to lift an object. The one downside of using multiple pulleys is that the rope's end must move across a longer distance than the object being lifted.
Wheel and Axle: Setup such that the axle is connected to the center of the wheel. This allows the wheel to be set in motion once the axle starts to turn.
Lever: This machine is such that when downward motion is applied at one end, upward motion is created at the other end.
Inclined Plane: This machine allows for an object to be moved vertically without being lifted.
Wedge: This machine allows motion from objects such as hammers to be transferred into a breaking, cutting, or splitting motion.

Screw: This simple machine is crafted in such a fashion to where a groove that wraps around a central material in the shape of a spiral. When placed into a slot that fits the screw's groove and shape, this allows for rotary motion.



Limitations:
To adequately answer this design problem, your team will need to strictly adhere to the following design criteria:

- Design teams must use only materials and tools supplied at the beginning of the design challenge.
- Completed prototypes must (at a minimum) use three simple machines.
- Completed prototypes must be submitted with a credible sketch of the device.
- Completed prototype must be safe during product testing.
- Completed prototype must be capable of lifting the weight to a height of six inches (from the floor) and hold for at least two (2) minutes
- Completed prototype must include labels for each of the simple machines (note: simple machines may be used more than once).
- Completed prototypes must utilize the least possible input force to accomplish the task.

Assessment:

CRITERIA	25 points	20 points	15 points	10 points
Input Force Required	The product required less than 25 pounds of input force to operate	The product required less than 50 pounds of input force to operate	The product required less than 75 pounds of input force to operate	The product required more than 75 pounds of input force to operate
Product Design	Clear evidence of extensive design, troubleshooting, testing, and refinements (used the design loop).	Clear evidence of design, troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence that the team used any features of the design loop.
Product Function	Product functions exceptionally well and achieves needed height	Product functions well and achieves needed height, but does not remain at height for two minutes	Product operates, but does not achieve needed height or meet time requirement	Fatal flaws in product. Does not function properly or is unsafe
Six Simple Machines (labeling, sketches)	Demonstrated a great deal of knowledge related to six simple machines	Demonstrated some knowledge of six simple machines	Exhibited only slight understanding of six simple machines	Clearly did not understand the basic principles of the six simple machines

Topic: A Long Slow Drink!

Suggested Grade Level: 4th Grade

Essential Question:
How will you and your team use recycles materials to build a model water filtration system that can be used to remove particulates from polluted water in almost any developing nation?

Scenario:
Although many Americans take it for granted, a clean glass of water is rare in many developing countries around the globe; water supplies are threatened in most developing nations by ground water contaminants, chemical runoff, pollution, poor sanitation, and particulate contamination. Some suggest that adequate supplies of pure, clean and safe drinking water will become a worldwide problem in the next twenty years.

Challenge:
Although the process of cleaning drinking water can be quite complex, sometimes it is just a matter of removing small particulates from the polluted water. However, the problem is compounded by the fact that most citizens in developing nations do not have adequate funds to purchase water-cleaning systems or even purchase the materials needed to build a water filtration system. Your task is to use recycled (free) materials to build a model water filtration system that could be used to remove particulates from polluted water in almost any developing nation. While your model will not likely remove all chemicals from the polluted water, it should demonstrate how a device could be used to remove particulates from collected water.

Tools & Materials:

- Sand
- Miscellaneous plastic jugs
- Plastic straws
- Charcoal briquettes
- Cotton
- Paper and cardboard stock
- Masking tape
- Hot glue gun and glue
- Miscellaneous fabric
- Stop watch for product testing

Big Ideas:

- Design and Troubleshooting
- Clean drinking water

Limitations:
Each team will be provided with 12 ounces of contaminated water (one to test with and one to be evaluated with).
Design teams must use only materials and tools supplied at the beginning of the design challenge.

The completed filtration system must filter at least 12 ounces of water and include a "catch basin" for the filtered water.
The catch basin must be removable so that the filtered water can be tested by the contest judges.
The filtration system must completely filter the 12 ounces of water in less than one (1) minute.

Assessment:
The contest judges will evaluate the filtered water for impurities. The final score will consist of combined scores for product design, function, and the estimated number of impurities or particulates remaining in the water sample.

High scores will determine team scores across the three (3) evaluation components listed below. The combined score will be recorded as the team score.

CRITERIA	30 points	20 points	15 points	10 points
Product Design	Clear evidence of extensive design, troubleshooting, testing, and refinements (used the design loop).	Clear evidence of design, troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence that the team used any features of the design loop.
Product Function	Product functions exceptionally well	Product functions well and did filter the water to some degree	Product operates, but does not function very well	Fatal flaws in product. Does not function properly or is unsafe
Particulates	Filtered water sample contained few remaining particulates	Filtered water sample contained some remaining particulates	Filtered water sample contained numerous remaining particulates	Water did not appear to have been filtered or had multiple remaining particulates.

Team Name: ____ **Total Score: _________**

Topic: Snowball Sling

Suggested Grade Level: 4-5

Essential Question: Using the materials and tools provided, how can you construct a mobile launching device that will be able to fling an object and hit the specified target?

Scenario: It's the middle of winter and you and your friends have decided to have a snowball fight. You both build you snow forts and begin! You now need to construct a device that will throw snowballs at your friend's fort and help you win the game!

Challenge: Participants will work in teams of three to design and prototype a launch device that will shoot a small bean bag about eight feet through the air and hit a target as accurately as possible. The completed device must be mounted to a base that can be transported to the testing area. The bean bag must be launched and cannot be thrown.

Tools and Materials:

Cardboard launch pad base (12"x12")	1 - Bean bag (to be shared among teams)
4 - Large rubber bands	4 - Wooden tongue depressors
4 - Plastic head push pins	2 - Sheets construction paper
2 - Spring clothes pins	6 - Inches masking tape
1 - Plastic cup	Misc. tools (scissors, pliers, ruler, etc.)

Big Ideas:

- Students will be able to understand the components of building a device for a specific purpose.
- Students will be able to understand the components of air resistance, gravity and mass of the object and how it will affect the outcome of the launch device.

Limitations: All teams must adhere to the following limitations

1. The student teams will use only the materials provided, however they do not have to use all materials.
2. The completed launch prototype must be designed in such a way as to be transported to the testing area (an 8 foot table with a target at one end).
3. Teams should make certain that the prototype includes space for at least two spring clamps.
4. Teams may test the device as many times as possible during the design and construction phase of the event, however teams will only have three attempts once official testing has begun.
5. The bean bag cannot be thrown.
6. The target will resemble a dartboard and scoring will be recorded in a similar fashion to the game of darts.

