Module Overview	
For Grade Level(s)	**Middle School: 6th – 8th grade** **High School: 9th – 12th grade**
Suggest Time	**MESA Period: 3 – 5 weeks of daily 50-60 minute sessions MESA Afterschool: 4 total sessions of 60-90 minutes each MESA Saturday: 2 Saturdays for total of 8 hours**
Purpose	The purpose of this unit is to introduce or reinforce the engineering design process while introducing students to the principles of mechanical engineering. By the end of the unit students will be prepared to build a mousetrap car which climbs a ramp (high school) or has the fastest elapse time (middle school) over 5 meters as outlined in the MESA Day Competition Rules.
Objectives	At the conclusion of this unit students will: -Understand the engineering design cycle and its parts and utilize them to design and build a mousetrap car -Critically analyze the parts of a vehicle and choose appropriate materials to build a mousetrap car -Solve problems related to force, acceleration and movement -Investigate motion, simple machines and mechanical energy to understand physics principles and engineering elements -Develop the "habits of mind" associated with science and engineering practices. -Develop an understanding of mechanical engineering and what mechanical engineers do -Adjust their use of spoken, written and visual language to communicate effectively with a variety of audiences and for different purposes.
Standards Addressed (Common Core and NGSS)	**Grade 6 - Expressions and Equations 6-EE** **6c.** Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems,. Perform arithmetic operations, including those involving whole-number exponents. **8.G** Understand congruency and similarity using physical models, transparencies or geometry software **NGSS** MS-LS1-1 Planning and carrying out investigation MS-LS1-2 Engaging in argument from evidence MS-LS1-8 Obtaining, evaluating and communicating information MS-LS 1-1 Interdependence of engineering and technology MS-LL1-3 Science is a human endeavor **ELA – Literacy** WHST.6-8.7 Conduct short research projects to answer questions WHST.6-8.8 Gather relevant information from multiple sources SL8.5 Integrate multimedia and visual displays **MS Engineering Design** MS-ETS1-1 Define criteria of a design project MS-ETS1-2 Evaluate competing design solutions MS-ETS1-3 Analyze data from tests MS-ETS1-4 Develop a model to generate data for iterative testing and modification

Assessment	Students will be evaluated through the following methods: • Assessment worksheets • Oral presentations with rubrics • Project testing and evaluation
Additional Resources	Car Construction http://www.docfizzix.com/topics/design-basics/MouseTrap-Cars/mousetrap-propulsion.shtml Careers: http://www.online.onetcenter.org/find http://www.bls.gov/oco/ http://science360.gov/obj/video/36a40333-a6c3-43c6-8216-9ed3c6e995e8/profiles-scientists-engineers-mechanical-engineer

Background

If you want to make life better, easier, less expensive or more fun, then engineering is the field for you. Engineering is progressive, challenging, creative and rewarding. As an engineer you can improve the environment, protect rare and endangered animals, explore other galaxies, help ease world hunger, investigate cures for cancer, work in fashion and much more.

There are more than 2.3 million engineers in our country today making it the second largest profession in America. Engineers design products such as cars, bridges, roads and streets. The work to make our environment cleaner, they design theme parks and shopping centers and develop better communications system. You will even find engineers working in the cosmetics industry making better, safer cosmetics. Nearly everything we use has been touched by an engineer in some way. Artificial joints, heart valves, knee and hip replacements, and prosthetics all are the work of engineers.

A degree in engineering can open many doors. Many people with degrees in engineering go on to other fields such as:

- Attorneys, doctors, entrepreneurs, teachers, writers and politicians
- Developing green technologies or solutions for sustainable living
- Reduce pollution
- Ease world hunger
- Invent exciting cutting-edge technology
- Develop new theories to change the ways we think about the world
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Engineers are also among some of the highest paid professionals in our society. The chart below shows the median and top salaries paid to engineers in various fields. As you can see, studying hard in college really does pay-off when you become an engineer.

