LESSON PLAN

Acoustic Shields (Grades 9-12)

+ OVERVIEW

In this design challenge, students will innovate the design of a bubble curtain for the Port of LU, which will be able to reduce underwater construction noises as the port builds its new dock. Students will learn about Avogadro's, Boyle's, and Charles' gas laws and how these laws are used by engineers in real-world applications. The students will be presented with the following problem: "The Port of LU wants to invest in a bubble curtain to help reduce underwater noise while constructing a new dock. They are very concerned with reducing their environmental impact while keeping their tight construction timeline. The Port of LU needs an engineering team that can design and manufacture one before construction begins." Students will engage in a STEM challenge to design an innovative bubble curtain and pitch that idea to their classmates (or a panel) to win the bid for the job with the Port of LU. Teams will be challenged to keep the cost low and consider other environmental mitigations for bonus points.

+ 2021 Science TEKS covered in this design challenge

High School Chemistry: CHEM.1.B, CHEM.1.E. CHEM.1.G, CHEM.10.B
High School Physics: PHY.1.B, PHY.1.E, PHY.1.G, PHY.8.D

+ Students will be able to:

- Understand what a bubble curtain is and its purpose
- Understand how noise reduction helps protect the environment
- Understand what Avogadro's, Boyle's, and Charles' gas laws are and how they relate to real-world applications
- Solve a problem using the engineering design process

+ Students will use the following STEM fluency skills:

- Communication
- Collaboration
- Creativity
- Critical Thinking
- Resilience
- Time/Resource Management
- Innovation
- Adaptability

+ Materials needed for this design challenge:

> Suction Cup	$300 per suction cup
> Tape	$115 per roll
> Glue Gun	$400 per glue gun
> Glue Sticks	$65 per 3 sticks
> Scissors	$140 per pair
> Vinyl Airline Tubing	$50 per inch
> Silicone Airline Tubing	$75 per inch
> Plastic Straws	$125 per 2 straws
> Water Bottle	$75 per bottle
> String	$30 per inch
> Air Stone	$1000 per stone
> Air Stone Connectors	$500 per connector
> Single Hole Puncher	$155 per hole puncher
> Ruler	$60 per ruler
> Air Hose Connectors	$60 per connector
> Thumb Tack/ Push Pin	$75 per thumb tack/push pin
> Duct Tape	$65 per inch
> Miniature Puncher	$70 per hole puncher
> Small Weights	$50 per g of weight (5g=5x130= $650)

+ Materials needed for the facilitator:

- Projector
- Computer
- Slide deck for the lesson
- Copies of the scorecard per group
- Underwater Microphone and associated cords
- Computer Software (dB Meter app)
- Tablet
- Fish Tank
- Water
- Sand (optional)
- Aquarium Salt (optional)
- Air Pump
- Scale

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+ FACILITATION GUIDE

SECTION	PROCEDURE
INTRODUCTION	**Slide 1: Acoustic Shields** > Introduce today's lesson on bubble curtains. **Slide 2-3: Objectives** > Explain to students that by the end of today's activity, they will have done all of the following: ▪ Understand what a bubble curtain is and its purpose ▪ Understand how noise reduction helps protect the environment ▪ Understand what Avogadro's, Boyle's, and Charles' gas laws are and how they relate to real-world applications ▪ Solve a problem using the engineering design process **Slide 4: Bubble Curtain** > Ask students if they know what a bubble curtain is? ▪ Play the video which shows an example of a working bubble curtain. ▪ After the video plays, discuss the bubble curtain asking them if they noticed the purpose of it. ▪ Get the students to start thinking about how a bubble curtain is made and whose job is it to invent or innovate equipment like this. **Slide 5: Marine Mammal Noise Threshold** > Introduce the students to the chart, and ask them what is the chart trying to teach us? ▪ Discuss how like humans, animals have hearing thresholds. The chart shows marine mammals broken down by different hearing frequencies, low mid, high and seals which come in and out of the water. Point out examples which are listed below the chart. ▪ Explain that there are two types of pile driving differentiated in the table: impact pile driving and vibratory pile driving. Explain that pile driving is needed to construct vertical columns that can create the foundation for a structure being built. • Impact pile driving involves lifting a heavy weight and dropping it on top of a pile, driving it into the ground. The blows are usually delivered at about one second intervals, and the process can take several hours depending on the pile's size, the sediment, and the desired penetration depth. Impact pile driving produces sharp, impulsive sounds. • Vibratory pile driving uses vibratory motion to drive the pile into the ground, rather than hammering it in. It can

