World of Waves: Explore Water, Sound, and Light waves

Discover how waves are everywhere in natural and constructed environments, from giant tsunamis to computer microprocessors, and build a deep understanding of the physics of waves. Explore how waves in water, sound, light, and other electromagnetic energies are involved in engaging real-world phenomena, like surfing in the ocean, animal communication, and mobile networks. Includes connections to engineering design and math and working with STEM Professionals:

Dr. Erin Fischell, Ph.D. - Robotics and Acoustics Researcher - Woods Hole Oceanographic Institution
Dr. Mara Orescanin, Ph.D. - Coastal Physical Oceanographer
Dr. Marcos Sastre-Cordova, Ph.D. - Senior Principal Systems Engineer - The Raytheon Company
Sally Sutherland-Pietrzak - Science and Technology Division Head, Sensors & Sonar Department, Naval Undersea Warfare
Lt. Angie Violante - Surface Warfare Officer - United States Navy

- ***Mission 1: Introduction to Waves -*** *Explore different types of waves that carry energy and discover characteristics of waves; find out what they have in common and how they are different; learn how waves can be used to transmit information.*
- ***Mission 2: Sound and Acoustics -*** *Explore the impact of sound waves on the world; from music to marine life, transmission of sound energy enables communication. Analyze sounds – from animals, musical instruments, machines, the weather, and human voice to learn how they are produced, recorded, transformed, and interpreted.*
- ***Mission 3: Light and Optics -*** *Discover astonishing ways the study of light and optics expands knowledge of humans, the world, and the universe. From microscopy that reveals the secrets of the human body, to undersea explorations unveiling creatures that produce their own light, to astronomical insights about distant planets from clues in stars' light, today's science is aglow with exciting discoveries.*

Cross-Curricular Connections

Reading & Writing for Technical Subjects:

LST.1: Read and comprehend science and technical texts independently and proficiently and write effectively for a variety of discipline-specific tasks, purposes, and audiences
LST.2:Extract and construct meaning from science and technical texts using a variety of comprehension skills
LST.2.2: Determine the central ideas or conclusions of a text; provide an accurate, objective summary of the text.
LST.2.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
LST.3.1: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to texts and topics.
LST.4.1: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
LST.7.1: Conduct short research assignments and tasks to answer a question (including a self generated question), or test a hypothesis, drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Math: Algebraic Problem Solving, Using Ratios, Creating and Analyzing Graphs (Bar, Pie, Best-Fit Line, Slope), Unit Conversions

Art: Woodblock Prints (Japanese), Light and color spectrums, Photography

Music: Instruments, Acoustics, Cymatics, Audacity

Grades 4-5 Science Content & Engineering Standards

4.PS.2 Investigate the relationship of the speed of an object to the energy of that object. (Missions: 1, 2, 3)
4.PS.4 Describe and investigate the different ways in which energy can be generated and/or converted from one form of energy to another form of energy. (Missions: 1, 2, 3)
4.PS.5 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. (Missions: 1, 2, 3)
3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on

materials, time, or cost. (Missions: 1, 2)
3-5.E.2 Construct and compare multiple plausible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. (Missions: 1, 2, 3)
3-5.E.3 Construct and perform fair investigations in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. (Missions: 1, 2, 3)
5.ESS.2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. (Mission 3)
5.LS.3 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. (Missions: 1, 2, 3)

Grades 6-8 Science Content & Engineering Standards

6.PS.1 Distinguish between the terms position, distance, and displacement, as well as, the terms speed and velocity. (Missions: 1, 2, 3)
6.PS.2 Describe the motion of an object graphically showing the relationship between time and position. (Missions: 1, 2, 3)
6.PS.3 Describe how potential and kinetic energy can be transferred from one form to another. (Missions: 1, 2, 3)
6.PS.4 Investigate the properties of light, sound, and other energy waves and how they are reflected, absorbed, and transmitted through materials and space. (Missions: 1, 2, 3)
6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (Missions: 1, 2, 3)
6-8.E.2 Evaluate competing design solutions using a systematic process to identify how well they meet the criteria and constraints of the problem. (Missions: 1, 2, 3)
6-8.E.3 Analyze data from investigations to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (Missions: 1, 2, 3)
6-8.E.4 Develop a prototype to generate data for repeated investigations and modify a proposed object, tool, or process such that an optimal design can be achieved. (Missions: 1, 2, 3)
7.PS.8 Investigate a process in which energy is transferred from one form to another and provide evidence that the total amount of energy does not change during the transfer when the system is closed. (Law of conservation of energy) (Missions: 1, 2)

