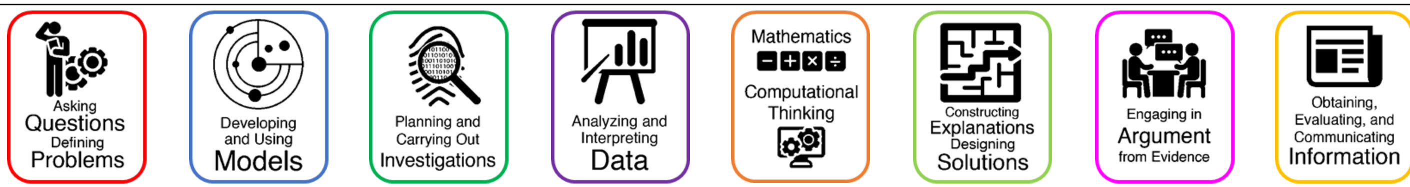
Unit 03: Investigating Energy & Waves
UNIT PLAN

TABLE OF CONTENTS

UNIT NARRATIVE
In lessons 1-6 students will explore transverse and longitudinal waves and the electromagnetic spectrum. Finally, in lesson 7-10 students learn about temperature, kinetic energy, and thermal energy transfer.

Focus on Disciplinary Literacy

In science, disciplinary literacy is synonymous with the science and engineering practices. The SEPs are the context through which all science concepts should be taught. In the lessons, you will find the Science and Engineering practices icons when the SEPs are being explicitly used by students.



CONENT STANDARDS

Below are the standards **taught** and **assessed** in this unit.

Supporting Standards
6.8C explain how energy is transferred through transverse and longitudinal waves. 8.8A Compare the characteristics of amplitude, frequency, and wavelength in transverse waves, including the electromagnetic spectrum. 8.8B Explain the use of electromagnetic waves in applications such as radiation therapy, wireless technologies, fiber optics, microwaves, ultraviolet sterilization, astronomical observations, and X-rays. 7.8A investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation 7.8C explain the relationship between temperature and the kinetic energy of the molecules within a substance

UNDERSTANDINGS AND QUESTIONS

Important big ideas and processes for the unit.

Key Understandings
• In transverse waves, energy moves perpendicularly to the direction the wave travels while in longitudinal waves, energy moves parallel to the direction of the wave. • Transverse waves have specific characteristics—such as amplitude, frequency, crest, trough, and wavelength. • Transverse waves have specific characteristics—such as amplitude, frequency, crest, trough, and wavelength these characteristics determine how much energy the wave carries and how it behaves. • Thermal energy is directly proportional to the temperature within a given system. Adding thermal energy to a system increases the kinetic energy of the molecules. Removing thermal energy from the system decreases the kinetic energy of the molecules. •

Key Questions
• How do particles in waves pass their energy to neighboring particles? • How do the particles in a longitudinal wave vibrate in relation to the moving energy? • How do the particles in a transverse wave vibrate in relation to the moving energy? • How do characteristics such as amplitude, frequency, and wavelength affect a wave's behavior? • What are the differences between a mechanical wave and an electromagnetic wave? • How do the amplitude of a wave, the frequency of a wave, and the wavelength of a wave differ? • What are some uses of electromagnetic waves in everyday life? • What is the electromagnetic spectrum? • How are wave types arranged on the electromagnetic spectrum?

- How is temperature related to the motion of molecules in a substance?
- What happens to the kinetic energy of molecules when thermal energy is added or removed from a system?
- How can we use models to represent the relationship between thermal energy, temperature, and particle motion?
- How do we know when a substance is gaining or losing thermal energy?

Common Misconceptions

- Students may think that all waves need a medium to travel through. Waves, like light and radio waves, can travel through space and don't need matter to travel through.
- Students may think that waves transport matter. When waves travel through solids, liquids, and gases, matter is not carried along with the waves. The energy is passed from molecule to molecule as the wave spreads out.
- Thinking that the direction of energy transfer in transverse waves must be up and down (or side to side), similar to the motion of the wave
- Confusing the direction of transverse and longitudinal wave movement
- Thinking energy transfers and energy transformations are the same thing
- Thinking that wave energy is carried by particles of the medium instead of particles that oscillate about their equilibrium positions
- Assuming energy is gradually lost as waves propagate through a medium
- Assuming speed determines wave energy and thinking that a faster-moving wave is more energetic than a slower one
- Thinking of waves as tangible physical objects rather than as patterns of energy transfer or disturbances that move through a medium or space
- Assuming all waves travel at the same speed.
- Molecules stop moving completely at room temperature or when they become solid. → Molecules in solids still vibrate in place unless they reach absolute zero (which is not possible in real-life conditions).