be more efficient and faster than impact pile driving, and it can also be more economical. Vibratory pile driving produces a more continuous, non-impulsive sound than impact pile driving.

- Looking under the types of pile driving show students that there a different columns: one for noises that will injure the animal (Auditory Injury Threshold) and the other for noises loud enough to change the behavior of the animal (Behavioral Disturbance Threshold).
- Why would this be important for not only us but industry experts to know and understand?

Slide 6: Noise

- Introduce the students to the diagram, so that they understand some of the similarities and differences in the different noises and decibel levels in both air and water
- Discuss the differences in air and water and how these sounds compare to the last chart
  - For example, what noises in the air would be comparable with damaging a dolphin's hearing or to what animal group would vessel noises because behavior disbalances/auditory damage?

Slide 7: ABC's of Gases

- Ask students the question: Can they name any of the gas laws?
- Explain to students they are going to watch a video with 3 different gas laws. Here is the link in case the video will not play on the PPT slides. Gas Law Video link: https://www.youtube.com/watch?v=BY9VGS2eXas
- Below are some further discussions on these three gas laws that can correspond with the video if you want to go deeper or to discuss if the video/link does not play for you.
  - A- Avogadro's Law
    - Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules.
    - This law basically means, when the **temperature and pressure** are constant the **volume** is directly **proportional** to the **number of molecules** (N).
  - B- Boyle's Law
    - The volume of a fixed mass of gas is inversely proportional to its pressure at constant temperature.
    - When the **volume increases** the **pressure decreases**. This applies only if the **temperature** and the **mass** of gas remain constant.
  - C- Charles' Law
    - The volume of a fixed mass of a gas at constant pressure is directly proportional to the temperature in kelvin scale.

- At a constant **pressure and fixed mass**, when there is an **increase in temperature** there in an **increase in volume**.
- Do you think the gas laws are important in engineering?

Slide 8: Engineering Design

> Ask students the question. What is engineering?
- Let the students give their ideas of what engineers do
- Some common misconceptions about engineers are:
  - Engineers work at a desk all day.
    - Engineers work in many different places, while some may work at a desk others may work in the field such as alongside scientist in a lab, with architects designing buildings, outside in the environment.
  - Engineers are not/cannot be women.
    - There are women in engineering, even though they are underrepresented. According to the Bureau of Labor and Statistics, 16% of all engineers are women and 50% of the biomedical engineering students are female.
  - Engineers are nerds, who wear pocket protectors, are loners, and have little to no social skills.
    - Engineering is a diverse field with a variety of people. Engineers rarely work alone, and have to give pitches and presentations, therefore they need to have great people skills.
  - Engineers is not a creative field.
    - Engineers innovate and invent, they solve problems, they design. Their job is extremely creative and they are only limited by their imagination and knowledge.

Slide 9-11: Engineering Design Jobs

> Ask students what are some different engineering jobs?
- Here are 3 different engineering careers that you could consider upon graduation.

> Environmental Engineering
- Environmental Engineer applies engineering principles to environmental issues in order to find solutions for problems like pollution, developing sustainable sources of energy, or waste management.

> Design Engineering
- Design Engineers use computer-aided design (CAD) software to develop, test and improve manufacturing processes and product designs.