Assessment:

The device that records the three most accurate launches (hits the center of the target the most consistently) will win. In the event of a tie, the target will be moved a greater distance.

Topic: Catapult Transportation Device

Suggested Grade Level: Grades 4-6

Essential Question:
How can you design a mechanical device that will catapult a Ping-Pong ball from a designated location (a table will be provided) toward the established target area (positioned flat on the floor)?

Scenario:
The design-based problem solving method involves the student (you) in developing a technical solution to a given problem. This activity will require you to use your problem solving skills to create a device that meets all parameters listed below.

Challenge:
Groups will design, construct, and test the catapult in the allotted time. Each team will be given two minutes to catapult their Ping-Pong ball as many times as they can to hit the target area.

Tools & Materials:

1 - Mousetrap	3 - Balloons	2- Plastic Spoons
1 - Ping-Pong Ball	4 - Rubber bands	1 - 6” x 6” Cardboard
1 –3/8” x 12” Dowel Rod	1 – 7/8” x 12” Dowel Rod	12 - Craft Sticks

Note 1: Handsaws will be available to cut dowel rods.
Note 2: Cutting tools and glue guns will be made available at a central location. Please follow safety guidelines established by your teacher when using the tools.

Big Ideas:
Forces and Motion
Problem Design and Troubleshooting

Limitations:
The catapult device must be located at least 10’ away from the target for Level 2 teams and 5’ away for Level 1 teams. The target area will be a 3’ diameter “bulls-eye” (tape on the floor) with an outer, middle, and inside rings.

Assessment:
The winner will be the team that most accurately hits the target the most during the time allowed.
Inside ring counts 50 points
Middle ring counts 25 points
Outside ring counts 10 points

Topic: Fishing Kit
Suggested Grade Level: 5th Grade

Essential Question: How will you and your partner design a fishing kit that will effectively catch fish for a food source in an environmentally safe way?

Scenario:
West African people live in a fishing community. Many of their jobs are being lost to large corporations and to personal diseases however, as they are facing widespread AIDS epidemics. While research is currently taking place to find better ways to combat the social and economical conditions, and with several approaches to solving the lack of available health care resources, many West Africans are losing their resources to fish, the primary source of food and income for their families.

Challenge:
Develop a basic fishing kit that could be used to effectively catch fish as an environmentally, as well as human safe food source, and may be used by any age, using only basic items that can be found around the house or small, underprivileged village. Work in pairs to complete this activity. Research and brainstorm ideas- *what* and *why* you might or might need for a basic fishing kit?

Tools & Materials:

- Empty film canisters
- Washers, nut, etc.
- Monofilament string
- Used thread spools
- Safety pins, paperclip, etc.
- Clothespins, Styrofoam, reusable containers, etc.
- Cloth
- Any other item that is free, recycled, **or** already used

Big Ideas:
Problem Design and Troubleshooting
Using limited recourses

Limitations:
1. Kit must be suitable for any age.
2. Must be compact and easily portable.
3. Must be made from items that are easily obtainable and: free, recycled, **or** already used.
4. Must not be harmful or unsafe to humans or environment.
5. Each group will submit a one-page paper rationalizing how you came to your end result.

Enduring Understanding: (*using STL 5*) Students will be able to solve natural problems using technology; they will be able to design systems and products that are environmentally conscious, through reuse, recycling, and/or reducing waste.

Assessment:
The ability to solve problems based on designing a solution that is suitable for a specific real world problem that helps local populations improve their quality of life is known as "appropriate technology." This refers to instances when basic needs are being met, such finding ways to reduce poverty, become more educated, or to satisfy hunger, thirst, healthy living, or simply creating a safe place to live.

Assessment Rubric:

5	4	3	2	1
Materials used are safe for humans and environment, made using only types of items limited to	Questionable materials, mostly adhering to types and limitations	Did not follow guidelines for types of material used, product might still work though	Did not follow guidelines for types of material used, product will likely not be useful	Did not complete project, did not follow any limitations
Worked thoroughly with group and listened to each others ideas	Participated as a group well	Stayed on task most of time	Was not cooperative as a group	Did not complete project
Insightful and argumentative with reasoning approach in reflective paper, clear evidence of brainstorming	Used some insight and reasoning skills, evidence of brainstorming, a little sketchy	Some valid arguments, not complete thoughts, some evidence of brainstorming	Little or no evidence of brainstorming or effort, reasoning lacks validity	Did not complete this part
Suitable for any age, easy to make and use	Suitable for any age, fairly easy to make and use	Suitable for most ages, moderately difficult to make and use	Suitable for few ages or difficult to make and use	Not possible to make or use

TOTAL____ / 20 pts

Topic: Something Old and Something New

Suggested Grade Level: Fifth Grade

Essential Question:
Using the design criteria listed below as your guide, develop a prototype of a marketable product that utilizes a used film canister as a primary component. Ultimately, your task is to help remove one product from the waste stream and create a useful product at the same time.

Scenario:
For over twenty years, Fred Murphy has operated the local camera supply and film developing company in your hometown. Recently, Mr. Murphy has become concerned about the amount of waste material created from his business. He read a newspaper story that suggested packaging materials, although only used for a few minutes, where a major contributor to the materials placed in landfills. After considering his own business, he was alarmed at the number of film canisters he placed in the waste-stream every day. These film canisters are made from a heavy plastic material and should be suitable for some additional use. He had to something. After developing a few of his own ideas for reusing the canisters (see figure 1.), he decided that he needed help from real designers. He contacted the local technology education teacher and sponsored a contest among students. He challenged the students to develop a prototype that illustrates ways to reuse the canisters to make useful and marketable products.

Challenge:
To adequately answer this design problem, you will need to strictly adhere to the following design criteria:

- Design teams must use only materials and tools supplied at the beginning of the design challenge and complete the challenge in the allotted time.
- Design teams must practice safety throughout the problem solving activity.
- The completed prototype or model should be attractive, marketable, and useful.
- Design teams will be required to develop a two-page "Design Portfolio." The design portfolio should <u>include a sketch</u> of the object and address as many of the following questions as possible:
- How would a manufacturer make this product?
- What (if any) specialized machinery or equipment would be needed to make this product in large quantities?
- How many and what kind of workers (skilled/unskilled) would be required to make this product?
- What group would be the target audience for this product?
- Why would this product appeal to that target audience?
- How much money would the completed product sell for and how much profit would the company stand to make on a 1,000 sold products (consider manufacturing & labor costs in this total)?