ROADMAP

ROADMAP AT A Glance: Unit 03 Investigating Waves				
Day	**Date**	**TEKS**	**Lesson**	**Lesson Title**
1		6.8C	01	Transferring Energy Through Waves
2		8.8A	02	Transverse Waves
3		8.8A	03	Characteristics of Waves
4		8.8A	04	The Electromagnetic Spectrum
5		8.8B	05	Using Electromagnetic Waves Part 1
6		8.8B	06	Using Electromagnetic Waves Part 2
7		7.8C	07	Temperature and Kinetic Energy Part 1
8		7.8C	08	Temperature and Kinetic Energy Part 2
9		7.8A	09	Thermal Energy Transfer Part 1
10		7.8A	10	Thermal Energy Transfer Part 2
11			Unit Exam	TX_SCI_8thScience_F25_UE03 Scanning Deadline:

Lesson # 01: Transferring Energy Through Waves | **Date:**

Objective

SWBAT compare and contrast transverse and longitudinal waves including how energy is transferred through the different wave types by completing a graphic organizer

Standards

TEKS

6.8C explain how energy is transferred through transverse and longitudinal waves.

Vocabulary

Compressions
Crest
Electromagnetic Wave
Longitudinal Wave

Science Practices

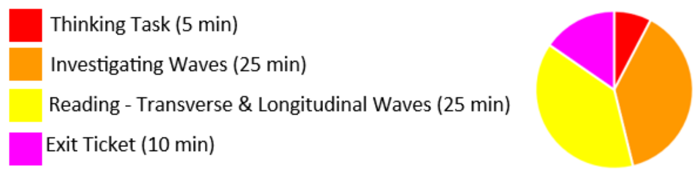
2. Developing and using models
8. Obtaining, evaluating, and communicating information

Recurring Themes and Concepts

A. Patterns

Instructional Notes

- Students engage in an investigation using a slinky to model transverse and longitudinal waves.
- Students will complete a reading to learn to deepen their understanding of the concepts they explored in the investigation



Lesson Look Fors

Look for teachers to:

☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
☐ Promote the use of partners and whole class discussion.

Look for students to:

☐ Engage in discourse and productive struggle
☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Students will complete a Venn diagram to compare and contrast transverse and longitudinal waves.

Know

- In transverse waves, energy moves perpendicularly to the direction the wave travels while in longitudinal waves, energy moves parallel to the direction of the wave

Lesson #02: Transverse Waves | **Date:**

Objective

SWBAT describe the characteristics of transverse waves including amplitude, frequency, crest, trough, and wavelength by modeling

Standards

TEKS

8.8A Compare the characteristics of amplitude, frequency, and wavelength in transverse waves, including the electromagnetic spectrum.

Vocabulary

amplitude
frequency
wavelength

Science Practices

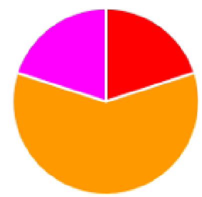
2. Developing and using models

Recurring Themes and Concepts

A. Patterns

Instructional Notes

- Students will complete a computer simulation to explore characteristics of waves.
- Students will develop the definitions for the terms, amplitude, frequency, crest, trough, and wavelength



Thinking Task (10 min)
Gizmo Transverse Waves (30 min)
Exit Ticket (10 min)

Lesson Look Fors

Look for teachers to:

☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
☐ Promote the use of partners and whole class discussion.

Look for students to:

☐ Engage in discourse and productive struggle
☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Students will match models, terms and definitions of the characteristics of waves.

Know

- Transverse waves have specific characteristics—such as amplitude, frequency, crest, trough, and wavelength. (these characteristics determine how much energy the wave carries and how it behaves.)

Lesson #03: Characteristics of Waves | **Date:**

Objective

SWBAT determine the characteristics of transverse waves including amplitude, frequency, and wavelength by interpreting graphs

Standards

TEKS

8.8A Compare the characteristics of amplitude, frequency, and wavelength in transverse waves, including the electromagnetic spectrum.

Vocabulary

amplitude
frequency
wavelength

Science Practices

2. Developing and using models

Recurring Themes and Concepts

A. Patterns

Instructional Notes

- Students will complete a reading to learn to deepen their understanding of the concepts they explored in Lesson 02.
- Students will practice determining the amplitude, frequency and wavelength of waves.

Thinking Task (7 min)
Characteristics of Waves Reading (30 min)
Properties of Waves Practice (15 min)
Exit Ticket (7 min)

Lesson Look Fors

Look for teachers to:

- ☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
- ☐ Promote the use of partners and whole class discussion.

Look for students to:

- ☐ Engage in discourse and productive struggle
- ☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Determine the characteristics of transverse waves including amplitude, frequency, and wavelength by interpreting graphs

Know

- Transverse waves have specific characteristics—such as amplitude, frequency, crest, trough, and wavelength these characteristics determine how much energy the wave carries and how it behaves.

