Introduction to Indiana's Academic Standards for Science – 2010

Indiana's Academic Standards for Science were last revised in 2000. This new document, Indiana's Academic Standards for Science – 2010, reflects the ever-changing science content and the underlying premise that science education should be an inquiry-based, hands-on experience. These standards were adopted by the Indiana State Board of Education in April, 2010, and will be implemented in the 2011-12 school year.

Indiana's Academic Standards for Science – 2010 reflect a few significant changes that are worth noting. Primarily, there are fewer standards and each grade level focuses on the big ideas for each of these sub-disciplines: physical science; earth science; life science; and science, technology and engineering. The overarching organization of the standards has also changed; they are divided into two sections: Process Standards and Content Standards, which are described in greater detail below.

Process Standards

The Process Standards are the processes and skills that students are expected to learn and be able to do within the context of the science content. The separation of the Process Standards from the Content Standards is intentional; in doing so we want to make explicit the idea that what students are doing while they are learning science is extremely important. The Process Standards reflect the way in which students are learning and doing science and are designed to work in tandem with the science content, resulting in robust instructional practice.

The Process Standards are organized in the following grade bands: K-2, 3-5, 6-8. Within each grade band, the Process Standards address a particular topic or topics. Kindergarten introduces The Nature of Science, while grades 1 through 5, reflect two parts: The Nature of Science and The Design Process. In grades 6 through 8, Reading for Literacy in Science and Writing for Literacy in Science have been added to emphasize these processes in science. For high school, the Process Standards include Reading and Writing for Literacy in Science as well as The Nature of Science.

As noted in the previous paragraph, grades 6 through 8 and high school content courses will include Reading and Writing for Literacy in Science. It is important to note that these Process Standards emerged with the adoption of the Common Core State Standards in the area of Reading and Writing for Literacy in Science. The Literacy Standards establish that instruction in reading, writing, speaking, listening, and language is a shared responsibility. The Literacy Standards are predicated on teachers in the content areas using their unique disciplinary expertise to help students meet the particular challenges of reading, writing, speaking, listening, and language in their respective fields. It is important to note that the literacy standards are meant to complement rather than supplant content standards in the disciplines.

Part of the motivation behind the disciplinary approach to literacy promulgated by the Literacy Standards is extensive research establishing the need for college- and career-ready students to be proficient in reading complex informational text independently in a variety of content areas. Most of the required reading in college and workforce training programs is informational in structure and challenging in content. Postsecondary education programs typically provide students with both a higher volume of such reading than is generally required in K-12 schools and comparatively little scaffolding.

The Literacy Standards make clear that significant reading of informational texts should also take place outside ELA classrooms in order for students to be ready for college and careers. Future assessments will apply the sum of all the reading students do in a grade, not just their reading in the ELA context. The Literacy Standards demand that a great deal of reading should occur in all disciplines.

The Literacy Standards also cultivate the development of three mutually reinforcing writing capacities: writing to persuade, to explain, and to convey real or imagined experience. College and career readiness requires that writing focus significantly on writing to argue and to inform or explain.

The Literacy Standards use grade level bands to present the standards. Teachers teaching at the beginning of the grade band may need to provide scaffolding for students to be successful, where teachers teaching at the end of the grade band should expect students to demonstrate the standards independently.

Content Standards

In grades 1 through 8, the Content Standards are organized in four distinct areas: 1) physical science; 2) earth science; 3) life science; and 4) science, technology and engineering. Kindergarten has only the first three areas: physical, earth and life science. In each of these areas there is at least one core standard, which serves as the big idea at that grade level for that content area. For the high school science courses, the content standards are organized around the core ideas in each particular course, which are represented by the core standard. The core standard is not meant to stand alone or be used as an individual standard, but instead is meant to help teachers organize their instruction around the “big ideas” in that content area and for grades K-8, at that particular grade level. Beneath each core standard are indicators which serve as the more detailed expectations within each of the content areas.

Finally, in the development of these revised science standards, careful attention was paid to how ideas are articulated across the grade levels so that content and skills that students will need to succeed in a particular sub-discipline are introduced in an appropriate manner in the early elementary grades and then progressed as students move towards high school.

Physics I

Process Standards

The Nature of Science

Scientific knowledge is scientists' best explanations for the data from many investigations. Ideas about objects in the microscopic world that we cannot directly sense are often understood in terms of concepts developed to understand objects in the macroscopic world that we can see and touch. Student work should align with this process of science and should be guided by those principles. Students should also understand that scientific knowledge is gained from observation of natural phenomena and experimentation by designing and conducting investigations guided by theory and by evaluating and communicating the results of those investigations according to accepted procedures. These concepts should be woven throughout daily work.

