The Power of Waves and Energy Conversion

Companion Lesson to X-STEM All Access Episode "High Altitude Inspiration"

Grade/ Grade Band 6-12	**Topic:** Energy	

Brief Lesson Description: In High Altitude Inspiration, Major Jay Park shares his experience of flying at Mach 1 and Mach 1.2 and breaking the sound barrier. In this lesson, students will examine the speed of sound.

Performance Expectation(s):
MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Specific Learning Outcomes:
Students will be able to calculate the speed of sound.
Students will illustrate what happens during a sonic boom.

Narrative / Background Information

Prior Student Knowledge:
Students should be able to calculate speed.
Students should be able to define energy and describe how it can manifest as motion, sound, light, and thermal energy.

Science & Engineering Practices:

Developing and Using Models
Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to describe, text, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-PS4-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)

Disciplinary Core Ideas:

PS4.A: Wave Properties

- A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3)

ETS1.A: Defining and Delimiting an Engineering Problem

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-PS3-3)

Crosscutting Concepts:

Structure and Function

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS4-2)

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)

Influence of Science, Engineering and Technology on Society and the Natural World

- Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

Possible Preconceptions/Misconceptions:
Students may believe that sound travels only to the person who hears it. Sound waves actually travel from the source in all directions like a 3-D sphere.

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Begin the lesson showing the High Altitude Inspiration video. Ask students to record 3 interesting facts about Major Jay Park. After viewing the video, students will discuss in pairs the facts they noted and explain why the facts interest them.

Then write the term **sound** on the board. Ask students to brainstorm what they know about sound. Record their responses.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

Prior to the lesson collect the following materials:

- Stopwatch (10-25)
- Thermometers (10)
- 10 meter sticks or measuring tape/wheel
- 2 wooden blocks
- 10 pieces of 100 m string
- 20 plastic cups
- Masking tape
- Scissors
- Calculators
- Find an outdoor space to measure 100 meters (i.e., your football field)

Students are going to calculate the speed of sound (343 m / s). Take the class outside to the field. Students measure off 100 meters. Have 1 student stand at one end of the field (origin) with the two blocks they will clap together. Give 9 students a thermometer and a stopwatch. These students will stand 10 meters apart (at the 10m, 20m, 30m, etc. marks); they will record the temperature for each trial when they hear the clap sound and record in Table A. Give the remaining students a stopwatch and stand them 100 meters away from the student with the blocks (origin). Students will start the stopwatch when they see the blocks touch (clapped together) and stop the stopwatch when they hear the clap sound. Record in Table B.2. Repeat trials 5-10 times.

Table A (to track temperature only)

Trial	Distance (m)	Time (s)	Temperature (°C)

Table B.1 (Temperature measured)

Trial	Temp (°C) @ 10m	Temp (°C) @ 20m	Temp (°C) @ 30m	Temp (°C) @ 40m	Temp (°C) @ 50m	Temp (°C) @ 60m	Temp (°C) @ 70m	Temp (°C) @ 80m	Temp (°C) @ 90m	Average

Trial	Student 1 Time	Student 2 Time	Student 3 Time	Student 4 Time (s)	Student 5 Time (s)	Student 6 Time (s)	Student 7 Time (s)	Student 8 Time (s)	Student 9 Time (s)	Average

Table B.2 (Time measured)

After collecting data, students will average their results and share with their classmates in Table C. Then they will calculate the speed.

Table C

Trial	Distance (m)	Averaged Time (s)	Speed (m/s)	Temperature (°C) (averaged)
	100m			
	100m			
	100m			
	100m			
	100m			

Note: the timing will be very short, hence multiple students collecting data which will be averaged before using to calculate speed; also, students standing at the 100 meter mark are spread out to illustrate that sounds travel in waves.