Lesson #04: The Electromagnetic Spectrum	**Date:**

Objective

SWBAT explore the characteristics of the transverse waves on the electromagnetic spectrum by comparing models

Standards

TEKS
8.8A Compare the characteristics of amplitude, frequency, and wavelength in transverse waves, including the electromagnetic spectrum.

Vocabulary

Electromagnetic Spectrum

Science Practices

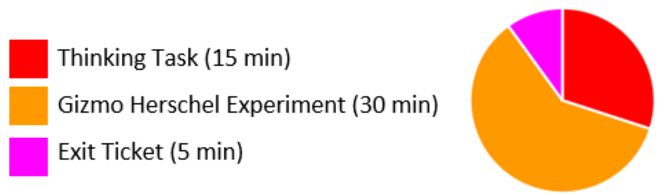
2. Developing and using models
4. Analyzing and interpreting data
8. Obtaining, evaluating, and communicating information

Recurring Themes and Concepts

A. Patterns

Instructional Notes

- Compare the characteristics of 7 different waves and order them from lowest to highest amplitude, frequency and wavelength.
- Use a computer simulation to explore how the temperature varies in the different areas of the visible light spectrum



Lesson Look Fors

Look for teachers to:

☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
☐ Promote the use of partners and whole class discussion.

Look for students to:

☐ Engage in discourse and productive struggle
☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Use a model to show where visible light, infrared and ultraviolet radiation fit in the electromagnetic spectrum and how they compare in terms of wavelength, frequency, and energy

Know

- In the electromagnetic spectrum, different types of waves (like radio, visible light, and X-rays) have different wavelengths and frequencies, which affect their energy and uses.

Lesson #05: Using Electromagnetic Waves Part 1

Date:

Objective

SWBAT describe the wavelength, frequency and energy of the different types of waves on the electromagnetic spectrum

Standards

TEKS 8.8B Explain the use of electromagnetic waves in applications such as radiation therapy, wireless technologies, fiber optics, microwaves, ultraviolet sterilization, astronomical observations, and X-rays

Vocabulary

Radio waves
Microwaves
Infrared Radiation
Visible Light
Ultraviolet Light
X-rays
Gamma Rays

Science Practices

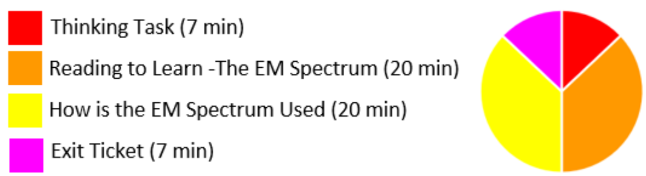
1. Asking questions and defining problems
2. Developing and using models
8. Obtaining, evaluating, and communicating information

Recurring Themes and Concepts

A. Patterns
E. Energy and Matter

Instructional Notes

- Students will engage in a reading to learn to deepen their understanding of the EM spectrum.
- Students will complete a card sort to describe the wavelength, frequency, energy and uses of the different types of waves on the electromagnetic spectrum.
- Students will describe the wavelength, frequency and energy of the different types of waves on the electromagnetic spectrum



Lesson Look Fors

Look for teachers to:

- ☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
- ☐ Promote the use of partners and whole class discussion.

Look for students to:

- ☐ Engage in discourse and productive struggle
- ☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Students will describe the wavelength, frequency and energy of the different types of waves on the electromagnetic spectrum

Know

- In the electromagnetic spectrum, different types of waves (like radio, visible light, and X-rays) have different wavelengths and frequencies, which affect their energy and uses.

Lesson #06: Using Electromagnetic Waves Part 2

Date:

Objective

SWBAT Explain the uses of electromagnetic waves creating a visual display

Standards

TEKS

8.8B Explain the use of electromagnetic waves in applications such as radiation therapy, wireless technologies, fiber optics, microwaves, ultraviolet sterilization, astronomical observations, and X-rays

Vocabulary

Radio waves
Microwaves
Infrared Radiation
Visible Light
Ultraviolet Light
X-rays
Gamma Rays

Science Practices

1. Asking questions and defining problems
2. Developing and using models
8. Obtaining, evaluating, and communicating information

Recurring Themes and Concepts

A. Patterns
E. Energy and Matter

Instructional Notes

- Students will research the uses of a specific type of wave on the EM spectrum

Thinking Task (7 min)
How is the EM Spectrum Used Research (20 min)
Make Uses Displays (10 min)
Gallery Walk (10 min)
Exit Ticket (7 min)

Lesson Look Fors

Look for teachers to:

- ☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
- ☐ Promote the use of partners and whole class discussion.

Look for students to:

- ☐ Engage in discourse and productive struggle
- ☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Students will explain the uses of electromagnetic waves by creating a visual display

Know

- In the electromagnetic spectrum, different types of waves (like radio, visible light, and X-rays) have different wavelengths and frequencies, which affect their energy and uses.