Industry	Median Salary	Top 10%
Biomedical Engineering	$81,540	$126,990
Civil and Environmental Engineering	$77,560	$119,320
Chemical Engineering	$90,300	$146,650
Electrical and Computer Engineering	$84,540	$128,610
Geological and Mining Engineering Sciences	$82,870	$129,700
Materials Science and Engineering	$83,120	$126,800
Mechanical Engineering	$78,160	$119,480

All figures are from the United States Department of Labor
Updated October 2013

Building a mousetrap car introduces you to the field of Mechanical Engineers. The majority of people in this career are concerned with the motion of things from car wheels to roller coasters to the working of machines. Mechanical Engineering is one of the broadest, oldest and most diverse of the engineering fields. Nearly every object you used today involved a mechanical engineer at some point.

Mechanical engineers use the principles of energy, mechanics, materials, mathematics and engineering science to research, design, develop, test and manufacture anything and everything with moving parts.

According to the Department of Labor, by the year 2018 there will be an extra 87,000 jobs for mechanical engineers. A great way to learn about mechanical engineering is to check out the information on the ASME (American Society of Mechanical Engineers) website at www.asme.org. You will be able to see the enormous impact mechanical engineering has on our world.

If you would like your students to know more about mechanical engineering, please refer them to the following:
www.workaday.org/**mechanical-engineering**-preview

http://science360.gov/obj/video/36a40333-a6c3-43c6-8216-9ed3c6e995e8/profiles-scientists-engineers-mechanical-engineer

http://education-portal.com/videos/Mechanical_Engineering_Career_Video_Becoming_a_Mechanical_Engineer.html

Engineering Design Factor

The engineering design process will be a theme that spans all of the PBL modules, so an extensive lesson isn't required to be included in each module. However, it may be more effective to focus on particular parts of the process that work well with this module.

Engineering Design Process/Module Content

Engineering is problem-solving and combines math, science, language arts, social studies, team building and creativity with a practical twist. In MESA students use hands-on activities and project-based learning to retain more math and science concepts. Utilizing the engineering design process to guide students through MESA's various project based learning modules provides students with insight into engineering as well as the skills to systematically approach real-world problems.

Using the 4 steps of the engineering design process: investigate, plan, create and evaluate, students will repeat the steps until they have a project worthy of entry into the MESA competition arena. Beginning with an activity to "set the stage" for the construction of a mousetrap car, students begin to acquire the vocabulary and engage in dialogue with other students.

LESSON #1 – Team Building

1. **Lesson Objectives**

   Students will:
   a. Learn how mechanical engineers impact our daily lives
   b. Identify goods and projects developed by mechanical engineers
   c. Understand the benefits of a career in mechanical engineering
   d. Identify the necessary skills to develop in high school
2. **Materials List**
   a. Team building activity
   b. Information regarding mechanical engineers and what they do
   c. Paper and pencil for each team
3. **Classroom Management & Delivery**
   a. Follow the guidelines of the team-building activity
   b. Reinforce the importance of teamwork in all MESA projects
   c. Reinforce the importance of teamwork in engineering
   d. Encourage students to take notes in their engineering notebooks
4. **What is a Mechanical Engineering**
   a. Access one of the websites noted in the "Background" section of this document
   b. Following the video, facilitate discussion of mechanical engineering
5. **Activity/Challenge**
   a. Review the rules of the team-building exercise
   b. Allow ample time – approximately 15 minutes- for the activity
   c. Reinforce the need for team members to work together and communicate to complete the task

TEAM BUILDING ACTIVITY - I SPY ENGINEERING

1. **Overview:**
   The objective of the following activity is for students to become more aware of mechanical engineering in our everyday lives.
2. **Materials Needed:**
   a. One pencil per team
   b. One sheet of paper per team
3. **Procedure:**
   a. Assemble students in teams of 2 -3 students
   b. Tell the teams they will have 3 minutes to write down everything they can see in the classroom, or out the window, that was designed or created by a mechanical engineer. Following the 3 minutes facilitate a discussion based on student responses. Show “Science 360” video – web location is listed in “additional materials section” under “careers”

LESSON #2 – AIR-POWERED VEHICLE CHALLENGE

Purpose:
The purpose of this activity is to help students understand the critical components of the vehicle design as well as develop skills in designing projects, collecting and analyzing data, communicating with team members, keeping records and reviewing math skills. Teachers may choose the activities that will most benefit their class.

