SAVVAS

PROGRAM OVERVIEW

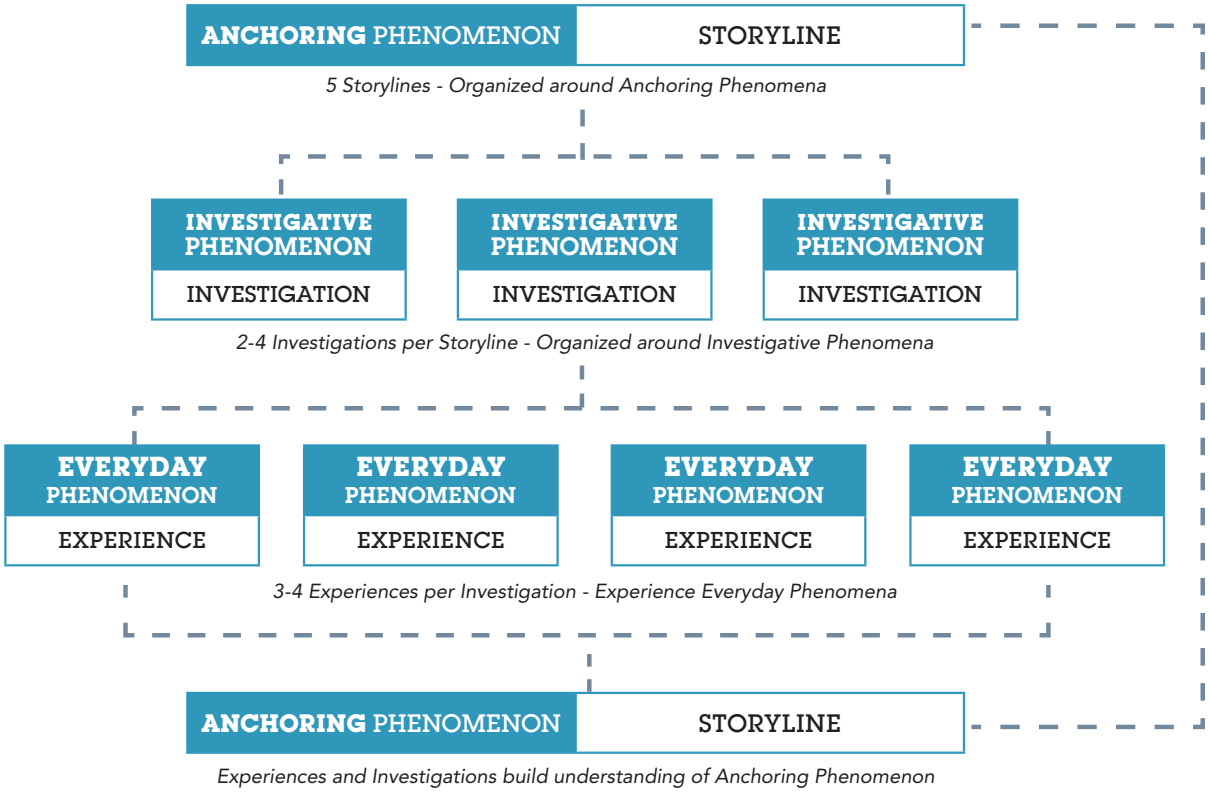
Experience Physics

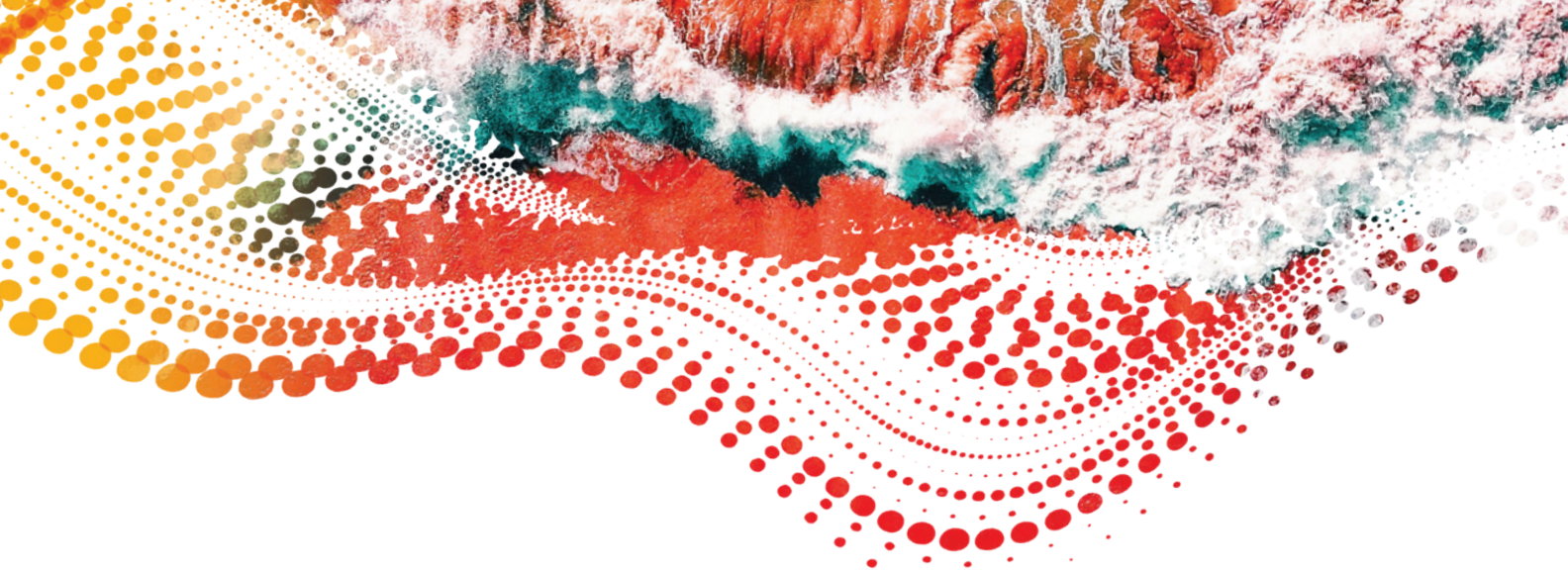
Phenomenal

experiences drive student inquiry.

Exploration begins with phenomena—showing students that physics is relevant to their lives. *Experience Physics* uses phenomena to engage students in scientific inquiry through its organizational structure and real-world storylines.

Phenomena Organization





Phenomena Launch

Exploration begins with a **phenomenon video** or **class demonstration** that introduces and unifies the physics concepts.

Student Sensemaking

Students gather information, develop arguments over time, and document their understanding using a Claim-Evidence-Reasoning model.

Everyday Phenomena

Engage students in a personal and relatable way. From Flinn Scientific inquiry labs to virtual simulations, students are motivated to figure out why and how a phenomenon happens.

Related Phenomena in the Teacher Guide offer alternative suggestions for every phenomenon.

Revisit

INVESTIGATIVE PHENOMENON

GO ONLINE to revisit your **Investigative Phenomenon CER** with the new information you have learned about Properties of Waves.

These questions will help you apply what you learned in this experience to the Investigative Phenomenon.

18 **SEP Use Mathematics** At the beach, you time the wave crests hitting the shore and determine there is 20 seconds between crests. Determine the frequency of the wave. Would you expect this frequency to change if you made your measurement further out from the shore?

19 **SEP Analyze and Interpret Data** After determining the frequency, you then use a handheld sonar system to determine the ocean depth at 10 m increments from the shore. The data is shown in the table. Complete the table and construct a graph of the wave speed as a function of the depth.

Distance (m)	Depth (m)	Speed (m/s)	Wavelength (m)

t both a distance
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as they

INVESTIGATIVE PHENOMENON DEMONSTRATION

Use a ripple tank or shallow baking pan to demonstrate the interaction between water waves and land. Put sand (or soil) at one end of the tank or pan, sloping down to the center of the pan. Fill the tank or pan with water. Then have a volunteer send waves from one end of the tank to the side that contains the sand. Have students observe how the waves interact with the sand.