Lesson #07 and 08: Temperature and Kinetic Energy Part 1 and 2 | **Date:**

Objective

SWBAT explain the relationship between temperature and kinetic energy of molecule within a substance by creating particle models and citing evidence from investigations

Standards

TEKS 7.8C - explain the relationship between temperature and the kinetic energy of the molecules within a substance

Vocabulary

Heat
Kinetic energy
Temperature
Thermal Energy

Science Practices

2. Developing and using models
4. Analyzing and interpreting data
8. Obtaining, evaluating, and communicating information

Recurring Themes and Concepts

A. Patterns

Instructional Notes

- FIRST, students will engage in an explore lab to investigate how temperature affects the rate at which food coloring spreads through water
- Students will explore the relationship between temperature and kinetic energy using a PhET simulation. Students will analyze the movement of the particles at various temperatures.
- Students will participate in science discourse and complete a reading to learn exercise where they apply what they observed in the lab and PhET simulation.
- Students will explain the relationship between temperature and kinetic energy of molecule within a substance by creating particle models and citing evidence from the lab, PhET and reading to learn.

Lesson Look Fors

Look for teachers to:

- ☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
- ☐ Promote the use of partners and whole class discussion.

Look for students to:

- ☐ Engage in discourse and productive struggle
- ☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Analyze and interpret models and graphs to describe how the movement of particles changes as temperature changes.
- Use evidence from a simulation to explain the relationship between temperature and the kinetic energy of particles.
- Use reading evidence to support scientific claims about heat, temperature, and state changes.
- Explain thermal energy transfer using real-world examples (e.g., cooling coffee, melting ice) and scientific vocabulary.

Know

- Temperature is the average kinetic energy of the molecules in a substance.
- Thermal energy is the total energy (kinetic + potential) of the particles in a substance.
- As thermal energy increases, molecules move faster, increasing kinetic energy and temperature. As thermal energy decreases, molecules move slower, decreasing kinetic energy and temperature.

Lesson #09: Thermal Energy Transfer Part 1 | **Date:**

Objective

SWBAT describe how thermal energy is transferred in and out of systems and moves by conducting investigation

Standards

TEKS 7.8A investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation

Vocabulary

Heat
Kinetic Energy
Temperature
Thermal Energy

Science Practices

1. Asking questions and defining problems
3. Planning and carrying out investigations
4. Analyzing and interpreting data

Recurring Themes and Concepts

A. Patterns
B. Cause and Effect
D. Systems and System Models
E. Energy and Matter

Instructional Notes

Students will participate in a 6-station rotation investigation where they will experience the three methods of thermal energy transfer.

Lesson Look Fors

Look for teachers to:

- ☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
- ☐ Promote the use of partners and whole class discussion.

Look for students to:

- ☐ Engage in discourse and productive struggle
- ☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Investigate the 3 methods of thermal energy transfer.

Know

(By the end of the next lesson)

- Thermal energy is transferred between substances in one of three ways, conduction, convection, and radiation.
- Thermal energy moves from warmer substances to cooler substances

Lesson #10: Thermal Energy Transfer Part 2	Date:

Objective

SWBAT identify and describe the methods of thermal energy transfer by analyzing images and real-world scenarios.

Standards

TEKS

7.8A investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation

Vocabulary

Conduction
Conductor
Convection
Insulator
Radiation

Science Practices

7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Recurring Themes and Concepts

A. Patterns

Instructional Notes

- Students will engage in a reading to learn and apply their observations from the investigations to identify the methods of thermal energy transfer that occurred at each station.
- Students will analyze images of everyday scenarios and identify the type of energy transfer.
- Students will identify and describe the methods of thermal energy transfer by analyzing images and real-world scenarios.

Lesson Look Fors

Look for teachers to:

- ☐ Engage students in ABC. (Activity before content) The teacher should stamp key points AFTER students have had the time to engage in the content (productive struggle) and discuss.
- ☐ Promote the use of partners and whole class discussion.

Look for students to:

- ☐ Engage in discourse and productive struggle
- ☐ Justify their reasoning and support their ideas with evidence.

Students Do and Know

Do

- Students will identify and describe the methods of thermal energy transfer by analyzing images and real-world scenarios.

Know

- Thermal energy is transferred between substances in one of three ways, conduction, convection, and radiation.
- Thermal energy moves from warmer substances to cooler substances.

UNPACKED STANDARDS

Focus standards for this unit.

Standard:	6.8C explain how energy is transferred through transverse and longitudinal waves.

Specificity

Cognition: explain
Content: how energy is transferred through transverse and longitudinal waves.
Including but not limited to:

- Wave
  - A disturbance that transfers energy from one place to another
- Longitudinal wave
  - Energy travels in the same direction (parallel) as the vibrations of the medium particles.
  - Ex:
    - Sound waves in air
    - Primary waves of an earthquake
    - Waves in a spring
    - Tsunami waves
- Transverse wave
  - Energy travels perpendicular to the vibrations of the medium particles.
  - Ex:
    - Ripples of the surface of water
    - Secondary waves of an earthquake
    - Human wave in a stadium
    - Waves on the strings of a guitar, etc.

