Name: ______________________________________ Date: _________________

● Introduction to Waves Reading Passage

INTRODUCTION TO WAVES

A **wave** is a regular pattern of motion created by a vibratory disturbance. A wave moves through matter or a medium. A **medium** is a gas, liquid or solid substance. Some waves can travel through a vacuum like outer space.

When a wave travels through a medium, it causes particles in that substance to oscillate. An **oscillation** is a repeating and regular motion (such as a back-and-forth motion). Most waves are periodic. Periodic waves move at a constant speed and oscillate regularly. Waves cause particles in a medium to oscillate across a point called equilibrium. **Equilibrium** is the rest position. After a wave passes, particles return to equilibrium.

A wave transfers energy as it moves from one place to another. When you see a wave move through a substance, you are observing the movement of energy through the medium. A wave does NOT transfer matter. It causes particles in matter to move up and down or left and right but the particles always return to equilibrium once a wave passes.

There are two main categories of waves: mechanical waves and electromagnetic waves. **Mechanical waves**, such as sound waves, are produced by a mechanical movement or vibrating object. They require a medium to travel through; they cannot travel through a vacuum. Mechanical waves transfer energy through a series of collisions. An initial particle is disturbed, which collides into other particles, which continue to collide with other particles so to transfer energy through the medium. This is why mechanical waves require a medium to travel through. **Electromagnetic waves**, such as light waves, are created by oscillations of electric and magnetic fields. Electromagnetic (EM) waves carry electromagnetic energy. Unlike mechanical waves, they do not require a medium to travel through; they can travel through a vacuum.

Questions

1. What is a wave?
2. Explain how a wave moves using the terms medium, oscillate and equilibrium.
3. What does a wave transfer as it moves?
4. Compare and contrast mechanical and electromagnetic waves.
5. How might life on Earth be different if light waves were mechanical waves?

Name: ____ Date: __________________

● Introduction to Waves Answer Sheet

Questions

1. What is a wave?

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2. Explain how a wave moves using the terms medium, oscillate and equilibrium.

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3. What does a wave transfer as it moves?

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4. Compare and contrast mechanical and electromagnetic waves.

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5. How might life on Earth be different if light waves were mechanical waves?

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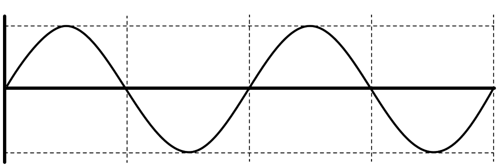
Name: ______________________________________ Date: __________________

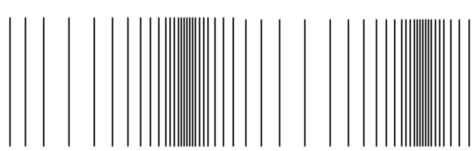
● Types of Waves Reading Passage Version 2

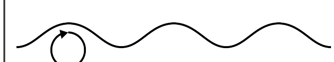
TYPES OF WAVES

There are two categories of waves: mechanical waves and electromagnetic waves. **Mechanical waves** are created by a mechanical movement or a vibrating object. Mechanical waves, like sound waves, can travel through a solid, liquid or gas but not a vacuum. **Electromagnetic waves** are created by oscillations of electric and magnetic fields. Electromagnetic (EM) waves, like light waves, can travel through a solid, liquid or gas as well as a vacuum.

There are two main types of mechanical waves: transverse waves, longitudinal waves and surface waves. With **transverse waves**, particles of the medium move perpendicular to the direction of the movement of the wave. In other words, particles move up and down when the wave moves left or right. With **longitudinal waves**, particles of the medium move in the same direction as the movement of the wave. In other words, particles oscillate parallel to the direction of the wave. A **surface wave** is a combination of a longitudinal and transverse wave. Surface waves travel along the surface of a medium, such as land or water. Only particles on the surface oscillate. The particles oscillate perpendicular *and* parallel to the motion of the wave. The combination of these motions causes particles to move in a circular motion. Graphics of transverse, longitudinal and surface waves are shown below.