Grades 9-12 Science Content Standards

PI.1.4 Describe the differences between the terms “distance,” “displacement,” “speed,” “velocity,” “average speed,” and “average velocity” and be able to calculate any of those values given an object moving at a single constant velocity or with different constant velocities over a given time interval. (Missions: 1, 2, 3)
PI.2.1 Develop graphical, mathematical and pictorial representations (e.g. a motion map) that describe the relationship between the clock reading (time) and velocity of an object moving at a uniformly changing rate and apply those representations to qualitatively and quantitatively describe the motion of an object. (Missions: 1, 2, 3)
PI.3.3 Construct force diagrams using appropriately labeled vectors with magnitude, direction, and units to qualitatively and quantitatively analyze a scenario and make claims (i.e. develop arguments, justify assertions) about forces exerted on an object by other objects for different types of forces or components of forces. (Missions: 1, 2, 3)
PI.4.1 Evaluate the translational kinetic, gravitational potential, and elastic potential energies in simple situations using the mathematical definitions of these quantities and mathematically relate the initial and final values of the translational kinetic, gravitational potential, and elastic potential energies in the absence of a net external force. (Missions: 1, 2)
PI.5.5 Classify an interaction (e.g. collision or separation) between two objects as elastic or inelastic based on the change in linear kinetic energy of the system. (Missions: 1, 2)
PI.6.1 Develop graphical and mathematical representations that describe the relationship between the amount of stretch of a spring and the restoring force and apply those representations to qualitatively and quantitatively describe how changing the stretch or compression will affect the restoring force and vice versa, specifically for an ideal spring. (Missions: 1, 2)
PI.6.2 Describe the slope of the graphical representation of restoring force vs. change in length of an elastic material in terms of the elastic constant of the material, specifically for an ideal spring. (Missions: 1, 2)
PI.6.4 Develop graphical and mathematical representations which describe the relationship between the strength of gravity, length of string, and period of a simple mass-string (i.e. pendulum) system apply the those representations to qualitatively and quantitatively describe how changing the length of string or strength of gravity will affect the period of the system in the limit of small amplitudes. (Missions: 1, 2)
PI.7.1 Differentiate between transverse and longitudinal modes of oscillation for a mechanical wave traveling in one dimension. (Missions: 1, 2, 3)
PI.7.2 Understand that a mechanical wave requires a medium to transfer energy, unlike an electromagnetic wave, and that only the energy is transferred by the mechanical wave, not the mass of the medium. (Missions: 1, 2, 3)
PI.7.3 Develop graphical and mathematical representations that describe the relationship between the frequency of a mechanical wave and the wavelength of the wave and apply those representations to qualitatively and quantitatively describe how changing the frequency of a mechanical wave affects the wavelength and vice versa. (Missions: 1, 2, 3)

PI.7.4 Describe the slope of the graphical representation of wavelength vs. the inverse of the frequency in terms of the speed of the mechanical wave. (Missions: 1, 2, 3)
PI.7.5 Apply the mechanical wave model to sound waves and qualitatively and quantitatively determine how the relative motion of a source and observer affects the frequency of a wave as described by the Doppler Effect. (Missions: 1, 2, 3)
PI.7.6 Qualitatively and quantitatively apply the principle of superposition to describe the interaction of two mechanical waves or pulses. (Missions: 1, 2, 3)
PI.7.7 Qualitatively describe the phenomena of both resonance frequencies and beat frequencies that arise from the interference of sound waves of slightly different frequency and define the beat frequency as the difference between the frequencies of two individual sound wave sources. (Missions: 1, 2, 3)