Vocabulary

energy	energy transfer	longitudinal wave
medium	motion	oscillation
transverse wave	vacuum	wave

Possible STAAR Stimuli

Investigation	Demonstration	Diagram
Model	Informational Text/List	

Content Builder

In transverse waves, energy moves at a right angle to the wave's direction. The wave goes up and down or side to side, and the energy moves with it. In longitudinal waves, energy moves in the same direction as the wave. The wave squeezes and spreads particles, causing the energy to transfer forward. Wave energy is carried by the disturbance itself and does not travel with the wave. Students may struggle to grasp the differences between transverse and longitudinal waves and how these properties affect the direction of energy transfer.

Instructional Implications

When you teach this concept, remember to:

- Use visual aids, models, animations, and hands-on demonstrations to illustrate the motion of transverse and longitudinal waves and how energy is transferred through them.
- Provide real-life examples of transverse and longitudinal waves such as light waves (transverse) and sound waves (longitudinal).
- Engage students in hands-on investigations where they can create and observe both transverse and longitudinal waves.
- Highlight the differences between transverse and longitudinal waves in terms of particle motion and energy transfer. Emphasize that in transverse waves, energy moves perpendicular to the wave direction while in longitudinal waves, energy moves parallel to the wave direction.

Misconceptions

- Students may think that all waves need a medium to travel through. Waves, like light and radio waves, can travel through space and don't need matter to travel through.
- Students may think that waves transport matter. When waves travel through solids, liquids, and gases, matter is not carried along with the waves. The energy is passed from molecule to molecule as the wave spreads out.
- Thinking that the direction of energy transfer in transverse waves must be up and down (or side to side), similar to the motion of the wave
- Confusing the direction of transverse and longitudinal wave movement
- Thinking energy transfers and energy transformations are the same thing
- Thinking that wave energy is carried by particles of the medium instead of particles that oscillate about their equilibrium positions
- Assuming energy is gradually lost as waves propagate through a medium

- Assuming speed determines wave energy and thinking that a faster-moving wave is more energetic than a slower one
- Thinking of waves as tangible physical objects rather than as patterns of energy transfer or disturbances that move through a medium or space
- Assuming all waves travel at the same speed

Standard: 8.8A Compare the characteristics of amplitude, frequency, and wavelength in transverse waves, including the electromagnetic spectrum.

Specificity

Cognition: Compare

Content: the characteristics of amplitude, frequency, and wavelength in transverse waves

Including but not limited to:

- Electromagnetic spectrum – the whole range of electromagnetic waves, sometimes referred to as radiation
- Waves – the movement of energy through a medium from one place to another
  - Transverse waves – Vibrations of the medium are perpendicular to the direction of waves.
    - Perpendicular is 90°; right angles
- Amplitude – distance from the mid-line of a wave, the equilibrium position, to the point of maximum vertical displacement (crest or trough)
  - The amplitude of an electromagnetic wave tells us its intensity.
  - The greater the amplitude, the more energy it carries.
    - In wireless communication, great amplitude means strong signals.
- Frequency – the number of times a wave passes a certain point in a given amount of time
  - Waves of the same frequency can have different amplitudes.
  - Ex: 6 per second or 6/sec
- Frequency and wavelength have an inverse relationship.
  - Higher frequency waves have shorter wavelengths.
  - Shorter frequency waves have longer wavelengths.
- Wavelength – distance from any one point on a wave to a corresponding point on the next wave; crest to crest or trough to trough
  - The wavelength determines the properties of a type of wave, including the colors of light in the electromagnetic spectrum.

Vocabulary

amplitude	crest	electromagnetic spectrum
energy	frequency	hertz
medium	oscillation	transverse wave

Content Builder

A transverse wave is one where the vibrations are perpendicular to the direction it moves. Electromagnetic waves in the electromagnetic spectrum are transverse waves, made of electric and magnetic fields. Unlike mechanical waves, electromagnetic waves do not need a medium to travel through and can move through empty space. Three key characteristics of transverse waves are amplitude, frequency, and wavelength. Amplitude represents the wave's strength, frequency controls its speed and regularity, and wavelength measures the distance between wave cycles. Students may struggle connecting transverse waves and the electromagnetic spectrum to real-life situations and applications.

Instructional Implications

When you teach this concept, remember to:

- Use visuals (models, diagrams, and animations) to show the relationship between amplitude, frequency, and wavelength. Demonstrations with ropes or water waves can also help.
- Relate concepts to real-life examples such as ripples on the surface of water and microwaves to make them more relatable.
- Include interactive simulations or online tools that let students manipulate amplitude, frequency, and wavelength values to see their impact on transverse waves.
- Explain the connections between amplitude (strength), frequency (speed), and wavelength (distance). Higher amplitudes mean more energy, higher frequencies indicate faster waves, and shorter wavelengths show more compressed waves.