Transverse wave


Longitudinal wave


Surface wave

Questions

1. What are the two main types of waves?
2. What are the three main types of mechanical waves?
3. Compare and contrast mechanical and electromagnetic waves.
4. Compare and contrast transverse and longitudinal waves.
5. Do you think an electromagnetic wave resembles a transverse or longitudinal wave? Justify your answer.

Name: ____ Date: ___________________

● Types of Waves Answer Sheet Version 2

Questions

1. What are the two main types of waves?

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2. What are the three main types of mechanical waves?

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3. Compare and contrast mechanical and electromagnetic waves.

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4. Compare and contrast transverse, longitudinal and surface waves.

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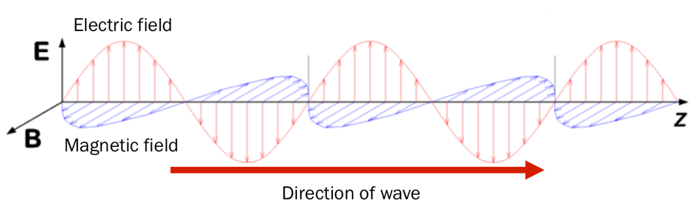
5. Below is a graphic of an electromagnetic wave. Do you think an EM wave resembles a transverse, longitudinal or surface wave? Justify your answer.



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Name: ______________________________ Date: ______________

● Wave Properties Reading Passage Version 1

WAVE PROPERTIES

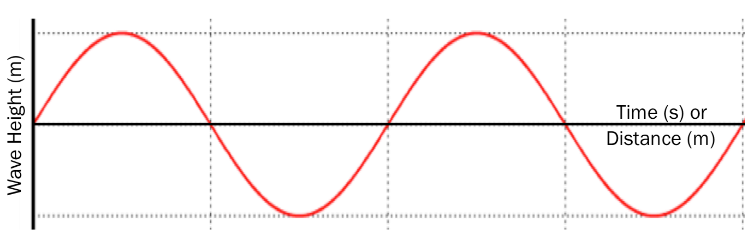
Wave properties describe how a wave moves and what a wave looks like. There are three important wave properties we study: amplitude, wavelength and frequency.

Amplitude is the height of a wave. It is the maximum displacement of a wave from its rest position, NOT the height of a wave from the lowest to highest point. For mechanical waves, amplitude is related to the energy of the wave. The higher the amplitude, the greater the energy carried by the wave. Amplitude is measured in meters.

Wavelength is the length of one wave cycle. A wave cycle is one complete path of a wave (a point on one wave cycle to a corresponding point on the next cycle). Wavelength is represented with the Greek letter lambda (λ) and is measured in meters.

Frequency is the number of times a wave cycles in one second. In other words, frequency is the number of wave cycles completed in one second. Frequency is measured in Hertz.

All waves have these properties, but they are easiest to study with transverse waves. For this reason, we study the properties on a graph of a transverse wave. We draw graphs of waves to better study amplitude, wavelength and frequency. The horizontal axis measures length or time and represents equilibrium. The vertical axis measures height.



Questions

1. What is amplitude?
2. What is frequency?
3. What is wavelength?
4. Compare the energy of a mechanical wave with a high and a low amplitude.
5. Label the amplitude and wavelength on the graph of the transverse wave.

Name: ______________________________ Date: ______________

Wave Properties Answer Sheet Version 1

Questions

1. What is amplitude?

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2. What is frequency?

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3. What is wavelength?

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4. Compare the energy of a mechanical wave with a high and a low amplitude.

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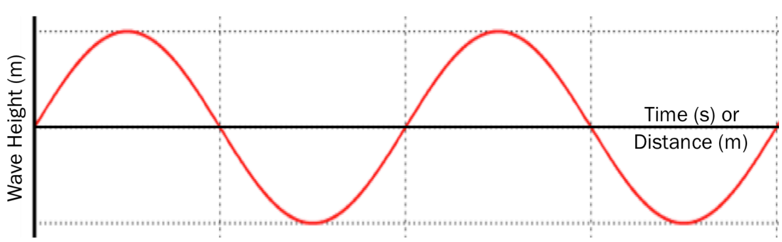
5. Label the amplitude and wavelength on the graph of the transverse wave.



