# Virginia Science Content Guidelines

# Physics II (03152)

# VDOE Draft

The Virginia Physics II Course Content Guidelines are designed to build on the content and practices that were introduced in Physics I (03151). Physics II (03052) is intended to provide in-depth instruction on the laws of conservation, thermodynamics, and kinetics; wave and particle phenomena; electromagnetic fields; and fluid dynamics. It is expected that teachers will offer a variety of learning experiences and content choices in which students explore technological advancements and innovative research in physics fields.

## I. Science and Engineering Practices

**Using the content in the Physics II – Advanced Physics Content Guidelines, students will demonstrate an understanding of scientific and engineering practices by**

1. **asking questions and defining problems**
* **ask questions that arise from careful observation of phenomena, examination of a model or theory, or unexpected results, and/or to seek additional information**
* **determine which questions can be investigated within the scope of the school laboratory**
* **make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated**
* **generate hypotheses based on research and scientific principles**
* **define design problems that involves the development of a process or system with interacting components and criteria and constraints**
1. **planning and carrying out investigations**
* **individually and collaboratively plan and conduct observational and experimental investigations**
* **plan and conduct investigations or test design solutions in a safe manner**
* **select and use appropriate tools and technology to collect, record, analyze, and evaluate data**
1. **interpreting, analyzing, and evaluating data**
* **record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms**
* **use data in building and revising models, supporting explanation for phenomena, or testing solutions to problems**
* **analyze data using tools, technologies, and/or models (e.g., computational, mathematical, statistical) in order to make valid and reliable scientific claims or determine an optimal design solution**
* **analyze data graphically and use graphs to make predictions**
* **consider limitations of data analysis when analyzing and interpreting data**
* **evaluate the impact of new data on a working explanation and/or model of a proposed process or system**
* **analyze data to optimize a design**
1. **constructing and critiquing conclusions and explanations**
* **make quantitative and/or qualitative claims based on data**
* **construct and revise explanations based on valid and reliable evidence obtained from a variety of sources**
* **apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions**
* **compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence**
* **construct arguments or counter-arguments based on data and evidence**
* **differentiate between scientific hypothesis, theory, and law**
1. **developing and using models**
* **evaluate the merits and limitations of models**
* **identify and communicate components of a system orally, graphically, textually, and mathematically**
* **develop and/or use models (including mathematical and computational) and simulations to visualize, explain, and predict phenomena and to interpret data sets**
* **derive equations from known equations and/or observations**
1. **obtaining, evaluating, and communicating information**
* **compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem**
* **gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source**
* **communicate scientific and/or technical information about phenomena and/or a design process in multiple formats**

## II. Content Guidelines

**PHII.2 The student will investigate and understand, through mathematical and experimental processes, that energy of a closed mechanical system can change form, is conserved, and is affected by work. Key ideas include**

1. **mechanical energy is conserved unless work is done on, by, or within the system;**
2. **torque and angular displacement are used to determine work and energy of rotational systems; and**
3. **the rate at which work is done or that energy is transferred varies according to power and the efficiency of the system.**

**Central Idea:** Energy in mechanical systems can shift from one form to another while the net amount of energy remains constant unless work is done on or by the system.

**PHII.3 The student will investigate and understand, through mathematical and experimental processes, that momentum in a closed system is governed by conservation laws. Key ideas include**

1. **impulse momentum theory describes the relationship between impulse and momentum;**
2. **the moment of inertia affects angular momentum within a system; and**
3. **angular momentum is conserved for objects in circular motion.**

**Central Idea:** Every moving object has momentum and momentum is always conserved in a closed system.

**PHII.4 The student will investigate and understand, through mathematical and experimental processes, that the structure of an incompressible nonviscous fluid determines many properties of the system. Key ideas include**

1. **fluids have macroscopic properties that result from the arrangement and interactions of the atoms and materials that make up the fluid;**
2. **pressure is a force that impacts fluid systems;**
3. **differences in pressures of a fluid system and another medium leads to buoyancy;**
4. **Bernoulli’s principle describes the relationship between pressure energy, kinetic energy, and gravitational potential energy of a flowing fluid; and**
5. **hydraulic systems have everyday applications.**

**Central Idea:** Pressure within a system of fluids is dependent on the characteristics of the fluid, elevation, and characteristics of the system. Flow rate of fluids are the same at all points within a closed system.

**PHII.5 The student will investigate and understand, through mathematical and experimental processes, the effects of thermal energy conversions on a system. Key ideas include**

1. **thermal energy is related to work, heat, and temperature;**
2. **the laws of thermodynamics can be used to predict the operation of physical systems; and**
3. **energy is transferred spontaneously from a higher-temperature system to a lower-temperature system until equilibrium is reached.**

**Central Idea:** Thermodynamics in physics involve the application of the law of conservation of energy and the interrelationships between thermal energy, work inputs and outputs, and transference to and from other forms of energy within systems.

**PHII.6 The student will investigate and understand, through mathematical and experimental processes, that field strength and interactions are determined by multiple factors. Key ideas include**

1. **Coulomb’s law reflects the relationship between magnitude of a particle charge and distance between the particles;**
2. **Coulomb’s law of magnetic force reflects the relationship between the pole strength and the distance between the poles;**
3. **electric and magnetic field lines are used as graphic models to show the direction and strength of a field;**
4. **Faraday’s law of electromagnetic induction predicts how a magnetic field will interact with an electric circuit to produce an electromagnetic force, and**
5. **Lorentz force law describes the effect electric and magnetic fields have on a moving charge.**

**Central Idea:** Electric fields and magnetic fields share similar characteristics in the way they exert forces on objects at a distance. The interrelationship between electricity and magnetism is fundamental to our understanding of generating electricity and creating electromagnets.

**PHII.7 The student will investigate and understand, through mathematical and experimental processes, that light behaves as particles and waves. Key ideas include**

1. **a photon is generated as energy is released at the atomic level;**
2. **the understanding that light behaves as particles and waves is referred to as the dual nature of light;**
3. **the characteristics of the electromagnetic radiation determines its placement on the electromagnetic spectrum;**
4. **technology is developed to address both the particle and wave behavior of light.**

**Central Idea:** Light emanates from a vibrating electric source as electrical and magnetic waves propagating perpendicular to each other in packets of energy called photons.

**PHII.8 The student will explore technological advancements and innovative research in physics fields.**

1. **AC/DC current and systems of electricity**
2. **quantum mechanics and uncertainty;**
3. **relativity;**
4. **nuclear physics;**
5. **solid state physics;**
6. **nanotechnology;**
7. **superconductivity;**
8. **the standard model; and**
9. **dark matter and dark energy.**

**Central Idea:** There is a long history of various people contributing to an evolving understanding of our world through the lens of physics and contributions are continuing to be made across many topics. Students should have opportunities to further their learning in physics topics and gain mastery of that content.