> Material Engineering
- Materials Engineering deals with the study and manipulation of materials to design and enhance their properties for various applications, such as developing new alloys, improving structural materials, and exploring advanced materials for specific purposes.

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Slide 12: Engineering Design Process

> - Ask students if they think all engineers solve their problems in one try. Explain to students that it takes many tries to get something correct in engineering. In engineering, there is no such thing as a mistake, only opportunities to learn. It is okay to fail. Just find the mistake and correct it. In engineering, there is never one correct solution.
> - It is important to understand that while this diagram linearly describes the engineering design process (EDP), but it is not so in reality. There will be times when you must go back through previous steps to redesign a new prototype. This is normal as this process is a roadmap for engineers to have to be able to solve real-life problems, and just as with life, it is not always straightforward. It's okay to fail at a prototype, engineers do it all the time. It's how we go back and try again that matters. There are always many solutions to a problem and always improvements that can be made. The steps that engineers take to find these solutions are called the *engineering design process*.
> - If we look at the EDP the first step is to identify, but what does that means?
>   - Engineers design solutions, what do they need to know first before they can find the answer? (The problem)
>   - How do people know when they have found the correct answer? In engineering, there are no correct answers, just better ones. However, engineers have certain criteria their innovation or product must have before they can have the solution that works. For example, when engineering a football, what does a football need to do? (Bounce, look a certain way, have laces, have air inside, etc.). Those are the criteria of a football, and how they know a football is a football and will work, but is a child-sized football the same as an adult football? They are similar, but different because of different criteria for engineers.
>   - Now, what are some things that could make it difficult for an engineer to design their solution? (Money, time, materials, etc.) These are the constraints an engineer may face when trying to design a solution, or rules that engineers must follow. There are always constraints for engineers when they are trying to find a solution to problems. Think about football again, what are the college and professional footballs made of? (Leather). But what if the rule was to not use leather, could another type of football be made instead? Many of the footballs for sale are made of rubber because the engineer had different constraints.
> - The second step is to Imagine.
>   - In this step, see what materials are available, then brainstorm, or think, about possible ideas/solutions to the problems.
>   - Explain to students that there are no right answers in engineering. Start with as many ideas as possible.
> - The third step is to plan.

	▪ This step is important but can sometimes be overlooked because it is not a fun step. Engineers must make sure that what is designed can be repeated. A plan will help an engineer identify where mistakes happen so they can be fixed. ▪ When planning, begin with the brainstorming phase. Each team member will contribute their ideas but all team members must be able to come to a consensus when finalizing the plan. ▪ Once ideas are combined into a single group idea, determine what materials will be used for the solution and make sure the design has met the criteria and constraints of the project. > The fourth step is to create. ▪ Engineers do not start this step with a finished product. The very first creation is called a prototype. A prototype is created to test the engineer's idea or concept. An important question an engineers must ask themselves is, "Did the idea work the way we wanted it to?" After testing the idea, the engineer will make improvements to the prototype. > The fifth and final step is to improve ▪ How does an engineer know if the prototype did well on the test? It must meet certain expectations and follow some rules, but how do engineers determine how well it met the expectations and how well it followed the rules? In school, how do you know if you mastered something? (Grades). The prototypes made today will be scored using a scorecard or rubric. By looking at the score, each team will determine if the design could be better. If improvements should be made, then the team will revisit the plan and decide what to do to improve the score. Remember, there are no correct answers in engineering, just better solutions.
IDENTIFY	**Slide 13-14: Identify** - Problem > Have students read the bolded section. ▪ Can anyone summarize for me what you will be doing for this engineering design challenge? **Slide 15: Identify** - Criteria (Desired Outcomes) > For the students to be successful today, what are the criteria? ▪ A successful bubble curtain will be able to: • Reduce underwater noise • Be watertight (not leak) • Stay in place when set > Pitch design to classroom panel ▪ Must be 2 minutes in length ▪ Must explain their design idea by including the following • Why their team chose their design • Each team members contribution to the project • Their budget for the project • Creativity/Innovation