Tools & Materials:
Design teams will be allotted a given time period to prepare the prototype and the design portfolio. Design teams will be allowed to use the following tools and materials to design the prototype and design portfolio:

- Miscellaneous plastic film canisters
- Plastic straws
- Paper and cardboard stock
- Miscellaneous markers/pens
- Masking tape
- Hot glue gun/glue
- Miscellaneous fabric
- Scissors and other cutting utensils
- Other miscellaneous materials

Figure 1. Pinhole camera made from a film canister

Big Idea:
Communicate and demonstrate the solution with others
Fundamentals of concepts of science, technology, engineering, and mathematics

Limitations:
Design teams must use only materials and tools supplied at the beginning of the design challenge and complete the challenge in the allotted time.

Assessment:
Team scores will be determined by high scores across the three (3) evaluation components listed below. The combined score will be recorded as the team score.

CRITERIA	30 points	20 points	15 points	10 points
Product Design	Clear evidence of extensive design, troubleshooting, testing, and refinements (used the design loop).	Clear evidence of design, troubleshooting, testing and refinements.	Some evidence of troubleshooting, testing and refinements.	Little evidence that the team used any features of the design loop.
Product Function	Product functions exceptionally well and illustrates a useful product	Product functions well, but is only marginally useful	Product operates, but does not function very well	Fatal flaws in product. Does not function properly or is not useful
Design Portfolio	Portfolio clearly illustrated the merits of the product and provided a convincing argument	Portfolio illustrated the merits of the product and provided some reasons to select the product	Portfolio only marginally illustrated the merits of the product and did not provide a convincing argument	Portfolio did not illustrate the merits of the product and was not convincing

Team Name: ________________________________ **Total Score: ______**

Topic: Seeds of Creativity

Suggested Grade Level: Fifth Grade

Essential Question: Can you develop a probe that is functional and appealing to the eye?

Scenario: *Assume the following*: It is the year 2056. You are the senior member of a top design team for the National Aeronautics and Space Administration (NASA). NASA is planning to launch an unmanned spacecraft to the planet Terrex in a neighboring solar system. When the spacecraft reaches Terrex, NASA plans to send a probe to the surface of the planet to collect data and send information back to the host spacecraft. At this time, NASA researchers know little about Terrex. They do know that the planet has a thick atmosphere similar to that of the Earth. Due to the thick cloud formations that continually shroud the planet, little visual information is available and the surface has never been seen by humans. Sending a traditional probe to the surface will be impossible because NASA scientists have no way of calculating the depth of the planets' atmosphere. Without this knowledge, the probe could impact the surface at a high rate of speed or run out of fuel before achieving gravitational entry. NASA scientists have developed metals that will withstand the heat of planetary entry, and a means of propelling the probe into the planets' outer atmosphere. What NASA needs is a design that will allow the probe to slowly descend to the planets' surface, regardless of the distance. NASA is particularly interested in using a design (based on the Ash tree seed) that you have been conducting research on for the past twenty years. Build a probe that satisfies the criteria listed within the "parameters" section below:

Challenge: During the completion of this activity, student teams will develop a technological device that is based upon a biological system. The seeds from Ash trees (see figure 1) have long intrigued inventors and designers, as well as children at play. They are intriguing because of their natural ability to disperse themselves widely. When the ash seed falls from the tree, they flutter helically in a pattern resembling the flight of a helicopter. This helical or rotary motion is created by the lack of balance in the seed. As you will note by examining the picture of the seed (figure 1), the seed pod is located at one end, while the other end of the seed includes a wing-like structure. This wing-like structure, coupled with the weight of the seed pod causes the seed to rotate as it descends to the earth. The motion of the seed during descent resembles flight. By rotating helically to the surface, the seed will likely fall outside the shadow of the host tree thereby, creating the possibility of germination and a continuation of the species.

Tools & Materials: Any combination and amount of the following materials may be used to solve the given problem: 12" of masking tape, 1 sheet of poster board, 5 plastic soda straws, 3 sheets of tissue paper, 1-8 ounce plastic cup, 4 paper clips, 2 rubber balloons, 12 ounces of sand, 18" of plastic wrap, 18" of cotton string, 1 raw egg (representing the payload). Additionally, any miscellaneous hand tools available from your instructor may be used to create your design.

Limitations: The probe must be designed in accordance with the following criteria:
1. The design team must conduct brainstorming sessions to identify at least four different design possibilities prior to construction (these design possibilities must be included with the final submission).

2. The design team must submit final sketches and a written description of the device (the final sketch and a written description must be included with the final submission).
3. A model of the probe must be designed to carry a payload (one raw egg) safely to the planet surface (concrete floor) when dropped from a height of 10 feet.
4. The designers may use only those materials supplied by their instructor.
5. The probe must rotate in a helical fashion as it descends to the floor.
6. The probe must be designed to fit within the space available on the host spacecraft (must fit within a 2'x 2'x 2' cube).
7. The probe must be designed to conform to the weight limitations of the host spacecraft (must not weigh more than 5 pounds).
8. The probe must be drop tested and the design team must record the performance rating of the probe for inclusion in the final submission.
9. After testing the probe, a package of materials must be prepared for submission to the technology teacher (see "evaluation" section).

Assessment: The probe design and team scores will be determined according to the level at which they perform/conform to the criteria listed below.

Function (20 points): Did the probe rotate in a helical fashion and deliver the payload safely to the surface?

Aesthetics (20 points): Is the probe attractive, clean, neat, and produced of sufficient quality?

Parameters (20 points): Did the probe design team meet all of the parameters identified for this activity (size, weight)?

Team Performance (20 points): Did the design team use adequate brainstorming and problem solving techniques to solve the problem?

Summary (10 points): Did the design team provide adequate answers to each of the questions listed in the "summary" section of the activity sheet?

Submission (10 points): Did the design team submit an orderly package of materials for evaluation that included: Brainstorming sketches, Final sketches and a written description of the device, The probe and results of drop test, Summary questions?

Teacher Introduction

Please relay the information provided in the "content" section of this activity to your students prior to assigning the activity. This activity is best used with students who have some experience working with teams. For ultimate efficiency, students should be grouped into teams of three to four students each. This activity was designed to be used with a technology design or production class however, it could be adapted to almost any technology education classroom environment. You will need to procure one set of the items listed on the "materials list" for each team completing the activity. You may want to adapt the materials list to more adequately fit the needs of your students. After the teams have developed their solutions, you may test the designs by dropping the probes from a height of 10 feet. After the drop test, ask team members to examine the payload for cracks. Probes that descend to the surface while protecting the payload have successfully met the design challenge.

