Fairfield Public Schools
Science Curriculum

Physics

BOE Approved 5/8/2018

Physics: Description

Physics is the study of natural phenomena and interactions and between matter and energy using mathematical models and laws to explain and understand them and how they impact our everyday lives. Students will build on their middle school experiences to delve more deeply into the concepts of forces and their interactions, energy and waves.

Standards for this course are taken from the *Next Generation Science Standards* and are of three types:

Disciplinary Core Ideas (DCIs): Shown as content objectives, these standards define what students should know about the most essential ideas in the major science disciplines. The focus is on a limited number of core ideas in science and engineering both within and across the disciplines to avoid the shallow coverage of a large number of topics and to allow more time for teachers and students to explore each idea in greater depth. Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented.

Science and Engineering Practices (SEP): These standards enable students to apply the content in the DCI's and the skills of practicing scientists and engineers to explain phenomena and solve real world problems. Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science.

Crosscutting Concepts: These standards provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. These broad concepts tie together the influence of engineering, technology, and science on society and the natural world.

http://www.nextgenscience.org/next-generation-science-standards

Physics: Overview

Enduring Understandings

Physicists investigate how and why objects move, and why some objects are attracted to each other while others are not. We predict interactions between objects and within systems of objects in the context of the conservation of total momentum of an isolated system.
Energy is understood as quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. Newer technologies use wave properties and the interactions of electromagnetic radiation with matter to transfer information across long distances, store information, and investigate nature on many scales.

Course Essential Questions

- How and why do objects move and what is involved in changes in motion?
- What are the roles of energy in changes in matter and how is energy changed from one type to another?
- How and why is energy transferred through waves?
- How can knowledge in the field of physics be used to greatly enhance our the world and our lives?

Physics: Year-at-a Glance

Unit	Title	Unit Essential Questions
1	Forces & Interactions: Newton's Laws	• How can we use mathematical representation of forces to describe and predict interactions between objects? • How can we use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system?
2	Energy	• How can energy be converted from one form to another? • How can we use two objects interacting through electric or magnetic fields to illustrate the changes in energy of the objects due to the interaction?

3	Forces & Interactions: Electricity & Magnetism	• How can we use two objects interacting through electric or magnetic fields to illustrate the forces between objects? • How are electric currents and magnetic fields related?
4	Waves & Applications	• What are some of the advantages to digital storage and transmission? • How are the principles of wave behavior and interactions with matter used to transmit and capture information and energy? • How does modern society depend on major technological systems?

Unit 1: Forces and Interactions: Newton's Laws

Overview

Classical mechanics describes the relationship between the motion of objects found in our world and the forces acting upon them. This unit involves Newton's three laws of motion and his law of gravity. Newton's three laws opened avenues of inquiry and discovery that are used routinely today in virtually all areas of mathematics, science, engineering, and technology. Newton's theory of universal gravitation had a similar impact, starting a revolution in celestial mechanics and astronomy that continues to this day. Newton's three laws of motion, together with his law of gravitation, are considered among the greatest achievements of the human mind.

Performance Expectations

At the conclusion of this unit, students will be able to:

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation to describe and predictthe gravitational forces between objects.

Unit Essential Question

- How can we use mathematical representation of forces to describe and predict interactions between objects?
- How can we use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system?

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5)
- Systems can be designed to cause a desired effect. (HS-PS2-3)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

PS2.A: Forces and Motion

- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3)

PS2.B: Types of Interactions

- Newton's law of universal gravitation ... provide(s) the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)
- Forces at a distance are explained by fields (gravitational) permeating space that can transfer energy (HS-PS2-4), HS-PS2-5)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)

Corresponding CT Core Standards:

ELA/Literacy – RST.11-12.1, RST.11-12.7, WHST.11-12.2, WHST.11-12.7, WHST.11-12.8, WHST.11-12.9

Mathematics – MP.2; MP.4; HSN.Q.A.1; HSN.Q.A.2; HSN.Q.A.3; HSA.SSE.A.1; HSA.SSE.B.3; HSA.CED.A.1; HSA.CED.A.2; HSA.CED.A.4; HSF-IF.C.7; HSS-IS.A.1

Unit 2: Energy

Overview

Energy is present in the universe in a variety of forms, including mechanical, chemical, electromagnetic, and nuclear energy. Although energy can be transformed from one kind to another, all observations and experiments suggest that the total amount of energy in an isolated system remains the same. The focus of this unit is mainly on mechanical energy, which is the sum of kinetic energy (energy of motion) and potential energy (energy of position). This unit is linked to Newtonian Mechanics through the concept of work.

