MECHANICAL ENGINEERING

This session will present an overview of the mechanical engineering discipline and will allow Explorers to conduct a short, fun experiment that is related to mechanical engineering.

CATEGORY

- Engineering
- Mechanical Engineering

OBJECTIVES

By the end of this session, participants will be able to:

- Define mechanical engineering.
- Help understand what mechanical engineers do.
- Demonstrate a key mechanical engineering concept.

RESOURCES

- Suggested website: United States Bureau of Labor Statistics Occupational Outlook Handbook, Architecture and Engineering Occupations: http://www.bls.gov/ooh/architecture-and-engineering/home.htm

SUPPLIES

- Computer with Internet access (for viewing videos with sound)
- Items for Activity 3—Basic (per team of two or three Explorers)
    - 30 to 40 craft sticks
    - One small piece of plywood (approximately 8 inches by 12 inches)
    - Several sheets of construction or copy paper
    - Pencils or pens for designing
    - Several small paper cups
    - Several plastic spoons
    - Several rubber bands of various sizes
    - Masking tape
    - String
    - One table tennis ball to launch

- Items for Activity 4—Advanced (per team of two Explorers)

    - A pair of scissors and a ruler (preferably with metric and standard units)

- One activity kit per team of two Explorers. Order and purchase the hydraulic catapult, or "Hydrapult," kit from Mechanical Kits Ltd, http://www.mechanical-kits.com/. The cost is approximately $15 per kit, plus shipping. Plan ahead and allow extra time for shipping.

ADVISOR NOTE: Text in italics should be read aloud to participants. As you engage your post in activities each week, please include comments, discussions, and feedback to the group relating to **Character, Leadership,** and **Ethics**. These are important attributes that make a difference in the success of youth in the workplace and in life.

ACTIVITY 1

Introduction: What Do Mechanical Engineers Do?

Tell participants: *Mechanical engineering is the branch of engineering dealing with the design, construction, and use of machines.*

Share the following explanation from the University of Washington:

> *Mechanical engineering is the broadest of all engineering disciplines, encompassing areas such as energy, fluid mechanics, dynamics, combustion, vibration, design, manufacturing processes, systems modeling and simulation, mechatronics, robotics, mechanics of material, rapid prototyping and composites.*
>
> *Mechanical engineers are employed in virtually every kind of industry. They are involved with seeking new knowledge through research, creative design and development, and with the construction, control, management, and sales of the devices and systems needed by society. A major strength of an education in mechanical is the flexibility it provides in future employment opportunities for its graduates.*
>
> (Source: https://www.me.washington.edu/prospective/whatisme.html)

Discuss with Explorers information about the field of mechanical engineering and what they could expect if they chose it as a career.

All remaining information for Activity 1 and Activity 2 is from the Bureau of Labor Statistics Occupational Outlook Handbook for Mechanical Engineers. (Source: http://www.bls.gov/ooh/architecture-and-engineering/mechanical-engineers.htm)

Mechanical engineers typically do the following:

- Analyze problems to see how mechanical and thermal devices might help solve a particular problem.
- Design or redesign mechanical and thermal devices or subsystems, using analysis and computer-aided design.
- Develop and test prototypes of devices they design.
- Analyze the test results and change the design or system as needed.
- Oversee the manufacturing process for the device.
- Mechanical engineers design and oversee the manufacture of many products ranging from medical devices to new batteries.

Mechanical engineers design power-producing machines, such as electric generators, internal combustion engines, and steam and gas turbines, as well as power-using machines, such as refrigeration and air-conditioning systems.

Mechanical engineers design other machines inside buildings, such as elevators and escalators. They also design material-handling systems, such as conveyor systems and automated transfer stations.

Like other engineers, mechanical engineers use computers extensively. Mechanical engineers are routinely responsible for the integration of sensors, controllers, and machinery. Computer technology helps mechanical engineers create and analyze designs, run simulations and test how a machine is likely to work, interact with connected systems, and generate specifications for parts.

Work Environment

Mechanical engineers generally work in offices. They may occasionally visit worksites where a problem or piece of equipment needs their personal attention. In most settings, they work with other engineers, engineering technicians, and other professionals as part of a team.

ACTIVITY 2

How to Become a Mechanical Engineer

Mechanical engineers typically need a bachelor's degree in mechanical engineering. Mechanical engineering programs usually include courses in mathematics and life and physical sciences, as well as engineering and design courses.

Important Qualities

- Creativity: Mechanical engineers design and build complex pieces of equipment and machinery. A creative mind is essential for this kind of work.
- Listening Skills: Mechanical engineers often work on projects with others, such as architects and computer scientists. They must listen to and analyze different approaches made by other experts to complete the task at hand.
- Math Skills: Mechanical engineers use the principles of calculus, statistics, and other advanced subjects in math for analysis, design, and troubleshooting in their work.
- Mechanical Skills: Mechanical skills allow engineers to apply basic engineering concepts and mechanical processes to the design of new devices and systems.
- Problem-Solving Skills: Mechanical engineers need good problem-solving skills to take scientific discoveries and use them to design and build useful products.

Pay

The median annual wage for mechanical engineers was $83,060 in May 2014. The median wage is the wage at which half the workers in an occupation earned more than that amount and half earned less. The lowest 10 percent earned less than $53,210, and the highest 10 percent earned more than $126,430. Most mechanical engineers work full time, and about 1 in 3 worked more than 40 hours a week in 2014.