Rationale

The process of invention and discovery is often misunderstood by members of our society. To be fully capable contributors to our technological society, students need to understand the relationship between technology, nature, and the development of new products and processes.

Content

The development of technological devices designed to make life easier dates from the earliest human existence on Earth. From the moment that early humans first picked up a stone or branch to use as a tool, life on our planet has been forever altered. The use of those tools, and the technologies created later, have continued to change the way humans work, eat, play, travel, and adapt to the environment.

Often, when most people examine a new invention or technology, they assume that it was created in isolation--more often, the opposite is true. Most famous inventions that we depend so heavily upon today, were, in fact, developed through the painstaking labors of many. The initial form of a technological invention is often based upon the knowledge available to the inventor during that period in time. For example, most early forms of the automobile resembled wagons or horse drawn carriages that were common during that period in history.

The development of technology can be described as a process of creating products that make life easier, more pleasant, more efficient, or longer. Humans have a natural desire to create technology that serves these purposes. As one traces the early forms of new technologies, it becomes clear that many inventors relied heavily upon the natural world for inspiration. Many technological innovations began as adaptations of biological, or naturally occurring phenomena. For example, when the first model of the submarine was developed in 1620 (Cornelis Drebbel) it was modeled after a saltwater fish called a batfish, the hearing aid, developed in 1880 (R. G. Rhodes) was modeled after the human ear drum. Additionally, the fountain pen was modeled after feather quills common in 1884 (Lewis Waterman), Velcro (Georges de Mestral, 1948) was modeled after a weed seed that attaches itself to animal fur or human clothing when they pass by the plant.

Even though we live in an advanced technological age, new products continue to be developed as adaptations of naturally occurring biological organisms. In fact, products adapted from biological systems are more prevalent today than at any previous period in human history. New medicines, tools, and products based on biological adaptations are reaching the marketplace daily. Indeed, the future is bright for bio-related technology products.

Summary

In this technological age, new products will continue to reach the marketplace at an astonishing rate. Some of these products will consist of adaptations of previous products while some will be based on the adaptation of our natural, biological world. On your next trip to the shopping mall, examine the products you see and try to determine whether the product is truly revolutionary or simply an adaptation of nature. Please answer each question below and submit your responses with the other materials requested in the "evaluation" section.

Please rate the efficiency of your design on a scale of 1 to 10 (1 = poor, 10 = exceptional).

How could you improve the design of your probe if you had a chance to repeat this activity?

What design characteristics from the probes designed by your classmates would have improved the your probe design?

What additional materials would have been helpful in the design of your probe?

Informal STEM Education Activities: Suggested Grades 6 - 12

Topic: Sailing along on the USS Archimedes

Suggested Grade Level: 6 – 8

Content Information: Archimedes discovered the law of buoyancy, or the upward force that keeps things afloat. One day when he stepped into his bathtub full of water, he noticed that the tub overflowed with the added volume. He was quite excited by this observation, and he ran into the streets, shouting "Eureka!" He had been given the task of finding out if the king's blacksmith had been using cheaper silver for his kingly crown, instead of the more expensive, denser gold. He suddenly realized how a pound of silver and a pound of gold would behave differently when immersed in water. What he found was that if you measured out an equal weight of gold and silver, the silver should have more volume because it was less dense than gold. Archimedes concluded that if the silver must have more volume, it would take up more space when fully immersed in the water, and the tub would overflow. All he had to do was place the crown and some gold on a scale until finding the perfect balance. He then placed the crown and gold in tubs of water. Unfortunately for the blacksmith, the crown displaced more water than the gold, proving that he was cheating the king. This is the same principle that boat makers have to keep in mind during their design process.

Essential Question: How can you build a boat made entirely of aluminum foil and packing peanuts that can withstand the weight of multiple golf balls without sinking?

Scenario: You are Christopher Columbus and need to get as many people (golf balls) onto the Mayflower (aluminum foil boat) as possible to take them over the sea to the "New World". Construct a boat that can hold the greatest number of people.

Challenge: You will have 30 minutes to design a boat from aluminum foil that will hold the greatest number of golf balls onboard without sinking.

Tools and Materials: Each team will be furnished with
a single piece of 12" X 24"aluminum foil
12 foam packing peanuts.
Golf balls
Rulers
tubs of water for testing

Big Ideas: Students will be able to understand the ideas of mass and buoyancy as it relates to the technology of a boat floating on top of water & how the mass inside the boat changes the buoyancy.

Limitations:
Each team will only receive one piece of foil.
During the judging, the boat must stay afloat with the golf balls aboard in order to count. The largest number of golf balls floating before your boat begins to take on water will count as the team's score.

Topic: Marshmallow Launcher

Suggested Grade Level: Grades 6 - 9

Essential Question:
How will you and your team design a device that will launch a marshmallow the greatest distance over a playing field?

Challenge:
Working as a member of an engineering design team, design a device that will launch a marshmallow the greatest linear distance over a playing field.

Tools & Materials:

Purchases/Rentals	Materials/Tools	Cost
	4 – Plastic push pins	2 credits
	1 – Cutting tool	2 credits (rental fee)
	1 – Set of utility pliers	2 credits (rental fee)
	1 – 24” length masking tape	1 credit
	1 – heavy rubber band	7 credits
	1 – Plastic spoon	4 credits
	4 – Chop sticks	3 credits
	1 – 36” wooden dowel rod	5 credits
	1 – 24” length of woven string	4 credits
	4 – Assortment plastic pulleys	3 credits
	1 – Metal clothes hanger	4 credits
	1 – Assortment metal springs	4 credits

*A 16” x 16” cardboard base and a marshmallow will be supplied to each team at no cost.

Note: Materials are credited to teams on a first-come, first-served basis. There is no implied guarantee that sufficient amounts of any given material will be available for all teams. Please return all undamaged materials and all rental tools at the conclusion of the challenge so they may be recycled.

Big Ideas:
- Forces and Motion
- Problem Design and Troubleshooting

Limitations:
To complete this engineering design challenge successfully, teams must strictly adhere to the following design parameters:
Teams will be allowed 50 minutes to: Brainstorm, conduct ideation, make sketches, test theories, obtain tools/materials, and build a working prototype that solves the design challenge described above
Teams will begin the challenge with 15 credits. These credits will be used to purchase or rent the tools or materials needed to construct the working prototype

The launcher must be constructed on a cardboard base provided, must be portable, and must be clearly labeled with the name of the team
Device must be mechanically propelled and constructed of materials supplied for the contest
Launchers deemed unsafe by the judges will not be allowed to launch and the decision of the judge is final.
Once the completed prototype is placed into position on the testing table, the completed structure must stand on its own.
Three attempts will be allowed once the device is placed into position on the testing table. The greater distance will be recorded;
Human interaction will only be allowed at the secondary level (i.e., flip a switch, release a lever, turn a crank, etc.). Direct human interaction will not be allowed.