Ask "How would increasing the size of the waves affect how the water interacts with the sand?" (Increasing the size of the waves would cause the water to carry away more of the sand.)

Flinn Scientific

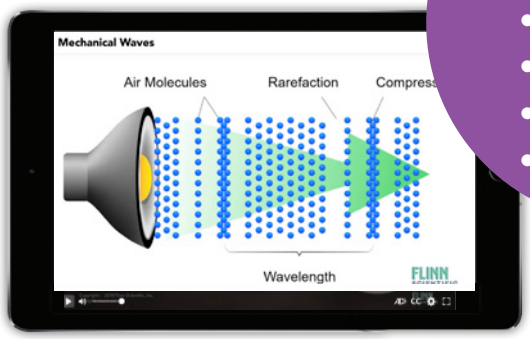
takes inquiry to a higher level.

Experience Physics is the science of doing! An exclusive partnership with Flinn Scientific, the leading classroom lab solution provider, gives students access to its labs and activities directly in *Experience Physics*.

Hands-on Labs

Every learning experience in *Experience Physics* includes a hands-on inquiry lab. To save you time, each lab is available in four versions and includes video support to meet your diverse classroom needs.

FLINN SCIENTIFIC



4

VERSIONS OF EVERY LAB

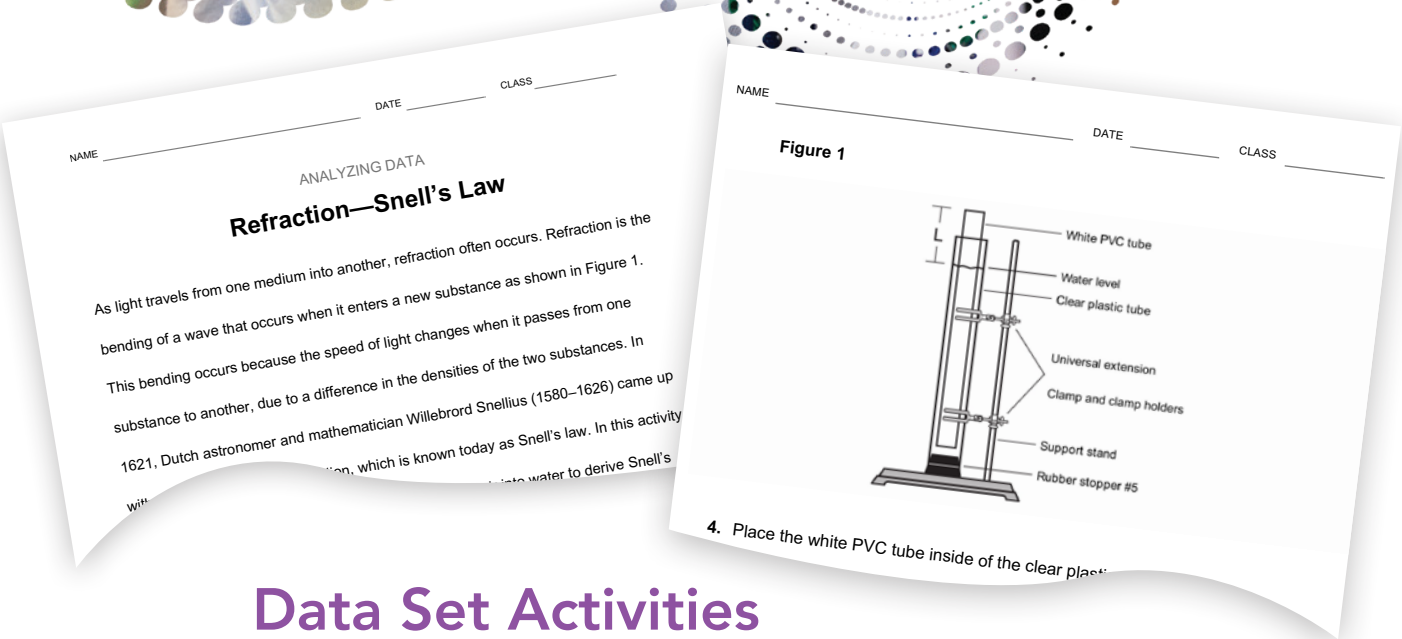
- Open-Ended
- Guided
- Shortened
- Advanced

Engineering Workbench

Students design, test, and evaluate solutions that mimic the real-world activities of engineers. Activities are connected to related careers on the ***Using Physics Today Hook & Inspire*** site.