	Bonus points will be awarded if the design group that thought about mitigating other environmental factors and had the lowest total cost to develop. **Slide 16-17: Identify** - Constraints (Limitations) > Explain the constraints for this engineering design activity are: ▪ **Time Limit:** Students will have 25 minutes to build their bubble curtain. ▪ **Materials:** Students will only be able to use the materials available for the activity. ▪ **Collaboration:** One design element from each team member must be used in the final design. Explain to students that a design element is taking one part of someone's idea and adding it to another. ▪ **Redesign:** Each team can test their prototype as many times as needed during the 25-minute design phase. Remind students what a prototype is. It is the first creation of our design.
IMAGINE	**Slide 18: Identify** - Explore Materials > Demonstrate the bubble curtain by showing an example. Before class, have the tank set up with the underwater microphone set up with worksheet provided, water, salt (optional), and sand (optional) ready to go. Take the air stone, tubing, and air pump. Plug the one end of the hose to the air stone, and the other end of the hose to the air pump. Ensure the air pump is plugged in and the valve is open on the air pump and have the students see a bubble curtain example. Measure the ambient sound by dropping a marble into the tank with the bubble curtain turned off. Turn the pump on and measure the sound again by dropping a marble to see the difference. Students will design their bubble curtain with this example in mind. > Go over the materials and cost and answer any questions as they may arise. **Slide 19: Imagine** - Brainstorm > Give students one minute to individually design and draw a plan of what they think their bubble curtain should look like. Emphasize that students should not talk during this minute or share ideas. Remind students their ideas will be used as design elements for the final design. > After a minute, give students 3 minutes to present and share their ideas with their group. Let students know that they should focus on key aspects of their idea that they like and want to be used as design elements for the final design when sharing. ▪ *Teacher's Note: If students are struggling with an idea for their design, provide ideas without giving the solution. For example, "This is a design that I tried earlier, but it failed. What could I do to improve it?" Emphasize that the design*

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	failed to reinforce that it is okay to fail and to let students know they cannot copy the design and expect success.
PLAN	**Slide 20: Plan** - Plan Development > Hand out the scorecard that will be used during the design challenge. Review the testing criteria with the class and answer questions. The testing criteria will inform their design decisions. > Have students collaborate to come up with a final design. Let students know they must include at least one element from each team member for their final design. > Ask students if they need to go back over the criteria one more time. If so, go back to that slide. > Students will need to select the materials to be used for the design and develop a budget for the project. The prices used in this challenge can be found in the materials list. Students will raise their hands when they are ready to purchase materials. The teacher will not guide students on following their budget. Students can buy supplies that are more costly, however not in excess.
CREATE	**Slide 21: Create -** Design Your Bubble Curtain > Let students know to have fun, be creative with their designs, and work together. > Remind students that being an engineer is not about getting the solution on the first try. There is no right answer, just better solutions. **Slide 22: Imagine** – Materials > Reminder slide for students to look at while working. **Slide 23-26: Create** - Test > Once students time is up, students will be called up to the testing station to test their bubble curtain. > Students will calculate their scores when testing in front of the teacher. The teacher will go through each of the categories on the scorecard with the students. > Each group will then get 2 minutes to pitch their idea to the class while the panel of judges. Judges can be a select number of classmates that rank them based on the listed criteria. The groups will total both scores (bubble curtain and panel pitch) to have a final overall score. > The teacher will recap the point total with the students and how many points the team received for each category to make sure it matches with what the students recorded.
IMPROVE	**Slide 27: Improve** - Redesign: Discussion > Students will reflect on their scores and discuss: ▪ What worked? ▪ What did not work? ▪ What do you want to improve? > Other topics that could be discussed:

	▪ What did you like or dislike about this process? ▪ How does this help the environment? ▪ What can we do to further help the environment? ▪ Do you see how the gas laws are important for engineers now? Why or why not?