Name: ______________________________________ Date: _________________

■ Transverse Waves Reading Passage

TRANSVERSE WAVES

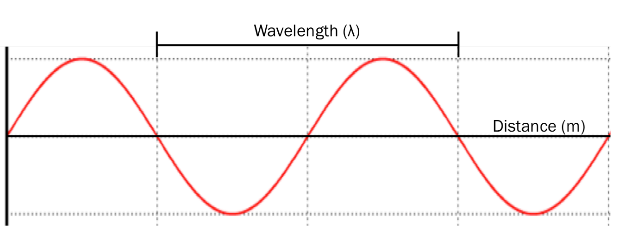
A **transverse wave** causes the particles of a medium through which the wave passes to oscillate perpendicular to its motion. In other words, if the wave moves left or right, the particles in the medium move up and down. You observe this when a person disturbs (or shakes) a rope up and down. The wave moves left or right while the "particles" (points along the rope) of the wave move up and down.

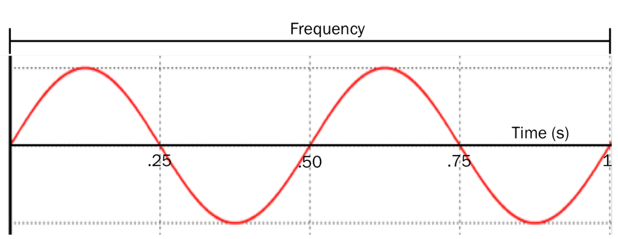
Electromagnetic (EM) waves are similar to transverse waves. The electric and magnetic fields oscillate perpendicular to the motion of the wave. For this reason, many texts will refer to EM or light waves as transverse waves.

When a transverse wave is graphed, the x axis represents the equilibrium. The x axis can measure time or distance. If it measures time, you can determine frequency of the wave. If it measures distance, you can determine the wavelength of the wave.

The up and down movement of the wave on a graph represents the movement of particles in the medium through which the wave passes. As a wave moves towards an area in the medium, particles in the medium move upward from their rest position. The maximum upward displacement is called a **crest**. As the disturbance moves away from that area, the particles move downward, past the rest position. The maximum downward displacement is called a **trough**.

You can measure wave properties of a wave on a graph. The distance from equilibrium to a crest or trough is **amplitude**. The **wavelength** of a transverse wave is the distance from the crest to crest, trough to trough or a point on one wave cycle to a corresponding point on the next cycle. The **frequency** of a transverse wave is the number of wave cycles completed in one second.





Name: ______________________________________ Date: __________________

■ Transverse Waves Answer Sheet

Questions

1. What is a transverse wave?

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2. What wave properties can you measure on a graph of a transverse wave?

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3. Why are electromagnetic waves similar to transverse waves?

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4. What is the difference between a crest and a trough?

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5. When provided a graph a transverse wave, can you determine both the wavelength and frequency of a wave? Explain your answer.

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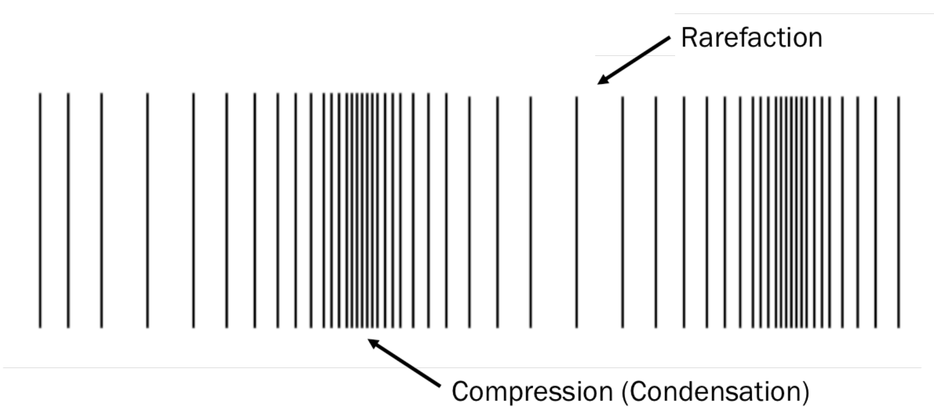
Name: ______________________________________ Date: _________________

■ Longitudinal Waves Reading Passage

LONGITUDINAL WAVES

Longitudinal waves, like sound waves, are waves that cause particles in a medium to oscillate parallel to the motion of the wave. In other words, particles in the medium oscillate left and right as the wave moves left or right. You observe this in a slinky. When a slinky is disturbed, a longitudinal wave moves through it. The wave moves to the left or right, causing areas of the slinky to be compressed and spread out.