Lab Kits

Simplify set-up with time-saving kits from Flinn Scientific. Foster greater inquiry learning by having readily accessible lab materials.



NAME _____ DATE _____ CLASS _____

ANALYZING DATA

Refraction—Snell's Law

As light travels from one medium into another, refraction often occurs. Refraction is the bending of a wave that occurs when it enters a new substance as shown in Figure 1. This bending occurs because the speed of light changes when it passes from one substance to another, due to a difference in the densities of the two substances. In 1621, Dutch astronomer and mathematician Willebrord Snellius (1580–1626) came up with ... which is known today as Snell's law. In this activity ... into water to derive Snell's

NAME _____ DATE _____ CLASS _____

Figure 1

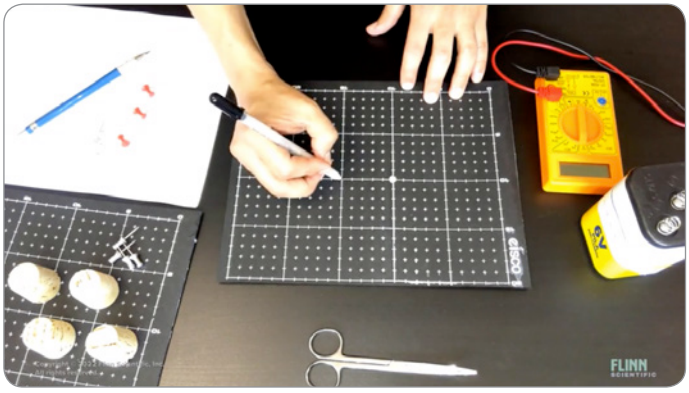
4. Place the white PVC tube inside of the clear plas...

Data Set Activities

Students develop mathematical fluency using data sets that connect physics concepts to real-world issues.

Performance Tasks

Students demonstrate standards mastery by applying their understanding to a new situation in a Performance-Based Assessment at the end of every Investigation.



Virtual Explorations

support the understanding of phenomena.

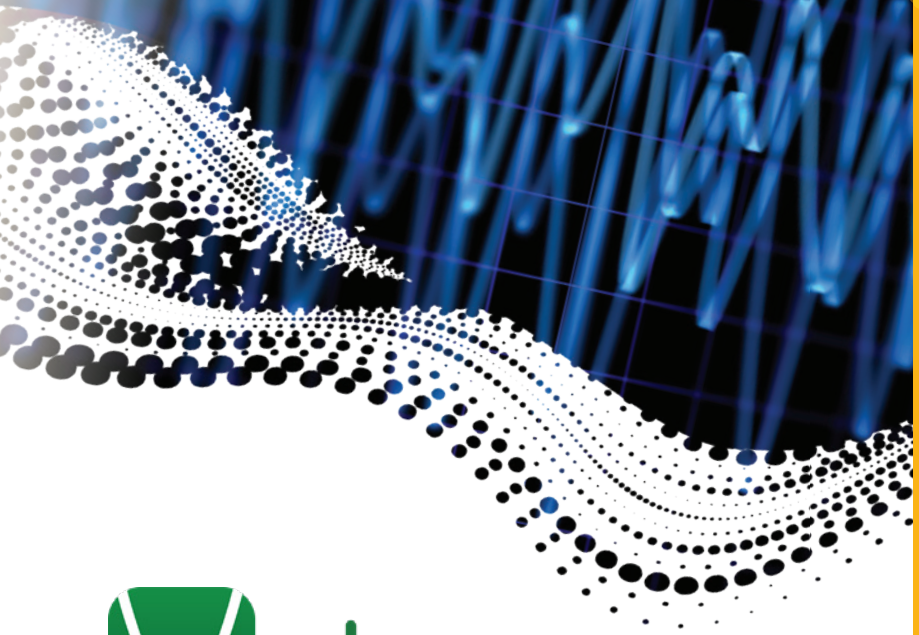
Savvas Realize™ is an award-winning platform that has transformed learning into an active and engaging experience for millions of students. In addition to digital versions of the Student Handbook and Teacher Guide, find a wealth of resources that enhance the student experience.