Assessment:
The Marshmallow Launcher that shoots the furthest distance across the playing field will win.

Topic: An Alien With an Attitude

Suggested Grade Level : 8th-12th

Teacher Overview: This design-based problem solving activity has been created to provide your students with the opportunity to construct, test and demonstrate a catapult type device. The implementation of this activity should follow a unit of study on mechanical power—specifically, simple machines and mechanical advantage. Although it is not essential, students participating in this activity could be assisted by having some background information and knowledge of typical woodworking tools and equipment. You will need to construct a model that can be used to represent the gorge during the testing phase of the activity. This model could be constructed of taped lines on the laboratory floor or two tables placed 36 inches apart. This activity is designed for secondary students working in small teams or individually. You will also need to gather all materials listed below, hot glue guns, and woodworking equipment prior to the implementation of this activity. The activity should take approximately three-50 minute class periods to complete.

Design Rationale: People use mechanical power, simple machines, and mechanical advantages every day. Due to the availability of technology in our society, most people are unaware that they are using these machines or a mechanical advantage throughout their daily routines. For example, you use simple machines and mechanical advantage when you ride a bicycle, open a door, use a pencil sharpener, or open a can of soda. Today, you will have an opportunity to use your knowledge of simple machines and mechanical advantage (as well as your problem solving and creative thinking abilities) to build a device that just might save the human race!

Essential Question: How can you create a mechanical device to launch a projectile at least 36 inches and hit a specified target?

Scenario: You have been selected to champion your species in a duel with a vile, ugly, rude, arrogant, obnoxious, musty, and slightly overweight alien with mild acne and a really bad attitude. The loser, and the rest of his/her species, will be instantly obliterated—their planet completely pulverized. Since the alien is such a massive entity, it is imperative that you rely on your vast knowledge of physics, mathematics, and technology—more specifically, mechanical power, simple machines, and mechanical advantage to construct an "equalizer". That is, a weapon that will allow you to defeat this hideous creature. In an effort to conserve natural resources, it was mutually decided to shrink both combatants to a more convenient size. You are now 3 inches tall, but the alien is still well over one foot tall! We all know that you're "bad", but he **doesn't** and all of your heavy weapons are still locked in your school locker!!! Fortunately, a bottomless gorge separates you from this hideous creature, but you will need help to deliver a projectile of sufficient mass to check this dude into the "maggot motel".

Challenge: You must create a mechanical device using the materials available that is capable of delivering a projectile (on target) from your side of the gorge to the alien side. For additional information about your assignment, read the "parameters" section of this activity sheet.

Tools and Materials: In addition to the testing area and the Nerf ball that will be used as the target, teams may use any of the following materials to solve the design problem:

10 wooden toothpicks	2 metal paper clips	2 metal staples
4 wooden popsicle sticks	2 wood pieces ¼”x1”x3”	2 rubber bands
1 8 inch dowel rod ¼ inch	6 small wire brads or nails	2 sewing spools
1 wooden base block 1”x4”x4”	1 plastic soda straw	1 pencil
1 12-inch piece of cotton string	1 hot glue gun & glue	Misc. tools/equipt.

Big Ideas
Students will gain understanding of simple machines
Students will understand gravity, mass and air resistance and their relation to the operating of simple machines.

Limitations
You must create a mechanical device using the materials available that is capable of delivering a projectile (a golf ball) from your side of the gorge to the alien side (36 inches) and be on target (at least 2 hits during 5 rounds).
You may only use the materials listed below, hot glue, and the equipment specified by your instructor.

Activity Content (reference material)
Mechanical energy is simply the energy of motion. For example, the mechanical energy of a moving hammer is used to drive a nail. Energy can be defined as the capacity to do work. Work, in turn, can be defined as useful motion, or motion that results in something useful being done. Work is a measurement of mechanical energy and can be calculated by multiplying weight times distance. Mechanical power is defined as energy per unit of time. Therefore, power is a measurement of work completed in a given period of time. Horsepower is the most common measurement of mechanical power. One horsepower is equal to the energy needed to lift 550 pounds 1 foot in 1 second.

There are many different devices used to modify mechanical power. These devices are called machines. There are basically six simple machines used to control and modify mechanical power. The simple machines are the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw. If you are not familiar with these machines, ask your instructor to show you some examples.

Another important form of measurement used in mechanical power is mechanical advantage. If you understand mechanical advantage, you can calculate exactly what you gain or lose when you use a machine. Mechanical advantage can be calculated using several different procedures. For this activity, we will calculate mechanical advantage by comparing output distance to input distance. To calculate the mechanical advantage for the device you build during this activity, simply measure the distance your machine moves (in order to catapult the load) with the distance the load is moved. Mechanical advantage is stated in a ratio. For example, your device might have a mechanical advantage of five to one or (5:1). After you have constructed your device, ask your instructor to help you calculate your mechanical advantage.

Assessment
Your team will be evaluated on this project using the following criteria:
Function: (30 points) Does the prototype device perform the intended function of hurling a projectile?
Accuracy: (20 points) Does the machine control the direction and elevation of the projectile? (2 hits from a maximum of 5 rounds)
Distance: (20 points) Does the machine have sufficient power to propel the projectile a minimum of 36 inches?
Questions: (20 points) Did the team provide adequate responses to each of the questions outlined in the "summary" section below?
Originality: (10 points) Points will be awarded for design originality
Extra credit: (10 points) Points will be awarded for the efficiency of your work or "time on task".

Summary: During the completion of this activity, you had the opportunity to use all of your physics, mathematics, and technological knowledge to construct a launching device or catapult. You had to call upon your problem solving skills and your knowledge of simple machines and mechanical power to construct the device. Now that you have created and tested your device, please take a few minutes to provide clear and concise answers to each of the questions listed below. After you have completed each of the questions, please submit your device and your answers to your instructor for grading.
On a scale of 1 to 10, rate the performance of your device?
After witnessing the testing of all devices created in your class, rank the performance of your device? Was it the best device (number 1)? Was it the fifth best (number 5)?
How could you improve your design if you have the opportunity to start over?
After witnessing the designs of your classmates, which of their ideas could be used to improve your design?
If you were able to use an unlimited amount of supplies to produce you device, what additional materials would have been helpful? Why?
If the human species were dependent upon the performance of you device, would we continue to exist?
Please make a sketch of the device you created and use arrows to identify the simple machines included in your design.
Using the formula provided in your textbook, please calculate "work" and the "mechanical advantage" for your device.
What changes could be made in your design to increase the mechanical advantage of your device?