Activity #1:

- Begin the discussion by asking students to name the parts of a vehicle. Answers will range from parts such as hood, roof, gas tank and windshield to axle, wheels, and seats. You may even list them on the board if you wish.
- Our vehicle will be using only straws, wooden beads, straight pins and a piece of paper. Explore with students what the various materials will be used for; straws for the frame/axles, wooden beads for wheels, pins as screws and bolts to hold the frame together.
- Talk about ways in which vehicles move air(sailboat), gasoline powered, water powered (such as a jet ski); Eventually lead them to realize the paper will be used to make a sail.
- Ask students to work in teams of 2 to design their vehicle and draw their design in their notebooks.
- Talk about the engineering design process – discuss, design, build, test, redesign, rebuild, final test

Activity #2:

- Distribute materials for the air-powered vehicle and allow one class period for construction, testing, redesign and rebuild

  Some tips you may want to share with students:
  (or you can choose to let them discover during the initial testing phase)

1. Pins should be inserted from the bottom up so they do not drag on the ground

2. Axles in front and back should be the same size to ensure the cars travels in a straight line
3. The vehicle must be symmetrical (the sides must be the same length so the car will not be skewed)
4. Think about the way a sail looks on a sailboat when designing the sail.
5. The side straws should go on top of the axles so that do not drag on the ground
6. Pins may be used to hold the wheels in place on the straw

Activity #3:

Students will race their cars using the power from a small fan to propel the car the greatest distance. (See MESA rules for fan specifications and racing guidelines)

Activity #4: (optional)

Have students write clear, complete instructions for building the car. The directions are tested by having another team of students build a car using the instructions provided.

Activity #5: Speed

Using a stop watch, determine the time for the car to travel a given distance. Using the data collected, students may calculate speed.

Activity #6: Discussion of most successful cars; what are their characteristics, how are they different from cars that were not so successful

Air-powered Vehicle

Type of Contest: Team
Composition of Team: 1 -2 Students Per Team

Overview: To design and construct a car with a wail that is powered by a standard 9 or 10 inch stationary fan positioned 14 inches behind the starting line; Objective is to construct a car that travels the greatest distance

Materials:
- Ten (10) drinking straws (approximately 7 ¼" x 1" x ¼"
- Four (4) wooden beads with large holes for straws to pass through (approximately 1" diameter with 3/8" diameter hole)
- Straight pins
- Scissors
- One (1) sheet 8 ½" x 11" paper
- Stationary fan as described in the overview
- Clock or stop watch (to verify construction time)

Rules of Construction:
1. Only materials listed above are allowed
2. Paper and straws may be cut with scissors
3. Construction time may be limited to 30 minutes if desired
4. Students should be encouraged to test, redesign and rebuild their vehicles

Racing Guidelines:
1. At race time, vehicle is placed with its rear wheels on starting line of designated racetrack area. The track area should be 3 – 4 feet wide.
2. The fan will be placed in the off position, 14 inches behind the starting line and centered behind the car. The fan should be tilted into the down positioned a 45-degree angle and taped to the floor. After the start signal is called, the fan will be turned to the HIGH speed. He fan will be turned off after the car stops or leaves the race track.
3. During the race, students may not touch any part of the vehicle.
4. No additional devices can e used to propel or assist the car down the track

Judging:
1. At the end of the race, distance is measured from the location that the car stops (from the wheel closest to the starting line) BACK TO THE STARTING LINE. If the car stops more than once after the fan is turned off, judging will be from the final stop.
2. The vehicle that travels the greatest distance will be the winner.