PhET™ Simulations engage students in an intuitive, game-like environment. Accompanying worksheets connect the simulations to the content.

Virtual Labs give all students access to compelling phenomena and advanced scientific equipment.

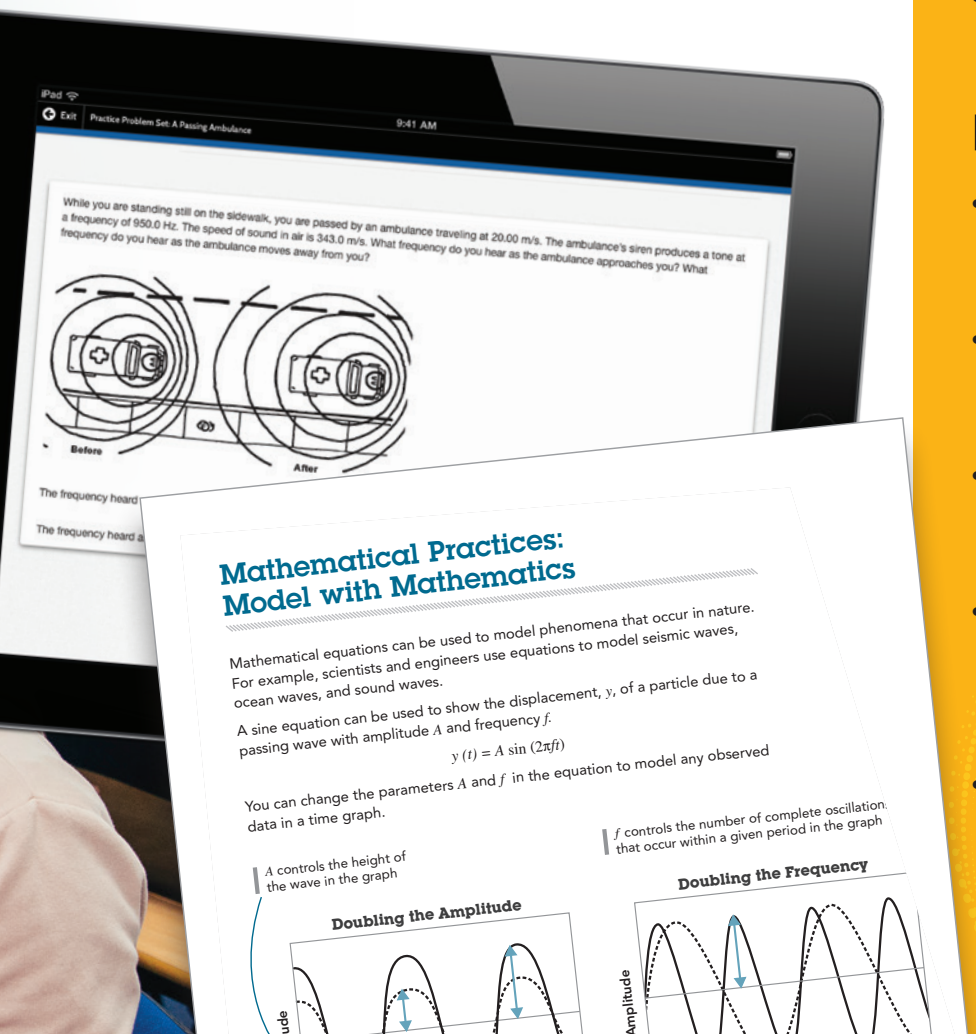
Boclips® Videos present physics concepts in an easy-to-understand way.