Student Misconceptions

- Students may think that waves transport matter. Waves transport energy through matter.
- Students may think that waves must have a medium to travel through.
- Thinking that amplitude, frequency, and wavelength are always directly related or have the same values
- Confusing wavelength with wave height or wave width
- Thinking that amplitude and frequency are the same thing or that they measure the same aspect of a wave
- Not recognizing the inverse relationship between frequency and wavelength

trough	wave	wavelength	• Generalizing their understanding of waves based solely on water waves (e.g., ripples in a pond), leading to misunderstandings when dealing with other types of waves

Possible STAAR Stimuli

Investigation	Demonstration	Diagram
Visual/Image/ Illustration	Model	Informational Text/List

Standard: 8.8B Explain the use of electromagnetic waves in applications such as radiation therapy, wireless technologies, fiber optics, microwaves, ultraviolet sterilization, astronomical observations, and X-rays.

Specificity

Cognition: Explain
Content: the use of electromagnetic waves in applications
Including but not limited to:

- Electromagnetic waves – a type of wave that can carry energy through empty space as well as other materials, like water.
  - Organized on a number line in order from low to high frequency
  - Ex: light, radio waves, microwaves, X-rays, and gamma rays
- Radio waves
  - Wireless technologies
    - WiFi – used to connect wireless devices to the internet
    - Cellular – uses multiple transmitters to project radio signals over great distances
    - Satellite – Signals from Earth are transmitted to satellites orbiting in space then back to Earth.
    - GPS – uses satellite data and maps to locate the precise location of objects on Earth
  - Astrological observations
    - Detect space bodies that do not emit visible light, such as quasers, pulsars, and the remnants of supernova
- Microwaves
  - Cooking – Microwaves are used to transmit thermal energy to matter.
  - Astronomical observations
    - Black holes
    - The center of galaxies
- Infrared waves
  - Night vision technology
  - Heat lamps

Content Builder

Electromagnetic waves are produced by vibrations between an electric and magnetic field. Electromagnetic waves do not require a medium to travel, and thus they can travel in space. Electromagnetic waves have many uses, including:

- Radiation therapy – help treat cancer by targeting and damaging cancer cells
- Wireless technologies – power devices such as smartphones and Wi-Fi for wireless communication
- Fiber optics – enable high-speed data transfer over long distances, supporting the internet
- Microwaves – heat food quickly and conveniently in microwave ovens
- Ultraviolet sterilization – disinfect water, air, and medical equipment by killing microorganisms
- Astronomical observations – used by telescopes to study stars and galaxies
- X-rays – help doctors see inside the body for diagnosing fractures and health conditions

Instructional Implications

- Students will use this as prior knowledge in 8.9A and 8.9C.

When you teach this concept, remember to:

- Use models, diagrams, illustrations, and animations to visually represent the concepts of electromagnetic waves and how they are applied in various fields.
- Conduct hands-on investigations to demonstrate practical uses such as heating food with microwaves or sterilizing objects with UV radiation.
- Discuss the broader impact of electromagnetic waves on society such as how fiber optics changed internet connectivity and astronomical observations improved our understanding of the universe.
- Have students explore specific applications of electromagnetic waves in their lives or research their significance in different fields.

Misconceptions

- Pulse oxygen monitors
- Astrological observations
  - Cooler objects, like planets
  - Objects hidden by cosmic dust
- Visible light waves
  - Vision
    - Human eye
    - Microwaves
    - Media – video and photographs
  - Communication
    - Light sensors – security alarms and fiber optics

Vocabulary

electromagnetic spectrum	electromagnetic wave	fiber optic
gamma	microwave	radiation therapy
radio wave	receiver	transmitter
ultraviolet sterilization	wireless technology	X-ray

- Students may assume that electromagnetic waves are only dangerous. In fact, they can be used in applications like in the medical field.
- Students may think that other types of energy, like light energy, are used in the production of televisions, laptops, or cell phones.
- Students may assume that what we know about space and our universe was learned through astronauts going into space**.**
- Thinking that all electromagnetic waves, including those used in wireless technologies and X-rays, are harmful to human health
- Thinking that X-rays can see through any material
- Thinking that all wireless technologies (e.g., Wi-Fi and mobile networks) use the same electromagnetic frequencies
- Thinking that fiber optic cables use electricity to transmit data instead of pulses of light to transmit data over long distances with minimal signal loss
- Thinking that X-rays are only used for medical imaging and forgetting that they are also used in materials testing, security screening at airports, and industrial applications

Vocabulary

Informational Text/List	Diagram
Visual/Image/ Illustration	Model

Standard:	7.8A investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation

Specificity

Cognition: Investigation
Content: methods of thermal energy transfer into and out of systems

Including but not limited to:

- Thermal energy – energy resulting from the motion of particles measured as the temperature of substances
- Medium – a substance or material that carries energy
- Conduction – transfer of thermal energy between objects that touch each other
  - Measure temperature change of a metal spoon placed in hot water.
- Convection – transfer of thermal energy through liquids and gases in currents

Content Builder

Thermal energy transfers between objects or systems in three distinct ways: conduction, convection, and radiation.