LESSON #3 – The MESA Mousetrap Car Challenge

In this lesson students will build the mousetrap car, drawing upon what they have learned about vehicles from the air-powered vehicle challenge. Since MESA uses a student-centered inquiry method which allows students to explore and develop their own design, it is best not to show students a "finished-product" but rather have them do research to determine the best design.

Lesson Objective: Students will design a car powered by energy released by the snap of the mousetrap.

Materials Needed:

Super glue, gorilla glue, standard Victor mousetrap, balsawood, cardboard or other materials for the base of the vehicle, CDs, hobby shop wheels, metal lever arm, inserts of CDs, wooden dowels for axles, small metal axels, string or fishing line, (optional: hammer, nails, screwdriver, buck saw), inexpensive placemats from the Dollar Store can be used as "gluing stations" for hot glue guns.

Activity #1:

a. Show the video referred to under "Car Construction" in the "Additional Materials" section at the beginning of these lesson plans.
b. Encourage students to take notes in their engineering notebook during the video
c. Forms teams of 2 students for the Mousetrap Car building activity.
d. Encourage teams to brainstorm about the design of their mousetrap car and take notes.
e. Take students to computer lab to research mousetrap car designs and takes notes

Activity #2:

a. Student teams begin drawing various designs for their car and discussing which design is best.
b. Teams finalize their design and have their design plan signed by the teacher

Activity #3:

a. Review the rules for the Mousetrap Car Competition found on the MESA website.
b. Discussion materials provided and materials needed.
c. Once teams have finalized their design and it has been approved by the teacher, provide materials.
d. Students are encouraged to build, test, evaluate, redesign and rebuild their vehicle until it meets their expectations and is competitive for the MESA Mousetrap Car Competition.

LESSON #4 – Communication/Presentation

Activity #1 – Choose any or all

a. Have students team develop and present a 2 -3 minute power point to the class about their experience
b. Have students make a short video about their experience
c. Have students calculate the velocity of their vehicle by measuring time over distance
d. For additional activities related to circumference of the wheels and distance traveled, vehicle mass and distance relationship or measuring potential energy please refer to: *Mousetrap Vehicles, Teacher's Guide – STEM Curriculum for Mousetrap Vehicles* available from PITSCO

NOTE: The MESA curriculum is intended to be flexible and meet the needs of all MESA delivery models. Therefore, students in a MESA period will complete more components than students in a lunch or after-school format.

PACING GUIDE

MESA Period:

Week One: Introduction to Mechanical Engineering	
Monday	Overview of Engineering and Specifically Mechanical Engineering
Tuesday	Show Engineering/Mechanical Engineering Video – Discuss
Wednesday	Team Building Activity
Thursday	Show “Science 360” video
Friday	Discuss Nate Balls’ teamwork

Week Two – Air-Powered Vehicle Challenge	
Monday	Activity 1– Discussion of Air-Powered Vehicle (APV)
Tuesday	Activity 2 – Building of the Air-Powered Vehicle
Wednesday	Activity 3 – Racing of the Air-Powered Vehicle
Thursday	Activity 4 – Recording the building process in the engineering notebook
Friday	Activity 5 – Determining the speed of your vehicle

Week Three- APV Follow-up and Introduction to Mousetrap Car	
Monday	Activity 6 - Explore Qualities of a Successful APV
Tuesday	Activity 1 - View and discuss mousetrap car video, form teams, brainstorm
Wednesday	Activity 2 – Research mousetrap car designs and begin drawing designs
Thursday	Activity 2 – Finalize Design
Friday	Activity 3 – Review Mousetrap Car rules, and materials list – finalize design

Week Four – Build the Mousetrap	
Monday	Build
Tuesday	Build
Wednesday	Test
Thursday	Evaluate
Friday	Redesign

Week Five – Build the Mousetrap Car	
Monday	Rebuild
Tuesday	Rebuild
Wednesday	Test
Thursday	Test
Friday	Evaluate

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