As a longitudinal wave moves towards an area in a medium, it causes particles in the area to collide. Particles are pressed together in this area. We call this area a **compression** or condensation. As the longitudinal wave moves away from this area, the particles stop colliding and spread out. This produces an area where particles are well separated. We call this area a **rarefaction**. A compression is analogous to a crest in a transverse wave. A rarefaction is analogous to a trough in a transverse wave.



The wavelength of a longitudinal wave is the distance between two consecutive compressions or two consecutive rarefactions. Remember, wavelength is the length of one wave cycle. In a transverse wave, you would measure wavelength between two consecutive crests or troughs. If crests and trough are analogous to compressions and rarefactions, respectively, then the distance between consecutive compressions and rarefactions equals the wave's wavelength.

It is difficult, but not impossible to determine the frequency of a longitudinal wave. Frequency is the number of wave cycles that occur in one second. If a longitudinal wave is "graphed" along an axis of time, you can determine frequency by counting the number of wave cycles that occur in one second.

Name: ______________________________________ Date: _________________

■ Longitudinal Waves Answer Sheet

Questions

1. What is a longitudinal wave?

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2. How can you determine the frequency of a longitudinal wave?

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3. What features of a transverse wave are analogous to compressions and rarefactions?

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4. What is the difference between a compression and a rarefaction?

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5. Could you measure or determine the amplitude of a longitudinal wave? If yes, how? Defend your answer.

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Name: ______________________________________ Date: _________________

■ Wave Behavior Reading Passage

WAVE BEHAVIOR

When a wave encounters a barrier or enters a new medium, it behaves a certain way. Its behavior depends on the type of wave, its properties and properties of the barrier.

When a wave encounters a barrier, it can bounce off the surface of that barrier. This is called **reflection**. Waves tend to reflect best off flat, smooth, hard and shiny surfaces. For example, sound waves best reflect off hard surfaces such as brick walls or tile floors. The reflection of sound produces an echo. Light waves best reflect off calm water or mirrors. The reflection of light waves produces a mirror image.

When a wave passes across a barrier into a new medium, such as from air into water, the wave bends. The bending of a wave is called **refraction**. A wave refracts because its speed changes in the new medium. When speed of the wave changes, the direction of the wave changes and so it bends.

Waves can also bend to get around small barriers or to "squeeze through" small openings within a barrier. This is called **diffraction**. Waves diffract if the obstacle is small or if the opening in the barrier is just wide enough to accommodate the wavelength of the wave.

When waves come into contact with each other, they interact. Specifically, they overlay or superimpose each other This is called **interference**. When waves interfere with each other, they combine to produce one wave called a resultant wave. The amplitude of the resultant wave depends on the amplitude of the interfering waves and the phase of those waves.

Questions

1. When do we describe a wave's behavior?
2. Off of what kind of surfaces do waves best reflect?
3. Why do waves refract?
4. How is diffraction similar to but different from refraction?
5. What can happen when waves come in contact with each other?

Name: ______________________________ Date: ________________

■ Wave Behavior Answer Sheet

Questions

1. When do we describe a wave's behavior?

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2. Off of what kind of surfaces do waves best reflect?

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3. Why do waves refract?

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4. How is diffraction similar to but different from refraction?

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5. What can happen when waves come in contact with each other?

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Name: ______________________________________ Date: _________________

■ Interference Reading Passage

INTERFERENCE

Interference describes the behavior of waves when two or more waves come in contact and interact with each other. When waves interfere, they combine to produce one wave called a resultant wave. The amplitude of the resultant wave depends on the amplitude of the interfering waves and the phase of the interfering waves.

Interference causes waves to overlay or superimpose each other. Sometimes the waves superimpose and reinforce each other. Sometimes the waves superimpose and cancel each other out. Phase determines whether the waves reinforce or cancel each other. Waves that have the same position at the same time are **in phase**. On the other hand, waves that have different positions at the same time are **out of phase**. Waves that appear to be "opposite" each other are 180 degrees out of phase. These waves are said to be **completely out of phase**.