Strategies for Solving Design Problems: Design problems always include the solution to the problem in the problem statement (e.g. design a vehicle that will travel the greatest distance using only the materials supplied). To solve technological design problems in technology education, students should employ the following steps:

Analyze and Clarify the Design Problem: Carefully analyze the design problem and break it into it's smallest systems and subsystems. Clarify the problem to determine exactly what you have been asked to create.

Formulate: Create as many possible solutions to the design problem as possible before attempting to implement any of them. Instructors should require students to produce several potential solutions prior to allowing the students to implement one of the solutions.

Question the Solution: Design teams should ask as many of the spur questions (below) as apply to the problem. By answering these questions, the team will add clarity to the proposed solution. The spur questions are as follows:
Is there another way to solve this problem or use these materials?
Can I borrow or adapt previous solutions or technologies?
Can I add a new element or twist that might lead to a solution?
Can I add more to the problem in an effort to find a solution?
Can I remove parts of the problem in an effort to solve it?
Can I incorporate substitutes or use other materials/technologies?
Can I rearrange the elements of the problem to find the solution?
Can I do the opposite of what I am currently thinking?
Can I combine elements or technologies to solve the problem?

Envision the Solution: Teams should make sketches and drawings of the proposed solution. By crafting these drawings, teams will add clarity to the final solution prior to implementing the solution.

Create: Select the most logical solution (often the simplest) and implement it (build it).

Evaluate the Solution: Test the solution and determine whether it indeed solves the problem. If it does not solve the problem, find out why and make changes.

Topic: Darting Off

Suggested Grade Level: 9-10

Essential Question:
How can you use troubleshooting to diagnose what is causing a plane to fly off course and correct the planes problem?

Scenario: Your cousin Timmy has built his own Delta Dart rubber band powered model plane for a contest at school. His class is scheduled to fly their planes tomorrow but Timmy has a problem. One of the things they are scored on is how straight their planes fly. For a reason Timmy cannot figure out his plane does not fly straight. He has come to you, his older and wiser cousin, for help in troubleshooting this problem.

Challenge: Your team will be given Timmy's model plane. Using the troubleshooting steps outlined on this activity sheet you will work as a group to troubleshoot Timmy's problem. As you diagnose and correct the problem found in Timmy's plane keep careful notes on each step. Once you have properly diagnosed and corrected the plane write a summary report illustrating what you did in each step to troubleshoot the problem.

Tools & Materials:
Class notes
Glue
Box cutter
Pencil and paper

Material Equipment: 5 constructed Delta Dart rubber band powered model planes with flaws.

Big Ideas:
Problem Design and Troubleshooting
Physics

Limitations:
Students will have only one 50-minute class period to troubleshoot the problem.
The summary report must outline how the troubleshooting steps were followed to diagnose and correct the problem.
Spelling and grammar must be correct.
Students must work as a team to troubleshoot the problem

Assessment:

The malfunction of the plane was properly diagnosed and corrected.	________/10 pts.
The summary report showed how all steps of the troubleshooting process were used and followed.	________/12 pts.
The summary report contained no spelling or grammatical errors.	________/ 8 pts.
The team worked together to troubleshoot the problem	________/ 5 pts.
Total Points	________**/35 pts.**

Result: At the end of this lesson students will understand the concept of troubleshooting and that there is not always one cause for a technology to malfunction.

Activity Challenge: Students will be divided into 5 teams. Each team will be given a Delta Dart rubber band powered model plane that contains a not so obvious flaw that causes it to not fly straight. Students are to diagnose what is causing the plane to fly off course. Once students have properly diagnosed the problem with their particular Delta Dart they will write a summary report to describe how they came to their conclusion (following the troubleshooting steps) and how the problem should be fixed.

Laboratory Preparation: The instructor will have built 5 Delta Dart rubber band powered model planes, each one containing a different flaw that causes it to not be able to fly straight. These flaws are not to be obvious.

Evaluation: Students will be evaluated on the proper diagnosis of the malfunction of their Delta Dart and the use of the troubleshooting process. They will also be evaluated on the efficiency and completeness of their summary reports. Spelling, grammar, and content will all be a part of the evaluation. They will also be assessed on their ability to work as a problem solving team.

Troubleshooting Steps:
Isolate the problem- what is or is not happening that does not align with the proper function of the device?
Identify the parts of systems- what parts or systems are involved? How do these parts and systems contribute to the proper functioning of the device?
Observe symptoms- Is there anything different about the device? Did anything happen to the device before it started malfunctioning?
Identify possible causes of the problem- Using your reasoning skills; try to think of which parts of the device could be affecting the problem. Consider the purpose and function of each part of the device.
Test for faults- Make adjustments to what you consider being the fault of the device and testing to see if your diagnosis was accurate. Do this as many times as needed. Be careful not to create any more malfunctions to the device during this stage of the process.
Correct the fault and assess the result- Correct the fault and verify that it was indeed the cause of the malfunction.

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

Post Activity Discussion:
What was wrong with each of your airplanes?
Why did you troubleshoot the problem? Why not throw out the bad plane and make a new one?
What other kinds of problems can be solved by using troubleshooting?

Topic: Class Reunion Launch

Suggested Grade Level : 9th-12th

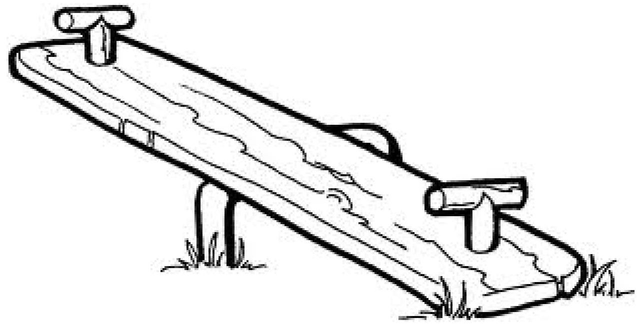
Overview: This engineering design challenge has been created to provide the student with the opportunity to construct, test and demonstrate a lever and fulcrum type device. This challenge will expand upon the students understanding of mass and distance ratios used in mechanical power and mechanical systems. Although it is not essential, learners completing this challenge could be assisted by having some background information and knowledge of typical hand tools and equipment. As the instructor, you will need to construct a testing area where the height of the launch can be measured. This testing area could be constructed of taped lines on the wall where the height of the launch could be gauged easy by sight. You will also need to gather all materials listed below, hot glue guns, and the basic tools identified prior to the implementation of this challenge. The challenge should take approximately 1 hour to complete.