Digital Interactivities simulate real-world problem-solving to increase student interest.



Desmos Graphing Calculator on the Savvas Realize™ digital platform supports students in problem solving and mathematics.

Math Tutorial Videos reinforce mathematical processes making them ideal for remediation.



3D Assessment

- **Performance Based-Assessments** measure students' mastery of the science and engineering practices.
- **Problem-Based Learning** projects require students to obtain and evaluate information about a related phenomenon and communicate their findings in a written report.
- **Revisit the Phenomenon** multiple times to help students make sense of the topic.
- **Online Quizzes** that are customizable and interactive conclude every Experience.
- **Assess-on-the-Spot** ideas in the Teacher Guide provide quick formative assessments.
- For a summative assessment of the Investigation, assign customizable **3-Dimensional Assessments** in Realize.
- **End-of-Year Tests** work well for a summative final exam.

Math Support

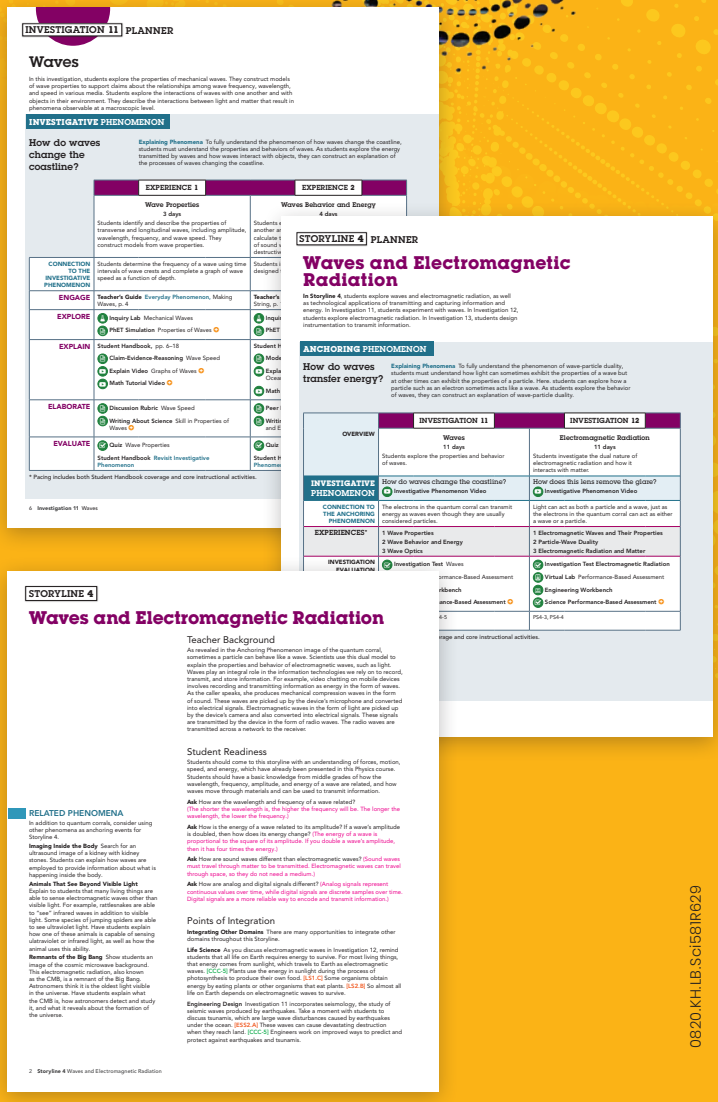
- **Physics and Math Skills Workbook** includes four pages of review and practice problems for every learning Experience.
- **Stepped-Out Examples** break down sample problems for clarity and process guidance.
- **Problem Banks** provide students with additional problems to build mathematical fluency.
- **Analyzing Data** activities include opportunities for students to apply mathematical concepts in real-world contexts.
- **Math Readiness Test** allows instructors to gauge student understanding before taking the course.