EXPLAIN: Concepts Explained and Vocabulary Defined:

Sound is a form of energy that travels in the form of vibrations through the air or any other medium. The speed of sound is the measure of the distance traveled per unit of time by a sound wave. At 20°C (68°F) the speed of sound is 343 m/s. Ask students, "how close were their calculations for the speed of sound?", "were there any differences based on where you were standing to collect the measurements?", "do you think the sound changed?", and "what are possible sources for any error?". (Possible errors: human error when measuring time, temperature fluctuations, human error when measuring distance, clapping blocks at different forces). You want to emphasize that sound travels in waves from the source through whatever medium.

Explain to students that Major Park shared he had traveled faster than the speed of sound and that traveling at that speed causes a loud explosive noise known as the sonic boom. Show this video clip from NASA explaining the sonic boom and how engineers are designing new aircrafts to eliminate the noise.

Vocabulary:

Sound - is a vibration that propagates as an acoustic wave, through a transmission medium such as a gas, liquid or solid

Sonic Boom - a loud explosive noise caused by the shock wave from an aircraft or other object traveling faster than the speed of sound

ELABORATE: Applications and Extensions:

Prior to starting the elaboration section of this lesson, you will need to gather the following materials (per group): 100 m string, 2 plastic cups (with a hole poked in the middle of the bottom), 4 pieces of masking tape, a stopwatch, and calculator

Students are going to assemble their own "telephone" by inserting the one end of the string in the bottom of each cup and securing it with the tape.

Students are going to repeat the experiment of calculating the speed of sound using their "telephone". Student A will hold their cup to their mouth and speak into it when Student B signals and starts their stopwatch. Student B will stop the stopwatch when they hear the sound Student A spoke into the cup. Students should repeat this experiment for at least 5 trials and then calculate the speed.

Trial	Distance (m)	Time (s)	Speed (m/s)
	100m		
	100m		
	100m		

	100m		
	100m		

Ask students, “how close were their calculations to their calculated speed of sound?” in the previous activity, “how close were their calculations to the actual speed of sound?” and “what are possible sources for any errors?”.

Students then create an illustration of how the sound traveled from the origin to the receiver based on the 2 investigations.

EVALUATE:

Formative Monitoring (Questioning / Discussion): Students will demonstrate their understanding based on their calculations of speed (distance ÷ time) and the source of errors.

Summative Assessment (Quiz / Project / Report): Students create illustrations of how sound travels as waves radiating from the origin source.

Elaborate Further / Reflect: Enrichment: Students create a model of a sonic boom and explain the difference between what happens to the sound waves during the sonic boom and their sound investigations**.**

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency: Self-Awareness
During Major Jay Park's presentation, he discusses his personal and cultural assets that led him to become who he is. Self-awareness is the ability to understand one’s own emotions, thoughts, and values and how they influence behavior across contexts. In this activity, students will recognize their strengths and limitations with a well-grounded sense of confidence and purpose.
Begin this activity with students writing for 3 mins: “Who are you? What do you want the world to say about you?”
Next share the video: Teen Voice: Who Are You on Social Media? from commonsense.org. Ask students the following questions:

1. Whose perspectives stand out and why?
2. Which perspectives do you agree/disagree with and why?
3. How do you curate your life on social media?
4. Does your social media tell the same story about you that you wrote about at the beginning of class? Why or why not?

Allow time for the discussion to develop so most students share personal experiences and make a connection between who they are, who they show on social media, and who they want to be.
Next step is a skills dump where the students brainstorm a list of their skills (academic, social, soft, personal) they use to complete a task. After creating the list of skills, students revisit the story they wrote at the start, compare to their list of skills, and re-write their story to include their strengths and areas of development to build onto their limitations.

INTERDISCIPLINARY CONNECTIONS/IDEAS

During this lesson students are calculating speed using the equation s=d/t, math common core standard 8.EE.B.5: ***Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways.***

Materials Required for This Lesson/Activity

Quantity	Description
Per student	Calculators
10-25	Stopwatch
10	Thermometers
10	Meter Sticks or measuring tape/wheel
2	Wooden blocks
10	Pieces of 100 m string
20	Plastic cups
	Masking tape

Per student	Scissors

Lesson Created by Stacy Douglas
For questions, please contact info@usasciencefestival.org