Engineering Design Rationale: People use mechanical power, simple machines, and mechanical advantages every day. Due to the availability of technology in our society, most people are unaware that they are using these machines or mechanical systems throughout their daily routines. In this example, we point out that some playground toys are really nothing more than simple machines. For example, the merry-go-round is a wheel and axle that clearly illustrates centrifugal force, the swing set is a perfect illustration of the pendulum, and the teeter-totter is a great example of the lever and fulcrum. Today, you will have an opportunity to use your knowledge of simple machines and mechanical advantage (as well as your problem solving and creative thinking abilities) to build a device that just might provide you with some long-overdue revenge.

Scenario: You graduated from high school in 1997, and then went on to graduate with honors from one of the finest universities and then launched the most successful shoelace manufacturing company in America. You might think that would be enough, but it isn't! Your thoughts often return to the torment that you suffered at the hands of Buffy in the halls of Central High School 14 years ago. Being king of the shoelace manufacturing world and the love of a great family just doesn't make up for the thousands of slights that you received at the evil hands of Buffy during high school. Then, while perusing Facebook® this morning, you found the answer that you've been searching to find for almost 15 years. You're having a class reunion and Buffy will be there! Better than that, there will be a class photo on the elementary school playground toward the end of the reunion--a perfect place to launch a class reunion ambush. After a great deal of thought (and evil-sounding laughter), you hit upon your most devious plan in years. You're going to rig the teeter-totter to launch Buffy into outer space--or at least as high as possible! To achieve perfection in this scheme, you must build a model to test your idea--you will only have one chance to pull this off.

Essential Question: How can you create a mechanical device that will launch an object high in the air?

Challenge: You must create a mechanical device using the materials available capable of launching Buffy (represented by a Wiffle© ball) as high as possible on command. For additional information about your assignment, read the “parameters” section of this challenge sheet.



Challenge Content: (reference material)
A teeter-totter is a long plank or platform, which is suspended on a fulcrum. When weights are placed at either end of the teeter totter, the plank may become balanced, in which case it moves to a horizontal position, or it may become imbalanced, with one side of the teeter totter being lower than the other. By adjusting the level and position of the weights, various levels of balance and imbalance can be achieved. Although a playground teeter-totter can be a great learning experience as well as a source of fun, it can also be potentially dangerous. Sudden shifts in weight may cause the device to become so unbalanced that children could fall off and hurt themselves.

Since the teeter-totter is initially in balance when it is not loaded, the center of gravity is right on the fulcrum. When two people sit on the teeter-totter, the lighter person's end will go up unless that person moves toward the fulcrum to adjust the center of gravity. Mass and distance are inversely related to one another when you are on a teeter-totter. The weight of the object on each end (the mass) and the distance of the mass from the fulcrum (distance) help you calculate center of gravity. To complete this calculation use the formula m1d1 = m2d2. For example: Assume that a 150-pound boy and a 100-pound girl are playing on a teeter-totter that is 11 feet long. The girl is sitting 3 feet from the pivot point. Where should the boy sit to balance the girl?

Torque girl = 100 lbs. * 3 ft = 300 ft.*lbs.
Torque boy = 150 * d
Torque boy = Torque girl
150 * d = 300
d = 2 m

In this example, the 150 pound boy must sit 2 feet from the pivot point to balance the 100 pound girl sitting 3 feet from the pivot point.

Materials/Resources: In addition to the testing area and the waffle ball that will represent Buffy and misc. hand tools, the learner may use any of the following materials to solve the engineering design problem:

10 - wooden craft sticks	1 - paint stick	1 - drinking straw
1 - mouse trap	2 - metal paper clips	4 - rubber bands
1 - 8" dowel rod ¼ inch dia.	Misc. duct tape/tools	2 - small paper cups
1 - base block	6 - small wire brads or nails	1 - Wiffle© ball

Big Ideas

Students will understand the components of a fulcrum and lever and how they work.
Students will understand mass and distance ratios and how they relate to the performance of a fulcrum and lever device.

Limitations: You must create a mechanical device using only the materials available that is capable of launching a Wiffle© ball as high as possible. You may only use the materials listed below, equipment/tools specified, and your own ingenuity. You will have a limited time to complete and test this model as the class reunion is this next weekend and you have to use what you learn from the model to hatch your devious plan with a full-scale model. You'll see how fabulous she is after being launched by the teeter-totter.

Strategies for Solving Engineering Design Challenges:
Engineering design challenges usually include the solution to the problem in the problem statement (e.g. design a vehicle that will travel the greatest distance using only the materials supplied). To efficiently solve engineering design problems, learners should employ the following steps:
Analyze and Clarify the Problem: Carefully analyze the engineering design problem and break it into its smallest systems and subsystems. Clarify the problem to determine exactly what you have been asked to create.
Gather Resources and Materials: Gather all available resources and materials and analyze these carefully. Sometimes the answer to the engineering design challenge may be found in the available tools and materials.
Formulate: Create as many possible solutions to the design problem as possible before attempting to implement any of them.
Question the Solution: The student should ask as many of the spur questions (below) as apply to the problem. By answering these questions, the learner will add clarity to the proposed solution. The spur questions are as follows:
Is there another way to solve this problem or use these materials?
Can I borrow or adapt previous solutions or technologies?
Can I add a new element or twist that might lead to a solution?
Can I add more to the problem in an effort to find a solution?
Can I remove parts of the problem in an effort to solve it?
Can I incorporate substitutes or use other materials/technologies?
Can I rearrange the elements of the problem to find the solution?
Can I do the opposite of what I am currently thinking?
Can I combine elements or technologies to solve the problem?
Envision the Solution: Students should make sketches and drawings of the proposed solution. By crafting these drawings, learners will add clarity to the final solution prior to implementing the solution.
Create: Select the most logical solution (often the simplest) and implement it (build it).
Evaluate the Solution: Test the solution and determine whether it indeed solves the challenge. If it does not solve the challenge, find out why and make changes.

Topic: Upon Def Ears
Grade level 9-12

Essential Question: Can you identify and repair your group's set of headphones using the tools and materials provided along with using the design loop?

