PHYSICS: COURSE OVERVIEW

The Physics academic standards were written to establish the core content and practices for all schools in the state of Tennessee. The core and component ideas in the Physical Sciences section in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ides* were used to subdivide the Physics course content into four sections:

Physics (PHYS)

Matter and Its Interactions
• Structure and properties of matter
• Chemical reactions • Nuclear process Motion and Stability: Forces and Interactions • Forces and motion
• Types of interactions • Stability and instability in physical systems Energy • Definitions of energy
• Conservation of energy and energy transfer • Relationship between energy and forces • Energy in chemical processes and everyday life Waves and Their Applications in Technologies
for Information Transfer • Wave properties • Electromagnetic radiation • Information technologies and instrumentation

PS1: Matter and Its Interactions

Properties of matter give rise to fields and forces. Students should understand that there are only a few properties of matter at a fundamental level and that these properties (charge, mass, spin) give rise to the fields and forces that exist as we understand them.

PS2: Motion and Stability: Forces and Interactions

An understanding of the forces and interactions between objects is important for describing an object's motion and determining the stability in a system. Students should understand that forces between objects arise from four types of interactions (gravitational, electromagnetism, and strong and weak nuclear interactions) and that some physical systems are more stable than others.

PS3: Energy

The concept of the transfer of energy in or out of a system can be explained and predicted. Students should understand the conservation of energy, how it is stored and transferred, the relationship between forces and how they are related to energy, and how we use energy in our everyday life.

PS4: Waves and Their Applications in Technologies for Information Transfer

Optics is the study of the interaction of optical photons (within the human visible range) with matter. These standards encompass the speed of light in a vacuum and other media, as well as diffraction, refraction, and the interference properties of light.

Throughout the Physics course, the seven crosscutting concepts should be reinforced in the appropriate context both in the classroom and hands-on experimentation. These standards also incorporate the core and component ideas in engineering, technology, and applications of science (cited throughout the standards) and should be implemented in this course.

Although science is a body of content knowledge consisting of theories that explain data, science is also a set of practices that use analysis and argumentation to establish, extend, and refine knowledge. The science and engineering practices are used as a means to learn science by doing science, thus combining content knowledge with skill. These practices are not intended to be a sequence of steps nor are they intended to be taught as a separate, introductory unit for the course. By combining content knowledge with skill, students discover how scientific knowledge is acquired and applied to solve problems or advance scientific knowledge further. In addition, there are seven crosscutting concepts that are fundamental to the nature of science and thus stretch across all science disciplines. The Physics standards have been constructed by explicitly integrating practices and crosscutting concepts, iteratively and in combination, within each core idea to provide students with a well-rounded education in science.

These standards were written to allow students to engage in scientific reasoning, critique, creative thinking, and applied learning through hands-on investigations.

These academic standards should be used in order to develop classroom and course-level assessments.

PHYSICS: ACADEMIC STANDARDS

PHYS.PS1: Matter and Its Interactions

1) Develop models to illustrate the changes in the composition of the nucleus of an atom and the energy released during the processes of fission, fusion, and radioactive decay.

2) Recognize and communicate examples from everyday life that use radioactive decay processes.

3) Investigate and evaluate the expression for calculating the percentage of a remaining atom (N(t)=N0e-λt) using simulated models, calculations, and/or graphical representations. Define the half-life (t1/2) and decay constant λ. Perform an investigation on probability and calculate half-life from acquired data (does not require use of actual radioactive samples).

PHYS.PS2: Motion and Stability: Forces and Interactions

1) Investigate and evaluate the graphical and mathematical relationship (using either manual graphing or computers) of one-dimensional kinematic parameters (distance, displacement, speed, velocity, acceleration) with respect to an object's position, direction of motion, and time.

2) Algebraically solve problems involving constant velocity and constant acceleration in one-dimension.

3) Algebraically solve problems involving arc length, angular velocity, and angular acceleration. Relate quantities to tangential magnitudes of translational motion.

4) Use free-body diagrams to illustrate the contact and non-contact forces acting on an object. Use the diagrams in combination with graphical or component-based vector analysis and with Newton's first and second laws to predict the position of the object on which the forces act in a constant net force scenario.

5) Gather evidence to defend the claim of Newton's first law of motion by explaining the effect that balanced forces have upon objects that are stationary or are moving at constant velocity.

6) Using experimental evidence and investigations, determine that Newton’s second law of motion defines force as a change in momentum, $F = \Delta p/\Delta t$.