Performance Expectations

At the conclusion of this unit, students will be able to:

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects).

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

HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Unit Essential Questions

- How can energy be converted from one form to another?
- How can we use two objects interacting through electric or magnetic fields to illustrate the changes in energy of the objects due to the interaction?

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HSPS3-1)

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HSPS3-3)
- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2)
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) (HS-PS3-3)
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be

used to predict and describe system behavior. (HS-PS3-1)

- The availability of energy limits what can occur in any system. (HS-PS3-1)
- Uncontrolled systems always evolve toward more stable states - that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

PS3.C: Relationship Between Energy and Forces

- When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Developing and Using Models

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HSPS3-5)

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)

Using Mathematics and Computational Thinking

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

Constructing Explanations and Designing Solutions

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HSPS3-3)

Corresponding CT Core Standards:

ELA/Literacy – RST.11-12.1, RST.11-12.7, WHST.11-12.2, WHST.11-12.7, WHST.11-12.8, WHST.11-12.9

Mathematics – MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3, HSA.SSE.A.1, HSA.SSE.B.3, HSA.CED.A.1, HSA.CED.A.2, HSA.CED.A.4, HSF-IF.C.7, HSS-IS.A.1

Unit 3: Forces and Interactions: Electricity & Magnetism

Overview

Electricity is the lifeblood of technological civilization and modern society. With the discovery and harnessing of electric forces and fields we can view arrangements of atoms, probe the inner workings of the cell, and send spacecraft beyond the limits of the solar system. In this unit, we use the effect of charging by friction to begin an investigation of electric forces. Coulomb's law is discussed, which is the fundamental law of force between charged particles. The unit continues on to discuss the connection between electric currents and magnetic fields (and vice versa).

Performance Expectations

At the conclusion of this unit, students will be able to:
HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Unit Essential Questions

- How can we use two objects interacting through electric or magnetic fields to illustrate the forces between objects?
- How are electric currents and magnetic fields related?

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-
- 1),(HS-PS2-5)

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)

Corresponding CT Core Standards:

ELA/Literacy – RST.11-12.1, RST.11-12.7, WHST.11-12.2, WHST.11-12.7, WHST.11-12.8, WHST.11-12.9,

Mathematics – MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3, HSA.SSE.A.1, HSA.SSE.B.3, HSA.CED.A.1, HSA.CED.A.2, HSA.CED.A.4, HSF-IF.C.7, HSS-IS.A.1

Unit 4: Waves and Electromagnetic Radiation

Overview

Periodic vibrations can cause disturbances that move in the form of waves. Many kinds of waves occur in nature, such as sound waves, water waves, and electromagnetic waves. These very different physics phenomena are described by common terms and concepts introduced here. In this unit, uses of waves in everyday life in technological tools and information storage and transfer will be analyzed.

Performance Expectations

At the conclusion of this unit, students will be able to:

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Unit Essential Questions

- What are some of the advantages to digital storage and transmission?
- How are the principles of wave behavior and interactions with matter used to transmit and capture information and energy?
- How does modern society depend on major technological systems?

Crosscutting Concepts

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)
- Systems can be designed to cause a desired effect. (HS-PS4-5)

Systems and System Models
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions-including energy, matter, and
- information flows-within and between systems at different scales. (HS-PS4-3)

Stability and Change
- Systems can be designed for greater or lesser stability. (HS-PS4-2)

NGSS Unit Standards

Asking Questions and Defining Problems
- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2)

Using Mathematics and Computational Thinking
- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)

Engaging in Argument from Evidence
- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)

Obtaining, Evaluating, and Communicating Information
- Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4)
- Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5)

Corresponding CT Core Standards:

ELA/Literacy – RST.9-10.8, RST.11-12.1, RST.11-12.7, RST.11-12.8, WHST.9-12.2, WHST.11-12.8,

Mathematics – MP.2, MP.4, HSA-SSE.A.1, HSA-SSE.B.3, HSA.CED.A.4