- **Conduction** is the transfer of thermal energy through direct contact between particles or objects. Convection involves the transfer of thermal energy through the movement of a gas or liquid.
- **Convection** occurs when heated particles become less dense, rise, and are replaced by cooler particles. This creates a circulating flow known as convection currents, which carries thermal energy from one region to another.
- **Radiation** is the transfer

Instructional Implications

- Radiation – transfer of thermal energy through space as waves
    - Measure the temperature change in sand placed under a heat lamp.

Vocabulary

Conduction	Convection	Energy transfer
Radiation	Thermal energy	

Student Misconceptions

Students may make the following mistakes:

- Thinking that radiation requires a medium to transfer thermal energy
- Thinking that all materials transfer heat equally
- Thinking of temperature as a measure of heat, rather than the movement of particles in a substance
- Thinking that heat is a substance rather than the transfer of energy due to temperature differences
- Assuming good conductors of heat are always hot to the touch
- Thinking that convection always involves upward movement
- Thinking that convection is the fastest method of heat transfer
- Thinking that radiation needs a material medium (similar to conduction and convection)
- Thinking that only hot objects emit thermal radiation
- Thinking that radiation is always visible light

When you teach this concept, remember to:

- Allow students to conduct hands-on experiments that explore each method of thermal energy transfer.
- Have students collect and analyze data during their investigations. This may involve measuring temperature changes, observing the behavior of fluids, or recording the intensity of radiation. By analyzing the data they collect, students can identify patterns and draw conclusions about the effectiveness and efficiency of each method of thermal energy transfer.
- Use diagrams, models, animations, or videos to help students visualize and understand the mechanisms of thermal energy transfer.
- Explore real-world applications of different methods of thermal energy transfer. Examine heating and cooling systems, energy-efficient designs, weather phenomena, or industrial processes to demonstrate the practical implications of each method.
- Provide opportunities for students to differentiate between conduction, convection, and radiation in scenarios, card sorts, and graphics.
- Explain that convection currents can be complex, with fluids moving in various directions depending on conditions.
- Clarify that radiation is not always visible light. Thermal radiation covers a broad range of electromagnetic waves, including infrared radiation, which is often associated with heat.

Vocabulary

Conduction	Convection	Energy transfer
Radiation	Thermal energy	

Standard:	7.8C explain the relationship between temperature and the kinetic energy of the particles within a substance

Specificity

Cognition: Explain
Content: relationship between temperature and the kinetic energy of the particles within a substance

Including but not limited to:

- Temperature ‐ measure of the average kinetic energy of the particles in a substance
- Kinetic energy ‐ the energy of motion
- When a substance is heated, the substances' particles speed up, which results in an increase in temperature.

Content Builder

Temperature is a measure of the average kinetic energy of the particles within a substance. Kinetic energy refers to the energy associated with the motion of particles such as atoms or molecules. The higher the temperature of a substance, the greater the average kinetic energy of its particles. Students may struggle to understand how temperature and kinetic energy are interrelated because they may have preconceived notions about each concept separately.

Instructional Implications

When you teach this concept, remember to:

- Use diagrams, animations, or hands-on demonstrations to help students visualize the relationship between temperature and kinetic energy. Use analogies or relatable examples to make the relationship more tangible (e.g., compare the motion of particles at different temperatures to the movement of people in a crowded room or the behavior of vehicles on a busy highway).

Student Misconceptions

Students may make the following mistakes:

- Thinking that temperature and heat are the same
- Thinking that all particles within a substance have the same kinetic energy
- Thinking that increasing the temperature means adding more particles to the substance
- Confusing temperature with heat content and thinking that a substance with a higher temperature contains more heat energy, not considering both temperature and mass
- Thinking that particles completely stop moving at absolute zero
- Thinking that cooling down a substance means the particles lose energy
- Thinking that temperature is a measure of how "hot" or "cold" an object feels to the touch

Assuming all substances conduct heat at the same rate

- Provide hands-on activities such as experiments or simulations that allow students to observe and explore the relationship between temperature and kinetic energy firsthand.
- Demonstrate with different materials that have varying thermal conductivities to show how objects transfer heat.
- Help students understand that particles do not "lose" energy. While the average kinetic energy decreases when matter cools, it's important to emphasize that the particles don't lose energy but rather transfer it to their surroundings.
- Make sure students have opportunities to explain their understanding both verbally and in writing.