Constructive interference occurs when waves are in phase. When two in-phase waves interfere, the resultant wave has an amplitude higher than the individual waves. Specifically, the amplitude of the resultant wave equals the sum of the individual waves.

Destructive interference occurs when waves are out of phase or completely out of phase. When two out-of-phase waves interfere, the resultant wave has an amplitude lower than the individual waves. Specifically, the resultant wave has an amplitude that is equal to the sum of the waves; one wave has a negative amplitude and thus, takes away from the other wave. If two waves with the same amplitude are completely out of phase, the waves "cancel each other out." In other words, the two waves destroy each other.

Questions

1. What is interference?
2. What is a resultant wave? What affects the amplitude of the resultant wave?
3. Compare and contrast in-phase, out-of-phase and completely-out-of-phase waves.
4. Compare and contrast constructive and destructive interference.
5. Noise-canceling headphones manipulate interference. How do you think they do this?

Name: ______________________________ Date: ______________

Interference Answer Sheet

Questions

1. What is interference?

2. What is a resultant wave? What affects the amplitude of the resultant wave?

3. Compare and contrast in-phase, out-of-phase and completely-out-of-phase waves.

4. Compare and contrast constructive and destructive interference.

5. Noise-canceling headphones manipulate interference. How do you think they do this?

Name: ______________________________________ Date: __________________

● Sound Waves Reading Passage

SOUND WAVES

Sound waves are longitudinal, mechanical waves that produce sound. Sound is produced by vibrating objects. Mechanical movements can an object to vibrate, which causes particles around it, including particles in the air, to vibrate. Vibrating air particles create waves that can be heard by humans. We call these waves sound waves. When studying sound waves, we study three important characteristics: pitch, volume and speed.

The frequency of a sound wave determines the pitch of the sound. **Pitch** describes the "highness" or "lowness" of sound. In music, pitch corresponds to the vertical position of a note on a musical scale. Sound waves with a low frequency produce sound with a low pitch and sound waves with a high frequency produce sound with a high pitch. Pitch is measured in Hertz. A healthy, young person can hear sound with a pitch between 20 and 20,000 Hertz. People lose the ability to hear sound with a higher pitch as they get older. The highest pitch a middle age adult can hear is 12,000 to 14,000 Hertz.

The amplitude of a sound wave determines the volume of the sound. **Volume** is a measure of loudness. As amplitude increases, volume increases. The higher the volume, the louder the sound. Volume is measured in decibels (dB). A soft sound, like a whisper, produces 15-20 decibels. A loud sound, like a jet engine, produces 150 decibels. Loud sound can damage a person's hearing. Prolonged or repeated exposure to sound with a volume of 85 dB or greater can cause hearing loss.

The speed of sound in dry air is 343 meters per second. The speed of sound is often compared to the speed of light. The speed of light is 300,000,000 meters per second – nearly 900,000 times faster than the speed of sound! Like all mechanical waves, the speed of sound increases as the density of the medium increases. In other words, sound moves faster through a liquid and even faster through a solid. For example, sound travels four times faster in water (1,482 m/s) and 13 times faster through steel (4,512 m/s).

Name: ______________________________________ Date: _________________

● Sound Waves Answer Sheet

Questions

1. What is sound?

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2. How does the speed of sound change as the density of a medium increases?

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3. What is the difference between pitch and volume?

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4. How does the pitch and volume of sound change as frequency increases and amplitude decreases?

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5. Do you think listening to very loud music or very high-pitched music is more harmful to your hearing? Defend your answer.

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Name: ______________________________________ Date: _________________

■ Wave Velocity Reading Passage Version 1

WAVE VELOCITY

Wave velocity is a measure of how fast a wave travels. Different types of waves travel at different speeds. The speed of light (an electromagnetic wave) travels 3.00×10^8 m/s whereas the speed of sound (a mechanical wave) travels 343 m/s. Light travels nearly 900,000 times faster than sound! We have technology to travel at or faster than the speed of sound but not the speed of light.