A phenomenal and flexible teaching experience

The *Experience Physics* Teacher Guide isn't a traditional teacher edition. We put the focus on teacher resources, with teacher background, learning objectives, lab and activity modifications, point-of-use formative assessments, professional learning, and more.

The flexible structure makes it easy to adapt your physics program for any classroom situation, no matter the level of your students or the location of your classroom.

- **"Got More Time?"** activities make it easy to enhance your instruction.
- **Related Phenomena** give you options when you want to make a substitution.
- **Detailed Planners** use the 5E model for an inquiry-based approach.
- **Activities** includes a wide variety of hands-on labs and virtual simulations.



INVESTIGATION 11 PLANNER

Waves

In this investigation, students explore the properties of mechanical waves. They construct models of wave properties to support claims about the relationships among wave frequency, wavelength, and speed in various media. Students explore the interactions of waves with one another and with objects in their environment. They describe the interactions between light and matter that result in phenomena observable at a macroscopic level.

INVESTIGATIVE PHENOMENON

How do waves change the coastline?

Explaining Phenomena To fully understand the phenomenon of how waves change the coastline, students must understand the properties and behaviors of waves. As students explore the energy transmitted by waves and how waves interact with objects, they can construct an explanation of the processes of waves changing the coastline.

	EXPERIENCE 1	EXPERIENCE 2
	Wave Properties 3 days	Waves Behavior and Energy 4 days
	Students identify and describe the properties of transverse and longitudinal waves, including amplitude, wavelength, frequency, and wave speed. They construct models from wave properties.	Students a another a calculate t of sound v destructive
CONNECTION TO THE INVESTIGATIVE PHENOMENON	Students determine the frequency of a wave using time intervals of wave crests and complete a graph of wave speed as a function of depth.	Students designed
ENGAGE	Teacher's Guide Everyday Phenomenon, Making Waves, p. 4	Teacher's String, p.
EXPLORE	Inquiry Lab Mechanical Waves PhET Simulation Properties of Waves	Inqui PhET
EXPLAIN	Student Handbook, pp. 6–18 Claim-Evidence-Reasoning Wave Speed Explain Video Graphs of Waves Math Tutorial Video	Student Mod Expla Cross Math
ELABORATE	Discussion Rubric Wave Speed Writing About Science Skill in Properties of Waves	Peer Writi and E
EVALUATE	Quiz Wave Properties Student Handbook Revisit Investigative Phenomenon	Quiz Student Phenome

* Pacing includes both Student Handbook coverage and core instructional activities.

6 Investigation 11 Waves

STORYLINE 4 PLANNER

Waves and Electromagnetic Radiation

In Storyline 4, students explore waves and electromagnetic radiation, as well as technological applications of transmitting and capturing information and energy. In Investigation 11, students experiment with waves. In Investigation 12, students explore electromagnetic radiation. In Investigation 13, students design instrumentation to transmit information.

ANCHORING PHENOMENON

How do waves transfer energy?

Explaining Phenomena To fully understand the phenomenon of wave-particle duality, students must understand how light can sometimes exhibit the properties of a wave but at other times can exhibit the properties of a particle. Here, students can explore how a particle such as an electron sometimes acts like a wave. As students explore the behavior of waves, they can construct an explanation of wave-particle duality.

	INVESTIGATION 11	INVESTIGATION 12
OVERVIEW	Waves 11 days Students explore the properties and behavior of waves.	Electromagnetic Radiation 11 days Students investigate the dual nature of electromagnetic radiation and how it interacts with matter.
INVESTIGATIVE PHENOMENON	How do waves change the coastline? Investigative Phenomenon Video	How does this lens remove the glare? Investigative Phenomenon Video
CONNECTION TO THE ANCHORING PHENOMENON	The electrons in the quantum corral can transmit energy as waves even though they are usually considered particles.	Light can act as both a particle and a wave, just as the electrons in the quantum corral can act as either a wave or a particle.
EXPERIENCES*	1 Wave Properties 2 Wave Behavior and Energy 3 Wave Optics	1 Electromagnetic Waves and Their Properties 2 Particle-Wave Duality 3 Electromagnetic Radiation and Matter
INVESTIGATION EVALUATION	Investigation Test Waves rformance-Based Assessment nbench ance-Based Assessment	Investigation Test Electromagnetic Radiation Virtual Lab Performance-Based Assessment Engineering Workbench Science Performance-Based Assessment
	6-5	PS4-2, PS4-4

rage and core instructional activities.