Vocabulary

Heat	Kinetic energy	particle
Temperature	Thermal energy	

Possible STAAR Stimuli

Demonstration	Visual/Image/Illustration	Model

VERTICAL STANDARDS

This section details the **progression** of key student expectations/standards** in the courses **before** and **after** this course. This will help you understand what **prior knowledge skills to build upon** and guide you in knowing what **skills you are preparing your students** for in the subsequent course.

6th Grade	7th Grade	8th Grade
		8.8A Compare the characteristics of amplitude, frequency, and wavelength in transverse waves, including the electromagnetic spectrum.
6.8C explain how energy is transferred through transverse and longitudinal waves.	7.8A: investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation	8.8B Explain the use of electromagnetic waves in applications such as radiation therapy, wireless technologies, fiber optics, microwaves, ultraviolet sterilization, astronomical observations, and X-rays.

VOCABULARY GLOSSARY

Domain-specific words and definitions for this unit.

Key Content Vocabulary
List and define key vocabulary terms **Compressions** – Areas in a longitudinal wave where particles are close together. **Crest** – The highest point of a transverse wave. **Electromagnetic spectrum:** A continuum of all electromagnetic waves arranged according to frequency and wavelength, from radio waves to gamma radiation **Electromagnetic Wave** – A wave that can travel through space and does not need a medium. **Gamma rays:** Electromagnetic waves with the shortest wavelengths, highest frequencies, and highest energy; produced by supernovas or the destruction of atoms **Infrared waves:** Electromagnetic waves with wavelengths longer than visible light but shorter than microwaves **Longitudinal Wave** – A wave where particles move back and forth in the same direction the wave travels. **Mechanical Wave** – A wave that needs a medium (like air, water, or solids) to travel through. **Medium** – The material through which a wave travels. **Microwaves:** Electromagnetic waves with wavelengths longer than infrared but shorter than radio waves **Radio waves:** Electromagnetic waves with the longest wavelengths, lowest frequencies, and lowest energy **Rarefactions** – Areas in a longitudinal wave where particles are spread apart. **Transverse Wave** – A wave where particles move up and down, perpendicular to the direction the wave travels. **Trough** – The lowest point of a transverse wave. **Ultraviolet waves:** Electromagnetic waves with wavelengths longer than X-rays but shorter than visible light waves; can cause tans, sunburns, and skin cancers **Visible light:** Electromagnetic waves with wavelengths longer than ultraviolet waves but shorter than infrared waves and within the range that can be detected by the eye **X-rays:** Electromagnetic waves with wavelengths longer than gamma rays but shorter than ultraviolet waves; used in medicine and astronomy **Conductor:** allow thermal energy to transfer easily **Heat:** the transfer of thermal energy from a warmer substance to a cooler one **Insulator:** slow down the transfer of thermal energy. **Kinetic Energy:** the form of energy that an object or a particle has by reason of its motion **Temperature:** the measure of the average amount of motion, or kinetic energy of the atoms or molecules in the system. **Thermal Energy:** the total of all kinetic energies within a given system.

Consumable Materials and Lab Supplies for Unit #3 (1 per group of 4 students unless noted)

Lesson	Commercial Vendor or Home	Lab Supplies (Science Vendor)
Lesson #01: Transferring Energy Through Waves	String coiled spring toy (slinky)	coiled spring toy (slinky) meter stick scissors
Lesson #02: Transverse Waves	none	Computer with internet accesses
Lesson #03: Characteristics of Waves	none	none
Lesson #04: The Electromagnetic Spectrum	none	Computer with internet accesses
Lesson #05: Using Electromagnetic Waves Part 1	none	none
Lesson #06: Using Electromagnetic Waves Part 2	none	none
Lesson #07 and 08: Temperature and Kinetic Energy	food coloring ice or refrigerator to cool water	Computer with internet accesses 3 beakers graduated cylinder thermometer stopwatch hot plate or microwave to heat water.
Lesson #09: Thermal Energy Transfer Part 1	<u>Station 1</u> Clothes pin Metal strip 2cm X 8 cm (cut from an aluminum pan) Candle wax shavings <u>Station 2</u> Pinwheel (purchase or make) <u>Station 3</u> Rice Plastic cup Spoon <u>Station 4</u> Bread Toaster (bring from home) <u>Station 5</u> Heat lamp <u>Station 6</u> Metal spoon Popsicle stick	<u>Station 1</u> Hot plate Ruler Timer Paper towels <u>Station 2</u> Hot plate 250 mL Erlenmeyer flask 100 mL graduated cylinder Heat resistant gloves Water Paper towels <u>Station 3</u> Hot plate 250 mL glass beaker Heat resistant gloves Water Paper towels <u>Station 4</u> Paper towels

		Station 6 500 mL beaker Timer
Lesson #10: Thermal Energy Transfer Part 2	None	None