Scenario: Imagine, you are about to go on a long trip with your family, and your father is going to make you listen to the music he had when his father took him on his first trip. Suddenly, your headset is not working! You are going to have to listen to your parent's music for the entire trip unless you can fix the problem in time!

Challenge: Working in groups of 3 students will be given a set of headphones that do not function properly. They must assess the situation, and formulate a theory as to why it is not working. After completing an ohm's test, the students will be given the needed equipment and headset to perform their task.

Tools and Materials: Students will be provided with the following:
A non-functioning headphones this could be accomplished in several ways:

Loose wire
Detached speakers
Poor connections at speaker ends
Nail polish or other inhibitor on plug end
Severed wire anywhere in between connectors and speakers
A functioning headphone, this should only be presented upon their request.
Pliers, ohms meters, tape, corrosion remover, wire strippers, crimpier, connectors, super glue, solder, soldering guns.

Big Ideas:

- Students will be able to understand the importance, and proper use of analytical thinking in examining a problem, and generating a solution.
- Develop an understanding of the role of trouble shooting, research and development, invention and innovation, and experimentation in problem solving.
- Understanding of electrical travel and resistance

Limitations:

- Prior to being given any materials or tools, students must demonstrate their proficiency in the skills needed to use an ohm's meter.
- Students **<u>must</u>** present evidence as to why their headsets did not work properly, and how they repaired them, if possible.

Prior Knowledge & Experiences: Students will need to be familiar with the following concepts:

Operation of headphones
Use of the design loop as covered previously in this class.
The ability to use an ohmmeter.

Upon completion of their hypothesis students will be asked to repair given headphones and prove they are functional.

Project Log

Follow up questions:

1. How would you change your tactics to make solving the problem more accurate?

____

____

2. How did you reach your decision on what caused the problem?

____

____

3. Was this really the problem? Explain why it was or was not the problem.

____

____

4. How many problems were there with your groups' headphones?

____

____

Scoring Rubric

Answers to follow up questions	1	2	3	4	5
Identification of the problem	1	2	3	4	5
Headphone now functions properly	1	2	3	4	5
Presentation and defense of theory	1	2	3	4	5

Total Pts (out of 20) ____________

Final Project Score: ____________

Topic: Distance and Time

Grade Level: 9th-12th

Essential Question: How can you construct a car that will go a minimum of 15ft. quickly with the tools and materials provided?

Scenario: You work for a company that designs and constructs toy model cars. The cars are supplied with a small motor and are powered by batteries. Through testing, your team discovered that the car works, but does not travel a long enough distance with the gearing sets that were installed.

Challenge: Given your team's knowledge of cars, design a car that will travel a minimum distance of fifteen feet with the materials supplied below in the fastest time possible.

Tools and Materials:

- 4 – I screws
- 4 – Wheels
- 1 – Gear set
- 10 – Craft sticks
- 5 – Straws
- 1 – Battery holder
- 2 – Axles
- 1 – Motor
- 1 – Styrofoam block
- 2 – Batteries
- X-Acto Knives
- Glue Guns

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Big Ideas: Energy and power technologies

Limitations:
Your group does not have to use all of the materials, but cannot add any material not provided below.
Students may not interact (touch) the car once it has been placed in the testing area.

Assessment:
Each car will be set-up to run on a pre-determined track (testing area). Each car will be timed for speed and measured for distance. The fastest car reaching fifteen feet (or the longest distance under fifteen feet) will determine the winner.
Each team should submit all developmental work including rough sketches of possible solutions and a detailed sketch of the final solution.
Each team should submit a written description of their design in paragraph form.
Each team will be required to calculate the speed of their vehicle.

Topic: Better Lockers, Better School!

Grade Level: 9th-12th

Essential Question: How can you construct a locker system that meets all of the specified qualifications and remains aesthetically pleasing to the students using them?

Scenario: As we go about daily activities, there are practical problems we encounter. Some problems involve the way we communicate with others, use transportation pathways, or access the buildings in which we work. At school you probably encounter a variety of practical problems, such as communicating with friends outside of class time, getting from one class to another on time, or having a school locker that meets your school-based needs. The locker problem, in particular, is one that provides daily frustration for students.

Students complain about the lack of room in their locker, the shelf that seems to be too high or too low, the door that never closes correctly, or the combination lock that doesn't seem to work. For students who share lockers, the problem is even worse! Often, one student has more belongings than the other, or organizes materials in a way different from his or her partner. The problem is compounded for handicapped students, who may not be able to reach the coat hook, access the bookshelf, or bend to retrieve items from the bottom of the locker. It seems there is a strong need to make lockers more accessible, flexible, and secure.

Challenge: For this activity, you will team with other students to explore solutions to a locker design problem. Using the school memorandum on the next page, your team will identify the problems and develop a solution. Design and build a scale model of a student locker that meets the student storage space system specifications and corrects the problems in the memo.

Materials and Tools
Foam board- 24" x 30", 2 sheets per subsystem
Straight pins
Paper clips
Construction paper
Miscellaneous springs, clips, small hardware
Markers
Cutting
Scissors, Rulers, Compasses

Big Ideas:
Use problem solving skills to solve a real-world problem
Students will be able to understand the components of brainstorming and planning before building a design.
Students will understand how many problems may have the capabilities to be solved with a simple solution.

Limitations:
Locker subsystems must fit in the given locker.
Locker interior design must address given problems.
Locker design must provide storage for outerwear, books, and electronic equipment.
Locker design must provide secure storage for valuable items.
Students will work in preselected teams of three students.
Be aesthetically pleasing to the eye.
The system must fit in the given locker space.
The system must be constructed with three sub-systems:
A subsystem to store school and personal items
A subsystem for input, storage, and retrieval of locker and student information
A subsystem designed to eliminate odors and pests
Each design team will be made up of 3 persons. Each person must design one subsystem.
The locker design must correct the findings in the activity memo.

Design Activity Phase
Brainstorm design ideas to solve the given problem.
Record ideas.
Using one of the design ideas, create one or more drawings to communicate detailed information about the locker design and how the subsystems will be constructed.

Model Fabrication Phase
Construct each subsystem according to the detailed drawing.
"Test" each subsystem and make adjustments.

Presentation Phase
Give an oral presentation of the design solution to the class.
Prepare a written summary of the design and problem solving process and how the group arrived at the chosen solution.

Assessment
Communication of Design and Problem Solving Process
Effectiveness of Model Design Solution
Presentation Skills and Format
Reflective Thinking