7) Plan, conduct, and analyze the results of a controlled investigation to explore the validity of Newton's second law of motion in a system subject to a net unbalanced force, $F_{net} = ma$ or $F_{net} = \Delta p/\Delta t$.

8) Use examples of forces between pairs of objects involving gravitation, electrostatic, friction, and normal forces to explain Newton's third law.

9) Use Newton’s law of universal gravitation, $F = G\frac{m_1 m_2}{r^2}$, to calculate the gravitational forces, mass, or distance separating two objects with mass, given the information about the other quantities.

10) Describe and mathematically determine the electrostatic interaction between electrically charged particles using Coulomb’s law, $F_e = k_e\frac{q_1 q_2}{r^2}$. Compare and contrast Coulomb’s law and gravitational force, notably with respect to distance.

11) Develop and apply the impulse-momentum theorem along with scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on an object during a collision (e.g., helmet, seatbelt, parachute).

12) Use experimental evidence to demonstrate that air resistance is a velocity dependent drag force that leads to terminal velocity.

13) Develop a model to predict the range of a two-dimensional projectile based upon its starting height, initial velocity, and angle at which it was launched.

14) Plan and conduct an investigation to provide evidence that a constant force perpendicular to an object's motion is required for uniform circular motion (F = m v2 / r).

PHYS.PS3: Energy

1) Identify and calculate different types of energy and their transformations (thermal, kinetic, potential, including magnetic and electrical potential energies) from one form to another in a system.

2) Investigate conduction, convection, and radiation as a mechanism for the transfer of thermal energy.

3) Use the principle of energy conservation and mathematical representations to quantify the change in energy of one component of a system when the energy that flows in and out of the system and the change in energy of the other components is known.

4) Assess the validity of the law of conservation of linear momentum (p=mv) by planning and constructing a controlled scientific investigation involving two objects moving in one-dimension.

5) Construct an argument based on qualitative and quantitative evidence that relates the change in temperature of a substance to its mass and heat energy added or removed from a system.

6) Define power and solve problems involving the rate of energy production or consumption ($P = \Delta E/\Delta t$). Explain and predict changes in power consumption based on changes in energy demand or elapsed time. Investigate power consumption and power production systems in common use.

7) Investigate and evaluate the laws of thermodynamics and use them to describe internal energy, heat, and work.

8) Communicate scientific ideas to describe how forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space. Explain how energy is contained within the field and how the energy changes when the objects generating and interacting with the field change their relative positions.

9) Describe, compare, and diagrammatically represent both electric and magnetic fields. Qualitatively predict the motion of a charged particle in each type of field, but avoid situations where the two types of fields are combined in the same region of space. Restrict magnetic fields to those that are parallel or perpendicular to the path of a charged particle.

10) Develop a model (sketch, CAD drawing, etc.) of a resistor circuit or capacitor circuit and use it to illustrate the behavior of electrons, electrical charge, and energy transfer.

11) Investigate Ohm's law ($I=V/R$) by conducting an experiment to determine the relationships between current and voltage, current and resistance, and voltage and resistance.

12) Apply the law of conservation of energy and charge to assess the validity of Kirchhoff's loop and junction rules when algebraically solving problems involving multi-loop circuits.

13) Predict the energy stored by a capacitor and how charge flows among capacitors connected in series or parallel.

14) Recognize and communicate information about energy efficiency and/or inefficiency of machines used in everyday life.

15) Compare and contrast the process, design, and performance of numerous next-generation energy sources (hydropower, wind power, solar power, geothermal power, biomass power, etc.).

PHYS.PS4: Waves and Their Applications in Technologies for Information Transfer

1) Know wave parameters (i.e., velocity, period, amplitude, frequency, angular frequency) as well as how these quantities are defined in the cases of longitudinal and transverse waves.

2) Describe parameters of a medium that affect the propagation of a sound wave through it.

3) Understand that the reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of characteristics of specific wave parameters and parameters of the medium.

4) Communicate scientific and technical information about how the principle of superposition explains the resonance and harmonic phenomena in air columns and on strings and common sound devices.

5) Evaluate the characteristics of the electromagnetic spectrum by communicating the similarities and differences among the different bands. Research and determine methods and devices used to measure these characteristics.

6) Plan and conduct controlled scientific investigations to construct explanations of light's behavior (reflection, refraction, transmission, interference) including the use of ray diagrams.

7) Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model.

8) Obtain information to construct explanations on how waves are used to produce, transmit, and capture signals and store and interpret information.

9) Investigate how information is carried in optical systems and use Snell’s law to describe the properties of optical fibers.