You can observe the difference in speed of light and sound during a thunderstorm. Although lightning and thunder occur at the same time, thunder seems to come after lightning. This is because light travels faster than sound. Therefore, you see lightning before you hear thunder. The difference in time between the sight of lightning and sound of thunder helps predict how far away the lightning strike took place. Count the number of seconds between seeing lightning and hearing thunder. Divide by five. This calculation will tell you how many miles away the lightning strike took place.

The velocity of a wave changes as in different mediums. The velocity of a mechanical wave changes differently to than the velocity of an electromagnetic wave. As the density of a medium increases, the speed of a light wave decreases. Electromagnetic waves move fastest in a vacuum. The particles of matter hinder the propagation of EM waves and so EM waves move fastest through a vacuum or gas. On the other hand, as the density of a medium increases, the speed of a sound wave increases. Mechanical waves move fastest in solids and slowest in gases. They rely on the collision of particles in the medium to propagate. When particles are packed together closely, the wave can move faster.

Questions

1. What is wave velocity?
2. Compare the velocity of a sound wave to a light wave.
3. How can you predict how far away a lightning strike occurs?
4. Compare how the velocity of a sound and light wave changes as the density of the medium through which the wave travels increases.
5. According to the reading, we can travel at or faster than the speed of sound. Do you think we will ever travel at or faster than the speed of light? Defend your answer.

Name: ______________________________________ Date: _________________

■ Wave Velocity Answer Sheet Version 1

Questions

1. What is wave velocity?

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2. Compare the velocity of a sound wave to a light wave.

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3. How can you predict how far away a lightning strike occurs?

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4. Compare how the velocity of a sound and light wave changes as the density of the medium through which the wave travels increases.

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5. According to the reading, we can travel at or faster than the speed of sound. Do you think we will ever travel at or faster than the speed of light? Defend your answer.

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Name: ____ Date: __________________

■ Wave Velocity Reading Passage Version 2

WAVE VELOCITY

Wave velocity is a measure of how fast a wave travels. Different types of waves travel at different speeds. The speed of light (an electromagnetic wave) travels 3.00 x 10^8 m/s whereas the speed of sound (a mechanical wave) travels 343 m/s. Light travels nearly 900,000 times faster than sound! We have technology to travel at or faster than the speed of sound but not the speed of light.

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Some planes can travel faster than the speed of sound. Traveling faster than the speed of sound is called **breaking the sound barrier**. A plane that travels at the speed of sound is said to travel Mach 1. A plane that travels twice the speed of sound is said to travel Mach 2 and so on.

As a plane approaches the speed of sound, sound waves bunch up in front of the plane. The plane “catches up” to the sound waves it produces. When a plane travels at the speed of sound, sound waves pile on top of each other in front of the plane. The sound waves cannot travel ahead of the plane because they move at the same speed as the plane. This piling of waves creates a wave with a large amplitude, called a **shock wave**. When the plane travels faster than the speed of sound, it “breaks through” the shock wave. When this happens, you see and hear the plane break the sound barrier. You see a visible cloud called a **vapor cone** and you hear a noise called a **sonic boom**.

Name: ______________________________________ Date: __________________

■ Wave Velocity Answer Sheet Version 2

Questions

1. What is breaking the sound barrier? What do you observe when a plane breaks a sound barrier?

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2. Compare the velocity of a sound wave to a light wave.

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3. How can you predict how far away a lightning strike occurs?

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4. Compare how the velocity of a sound and light wave changes as the density of the medium through which the wave travels increases.

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5. According to the reading, we can travel at or faster than the speed of sound. Do you think we will ever travel at or faster than the speed of light? Defend your answer.

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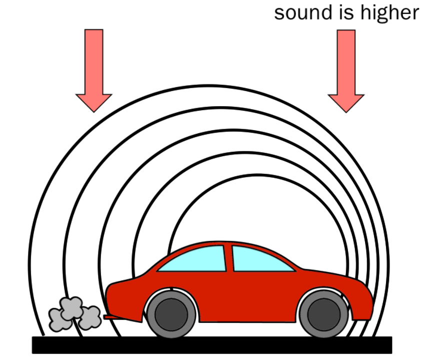
Name: ___________________________________ Date: _________________

◆ Doppler Effect & Sound Reading Passage

DOPPLER EFFECT & SOUND

When an object moves, the waves produced by that object are distorted. Specifically, the frequency of the wave changes. This phenomenon is called the **Doppler Effect**. The Doppler Effect depends on the relative position of the object emitting the waves and observer. If the observer is stationary and the object is moving, the frequency of the waves produced by the object will change for the observer.