STORYLINE 4

Waves and Electromagnetic Radiation

Teacher Background

As revealed in the Anchoring Phenomenon image of the quantum corral, sometimes a particle can behave like a wave. Scientists use this dual model to explain the properties and behavior of electromagnetic waves, such as light. Waves play an integral role in the information technologies we rely on to record, transmit, and store information. For example, video chatting on mobile devices involves recording and transmitting information as energy in the form of waves. As the caller speaks, she produces mechanical compression waves in the form of sound. These waves are picked up by the device's microphone and converted into electrical signals. Electromagnetic waves in the form of light are picked up by the device's camera and also converted into electrical signals. These signals are transmitted by the device in the form of radio waves. The radio waves are transmitted across a network to the receiver.

Student Readiness

Students should come to this storyline with an understanding of forces, motion, speed, and energy, which have already been presented in this Physics course. Students should have a basic knowledge from middle grades of how the wavelength, frequency, amplitude, and energy of a wave are related, and how waves move through materials and can be used to transmit information.

Ask How are the wavelength and frequency of a wave related? (The shorter the wavelength is, the higher the frequency will be. The longer the wavelength, the lower the frequency.)

Ask How is the energy of a wave related to its amplitude? If a wave's amplitude is doubled, then how does its energy change? (The energy of a wave is proportional to the square of its amplitude. If you double a wave's amplitude, then it has four times the energy.)

Ask How are sound waves different than electromagnetic waves? (Sound waves must travel through matter to be transmitted. Electromagnetic waves can travel through space, so they do not need a medium.)

Ask How are analog and digital signals different? (Analog signals represent continuous values over time, while digital signals are discrete samples over time. Digital signals are a more reliable way to encode and transmit information.)

Points of Integration

Integrating Other Domains There are many opportunities to integrate other domains throughout this Storyline.

Life Science As you discuss electromagnetic waves in Investigation 12, remind students that all life on Earth requires energy to survive. For most living things, that energy comes from sunlight, which travels to Earth as electromagnetic waves. [CCC-5] Plants use the energy in sunlight during the process of photosynthesis to produce their own food. [LS1.C] Some organisms obtain energy by eating plants or other organisms that eat plants. [LS2.B] So almost all life on Earth depends on electromagnetic waves to survive.

Engineering Design Investigation 11 incorporates seismology, the study of seismic waves produced by earthquakes. Take a moment with students to discuss tsunamis, which are large wave disturbances caused by earthquakes under the ocean. [ESS2.A] These waves can cause devastating destruction when they reach land. [CCC-5] Engineers work on improved ways to predict and protect against earthquakes and tsunamis.

RELATED PHENOMENA

In addition to quantum corrals, consider using other phenomena as anchoring events for Storyline 4.

Imaging Inside the Body Search for an ultrasound image of a kidney with kidney stones. Students can explain how waves are employed to provide information about what is happening inside the body.

Animals That See Beyond Visible Light Explain to students that many living things are able to sense electromagnetic waves other than visible light. For example, rattlesnakes are able to "see" infrared waves in addition to visible light. Some species of jumping spiders are able to see ultraviolet light. Have students explain how one of these animals is capable of sensing ultraviolet or infrared light, as well as how the animal uses this ability.

Remnants of the Big Bang Show students an image of the cosmic microwave background. This electromagnetic radiation, also known as the CMB, is a remnant of the Big Bang. Astronomers think it is the oldest light visible in the universe. Have students explain what the CMB is, how astronomers detect and study it, and what it reveals about the formation of the universe.

2 Storyline 4 Waves and Electromagnetic Radiation

Experience It for Yourself

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