Physics Standards

The Science Georgia Standards of Excellence are designed to provide foundational knowledge and skills for all students to develop proficiency in science. The Project 2061's *Benchmarks for Science Literacy* and the follow up work, *A Framework for K-12 Science Education* were used as the core of the standards to determine appropriate content and process skills for students. The Science Georgia Standards of Excellence focus on a limited number of core disciplinary ideas and crosscutting concepts which build from Kindergarten to high school. The standards are written with the core knowledge to be mastered integrated with the science and engineering practices needed to engage in scientific inquiry and engineering design. Crosscutting concepts are used to make connections across different science disciplines.

The Science Georgia Standards of Excellence drive instruction. Hands-on, student-centered, and inquiry-based approaches should be the emphasis of instruction. The standards are a required minimum set of expectations that show proficiency in science. However, instruction can extend beyond these minimum expectations to meet student needs. At the same time, these standards set a maximum expectation on what will be assessed by the Georgia Milestones Assessment System.

Science consists of a way of thinking and investigating, as well a growing body of knowledge about the natural world. To become literate in science, students need to possess sufficient understanding of fundamental science content knowledge, the ability to engage in the science and engineering practices, and to use scientific and technological information correctly. Technology should be infused into the curriculum and the safety of the student should always be foremost in instruction.

The Physics Georgia Standards of Excellence are designed to continue the student investigations of the physical sciences that began in grades K-8, and provide students the necessary skills to be proficient in physics. These standards include more abstract concepts such as nuclear decay processes, interactions of matter and energy, velocity, acceleration, force, energy, momentum, properties and interactions of matter, electromagnetic and mechanical waves, and electricity, magnetism and their interactions. Students investigate physics concepts through experiences in laboratories and field work using the science and engineering practices of asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

Physics

SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time.

a. Plan and carry out an investigation of one-dimensional motion to calculate average and instantaneous speed and velocity.
   - Analyze one-dimensional problems involving changes of direction, using algebraic signs to represent vector direction.
   - Apply one-dimensional kinematic equations to situations with no acceleration, and positive, or negative constant acceleration.

b. Analyze and interpret data using created or obtained motion graphs to illustrate the relationships among position, velocity, and acceleration, as functions of time.

c. Ask questions to compare and contrast scalar and vector quantities.

d. Analyze and interpret data of two-dimensional motion with constant acceleration.
   - Resolve position, velocity, or acceleration vectors into components (x and y, horizontal and vertical).
   - Add vectors graphically and mathematically by adding components.
   - Interpret problems to show that objects moving in two dimensions have independent motions along each coordinate axis.
   - Design an experiment to investigate the projectile motion of an object by collecting and analyzing data using kinematic equations.
   - Predict and describe how changes to initial conditions affect the resulting motion.
   - Calculate range and time in the air for a horizontally launched projectile.

SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects.

a. Construct an explanation based on evidence using Newton's Laws of how forces affect the acceleration of a body.
   - Explain and predict the motion of a body in absence of a force and when forces are applied using Newton's 1st Law (principle of inertia).
   - Calculate the acceleration for an object using Newton's 2nd Law, including situations where multiple forces act together.
   - Identify the pair of equal and opposite forces between two interacting bodies and relate their magnitudes and directions using Newton's 3rd Law.

b. Develop and use a model of a Free Body Diagram to represent the forces acting on an object (both equilibrium and non-equilibrium).

c. Use mathematical representations to calculate magnitudes and vector components for typical forces including gravitational force, normal force, friction forces, tension forces, and spring forces.

d. Plan and carry out an investigation to gather evidence to identify the force or force component responsible for causing an object to move along a circular path.
   - Calculate the magnitude of a centripetal acceleration.

e. Develop and use a model to describe the mathematical relationship between mass, distance, and force as expressed by Newton's Universal Law of Gravitation.

SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems.

a. Ask questions to compare and contrast open and closed systems.

b. Use mathematics and computational thinking to analyze, evaluate, and apply the principle of conservation of energy and the Work-Kinetic Energy Theorem.
   - Calculate the kinetic energy of an object.
   - Calculate the amount of work performed by a force on an object.

c. Plan and carry out an investigation demonstrating conservation and rate of transfer of energy (power) to solve problems involving closed systems.

d. Construct an argument supported by evidence of the use of the principle of conservation of momentum to
   - explain how the brief application of a force creates an impulse.
   - describe and perform calculations involving one dimensional momentum.
   - connect the concepts of Newton's 3rd law and impulse.
   - experimentally compare and contrast inelastic and elastic collisions.

SP4. Obtain, evaluate, and communicate information about the properties and applications of waves.

a. Develop and use mathematical models to explain mechanical and electromagnetic waves as a propagating disturbance that transfers energy.
   (*<u>Clarification statement:</u>* Mathematically describe how the velocity, frequency, and wavelength of a propagating wave are related.)

b. Develop and use models to describe and calculate characteristics related to the interference and diffraction of waves (single and double slits).

c. Construct an argument that analyzes the production and characteristics of sounds waves.
   (*<u>Clarification statement:</u>* Includes, but not limited to, Doppler Effect, standing waves, wavelength, the relationship between amplitude and the energy of the wave, and the relationship between frequency and pitch.)

d. Plan and carry out investigations to characterize the properties and behavior of electromagnetic waves.
   (*<u>Clarification statement:</u>* Properties of waves include, but not limited to, amplitude, frequency, wavelength, and the relationship between frequency or wavelength and the energy of the wave.)

e. Plan and carry out investigations to describe common features of light in terms of color, polarization, spectral composition, and wave speed in transparent media.
   - Analyze experimentally and mathematically aspects of reflection and refraction of light waves and describe the results using optical ray diagrams.
   - Perform calculations related to reflections from plane surfaces and focusing using thin lenses.

f. Plan and carry out investigations to identify the behavior of light using lenses.
   (*Clarification statement:* Investigations concerning Snell's Law, optical ray diagrams, and thin lens equation should be conducted.)

g. Plan and carry out investigations to describe changes in diffraction patterns associated with geometry and wavelength for mechanical and electromagnetic waves.

SP5. Obtain, evaluate, and communicate information about electrical and magnetic force interactions.

a. Develop and use mathematical models and generate diagrams to compare and contrast the electric and gravitational forces between two charged objects.

b. Plan and carry out investigations to demonstrate and qualitatively explain charge transfer by conduction, friction, and induction.

c. Construct an explanation based on evidence of the behavior of charges in terms of electric potential energy.

d. Plan and carry out an investigation of the relationship between voltage, current, and power for direct current circuits.
   (*Clarification statement:* Application of Ohm's Law to different circuit configurations, not limited to parallel and series, and calculations of equivalent resistance are expected.)

e. Plan and carry out investigations to clarify the relationship between electric currents and magnetic fields.
   (*Clarification statement:* This includes coils and their importance in the design of motors and generators.)

SP6. Obtain, evaluate, and communicate information about nuclear changes of matter and related technological applications.

a. Develop and use models to explain, compare, and contrast nuclear processes including radioactive decay, fission, and fusion.

b. Construct an argument to compare and contrast mechanisms and characteristics of radioactive decay.
   (*Clarification statement:* Include alpha, beta, and gamma decays and their effects.)

c. Develop and use mathematical models and representations to calculate the amount of substance present after a given amount of time based on its half-life and relate this to the law of conservation of mass and energy.