The frequency, and thus pitch, of a sound wave will change and sound different to an observer if an object producing the sound moves towards or away from the observer. When an object moves towards the observer, the sound waves “bunch up” in front of the object. Successive waves are emitted closer to the previous wave. When the waves bunch up, frequency increases. When an object moves away from the observer, the sound waves “spread out” behind the object. Each successive wave is emitted further away from the previous wave. When waves spread out, frequency decreases.

The frequency of the sound produced by the object does not change. For example, as a car travels down the road, the sound of the car’s engine has a constant pitch which is heard by the driver and passengers in the car. In other words, the sound of the engine is a constant humming. This is because the sound produced by the engine is not moving towards or away from them; the driver and passengers are moving *with* the car.

Questions

1. What is the Doppler Effect?
2. What happens to sound waves in front of a moving object?
3. What happens to sound waves behind a moving object?
4. Compare and contrast how sound is heard by a person who observes a moving car to a person who is moving *with* the moving car.
5. Do you think the Doppler Effect’s intensity is different for slow and fast moving cars?

Name: ______________________________________ Date: __________________

◆ Doppler Effect & Sound Answer Sheet

Questions

1. What is the Doppler Effect?

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2. What happens to sound waves in front of a moving object?

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3. What happens to sound waves behind a moving object?

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4. Compare and contrast how sound is heard by a person who observes a moving car to a person who is moving *with* the moving car.

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5. Do you think the Doppler Effect's intensity is different for slow and fast moving cars? Defend your answer.

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Name: ______________________________________ Date: __________________

● Acoustics Reading Passage

ACOUSTICS

Acoustics is the science of sound. Scientists, engineers and musicians study acoustics so to better understand how sound travels and behaves. We want to understand sound for many reasons. Sound and hearing are important to animal survival. Speech, which produces sound, is a vital part of human culture. We rely on our ability to produce sound to communicate with each other. Also, applications of acoustics are important to many aspects of modern society, including noise control and audio industries.

Studying acoustics helps scientists better understand animal survival and behavior. Many animals rely on the ability to hear sound. This is important to survival because animals that hear are able to detect sound made by predators or other threats. Many animals, including humans, rely on the ability to produce sound to communicate with each other. Birds and frogs use sound in mating rituals and to mark territories. Humans rely on the ability to speak so to communicate with each other.

Studying ultrasound, sound that cannot be heard by humans, helps us better understand how some animals navigate and hunt. Animals like whales use sonar to navigate the vast ocean. The study of ultrasound has led to the development of sonar. Sonar is a navigational technique used by ships and submarines to explore and navigate the ocean.

Seismic waves are waves produces by earthquakes and volcanoes. Studying seismic waves helps scientists better predict when and where these events occur. Studying seismic waves also helps locate fossil fuels such as oil and natural gas.

Acoustics helps engineers design libraries, lecture halls, auditoriums and movie theaters. Understanding how sound travels helps everyone in an auditorium hear music played by a band or helps muffle sound in a library. Engineers manipulating the materials used to construct the room so to control reverberation and absorption. **Reverberation** is the persistence of a sound after the sound is produced. It is caused by reflected sound waves that bounce off surfaces in a room. If you construct a room with materials that reverberate sound, such as tile, you produce a loud room. **Absorption** is the dampening of a sound. Absorption occurs because sound waves are absorbed rather than reflected off surfaces in a room. If you construct a room with materials that absorb sound, such as carpet and curtains, you will produce a quiet room.

Name: ______________________________ Date: ______________

● Acoustics Answer Sheet

Questions

1. What is acoustics?

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2. How does studying acoustics help us understand animal survival and behavior?

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3. What are different ways scientists and engineers have applied acoustics?

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4. What is the difference between reverberation and absorption?

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5. What materials would you use (and not use) to design a library? Justify your answer.

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