ACTIVITY 3—Basic

Building a Catapult

In this activity, teams of two or three Explorers will work together to build a catapult with the goal of launching a table tennis ball the farthest distance. Divide Explorers into teams and remind them that each member of the team should contribute to the design and the creation of the catapult.

The activity will have three parts: design (10 minutes), building (30 minutes), and testing (10 minutes).

- Have Explorers begin by gathering materials and brainstorming design ideas. Teams have 10 minutes to plan and draw designs for their catapults based on the available materials. Visit with each group and ask questions or offer guidance as needed.

- Alert the Explorers when the design time is finished and the building time has begun. Continue to offer support as needed for groups, and encourage involvement from all Explorers. If and when a structure breaks, be prepared to reassure the team that mistakes are essential to engineers and that they should make changes and start again.

- When the building time is over, set up a safe testing area and have Explorers stand behind a line marked on the floor. Have one team at a time bring their catapult to the line and take two turns launching the table tennis balls. If you choose to track the distances, use pieces of masking tape to mark the approximate spots where balls land.

Following the activity, reflect on the process and the ways that different designs affected the launch. After completing the activity, it is important to discuss what happened and why. The process of helping the youth learn from the activity is just as meaningful to their learning experience as is the actual activity.

ACTIVITY 4—Advanced

Building a Hydraulic Catapult

In this activity, teams of two Explorers will work together to build a catapult with the goal of reaching the farthest target. Divide Explorers into teams and remind them that each member of the team should contribute to the design and the creation of the catapult.

The activity will have three parts: design (5 minutes), building (45 minutes), and testing (10-20 minutes).

- Have Explorers begin by gathering materials and brainstorming design ideas. Teams have five minutes to plan and draw designs for their catapults based on the available materials. Visit with each group and ask questions or offer guidance as needed.

- Have teams open the box and lay out its contents. The first thing Explorers should notice is that the dimensions of the parts are in metric units, as the kit is used internationally. You can choose to use the metric units or use the table below to convert metric to standard units:

cm	inch
6.6	2.6
4.5	1.8
3.5	1.4
2.5	1.0
0.5	0.2
1.5	0.6
1.1	0.4+

- Explorers will learn about the difference between pneumatics and hydraulics, using two pistons and a length of tubing (see page 2). Air is a compressible fluid, whereas water is not.
- Follow the instructions provided in the kit for steps 1 through 13; notice the numbers in the O's refer to the parts diagram on page 2.
- In this setup, the top arm connected to the piston is a first-class lever, as the fulcrum or pivot is in the middle between the force and the weight of the arm. Because the hydraulic force is exerted close to the fulcrum, this system provides a large mechanical advantage to hurl the object once it hammers the second arm, which is also a first-class lever. Check out page 12 for more information about levers.
- Alert the Explorers when the design time is finished and the building time has begun. Continue to offer support as needed for groups, and encourage involvement from all Explorers. If and when a structure breaks, be prepared to reassure the team that mistakes are essential to engineers and that they should make changes and start again.
- Once teams have their hydrapults set up, they should test it out once or twice. Then measure 10 throws, and find the average distance the clay object is hurled.

Extra Advanced activity for older youth—suggested for grade 11 Explorers who have had or are currently in trigonometry and are looking for an additional challenge:

- If participants wish to pursue the mathematics of projectiles further and are familiar with trigonometry, they can use a stopwatch to measure the time of flight of the object. Once they are ready, they can measure the time of 10 flights and take the average. Also have them estimate the angle of projection, that is, the angle to the horizontal when the clay object leaves the second arm (about 70 degrees). Using the formula $T = (2u \sin 70)/g$, where T is the time of flight and $g=32$ *ft./sec²*, calculate u, the velocity of the object in ft./sec².
- As extension activities, pages 9 and 10 of the instructions give directions to build two other arrangements to compare how the device operates.
- Following the activity, reflect on the process and the ways that different designs affected the launch. After completing the activity, it is important to discuss what happened and why. The process of helping the youth learn from the activity is just as meaningful to their learning experience as is the actual activity.

Some sample questions are below. They are designed to help the participants apply what they have learned to their own interests. You are welcome to use these questions or develop your own questions that relate to your post or specific focus area.

Focusing Questions	▪ *What was the purpose of these activities? Why did we do them?* ▪ *Which parts of today's session did you enjoy most?* ▪ *What new things did you learn?*
Analysis Questions	▪ *How did you use engineering concepts and skills to build your catapult?* ▪ *How did you overcome challenges while designing and building your catapult?* ▪ *Could you have benefited from having more design, build, or test time?* ▪ *Which one would have been the most helpful? How would that have helped?* ▪ *Now that you have completed the activity, what else could have been helpful to you in building a better catapult?* ▪ *Did you see any good ideas from the other teams? What other design(s) would you like to try and why?* ▪ *If you had to do this activity again, would you change anything? What would you change and why?* ▪ *Why could working on a team be a benefit for engineers?*
Generalization Questions	▪ *What aspects of mechanical engineering would you like to learn more about?* ▪ *What subjects in school do you believe you will need in order to pursue a career in mechanical engineering?*

ADVISOR AND OFFICER REVIEW

After the meeting, address the following:

- Identify what was successful from the meeting.
- Identify what needed improvement.

Schedule an officer and Advisor planning meeting to prepare for next the post meeting or activity.