- Develop explanations based on reproducible data and observations gathered during laboratory investigations.
- Recognize that their explanations must be based both on their data and other known information from investigations of others.
- Clearly communicate their ideas and results of investigations verbally and in written form using tables, graphs, diagrams and photographs.
- Regularly evaluate the work of their peers and in turn have their work evaluated by their peers.
- Apply standard techniques in laboratory investigations to measure physical quantities in appropriate units and convert quantities to other units as necessary.
- Use analogies and models (mathematical and physical) to simplify and represent systems that are difficult to understand or directly experience due to their size, time scale or complexity. Recognize the limitations of analogies and models.
- Focus on the development of explanatory models based on their observations during laboratory investigations.
- Explain that the body of scientific knowledge is organized into major theories, which are derived from and supported by the results of many experiments and allow us to make testable predictions.
- Recognize that new scientific discoveries often lead to a re-evaluation of previously accepted scientific knowledge and of commonly held ideas.
- Describe how scientific discoveries lead to the development of new technologies and conversely how technological advances can lead to scientific discoveries through new experimental methods and equipment.
- Explain how scientific knowledge can be used to guide decisions on environmental and social issues.

Reading Standards for Literacy in Science

Key Ideas and Details

11-12.RS.1 Cite specific textual evidence to support analysis of science, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

11-12.RS.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

11-12.RS.3 Follow precisely a complex multistep procedure when carrying out experiments or taking measurements; analyze the specific results based on explanations in the text.

Craft and Structure

11-12.RS.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific context relevant to *grades 11-12 texts and topics*.

11-12.RS.5 Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

11-12.RS.6 Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas

11-12.RS.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

11-12.RS.8 Evaluate the hypotheses, data, analysis, and conclusions in a science text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

11-12.RS.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Range of Reading and Level of Text Complexity

11-12.RS.10 By the end of grade 12 read and comprehend science texts in the grades 11-CCR text complexity band independently and proficiently.

Writing Standards for Literacy in Science

Text Types and Purposes

11-12.WS.1 Write arguments focused on *discipline-specific content*.

a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
e. Provide a concluding statement or section that follows from or supports the argument presented.

11-12.WS.2 Write informative/explanatory texts, including scientific procedures/ experiments.

a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.
e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

11-12.WS.3 *Note: Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In science, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations that others can replicate them and (possibly) reach the same results.*

Production and Distribution of Writing

11-12.WS.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

11-12.WS.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

11-12.WS.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge

11-12.WS.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

11-12.WS.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectivity to maintain the flow of ideas, avoiding plagiarism and overreliance on any once source and following a standard format for citation.

11-12.WS.9 Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing

11-12.WS.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Content Standards

Standard I: Motion and Forces

Core Standard

Collaboratively describe, test through experiments, explain and defend mathematical models of the motion of macroscopic objects in terms of Newton’s laws.

P.1.1 Using motion, maps, graphs and algebraic equations, describe, measure, and analyze constant acceleration motion in one dimension in terms of time and the vector quantities of displacement, velocity and acceleration.

P.1.2 Using motion, maps, graphs and algebraic equations, describe, measure, and analyze constant acceleration motion in two dimensions in terms of time and the vector quantities of displacement, velocity and acceleration. Consider specifically projectile motion and uniform circular motion.

P.1.3 Describe the magnitude and direction of kinds of forces, including both contact forces and non-contact forces, those that act at a distance. Find the net force acting on an object using free-body diagrams and the addition of forces. Use Newton’s three laws to deductively analyze static and dynamic systems.

P.1.4 Use Newton’s Law of Universal Gravitation and the laws of motion to quantitatively analyze the motions of orbiting objects such as the moon, the planets and satellites (i.e., Kepler’s Third Law of Planetary Motion).

Standard 2: Energy and Momentum

Core Standard

Collaboratively describe, test, explain and defend mathematical models of the motion of macroscopic objects in terms of energy, momentum and their conservation laws as developed using Newton’s three laws of motion.

P.2.1 Describe qualitatively and quantitatively the concepts of momentum, work, kinetic energy, potential energy and power.

P.2.2 Quantitatively predict changes in momentum using the impulse-momentum theorem and in kinetic energy using the work-energy theorem.

P.2.3 Analyze evidence that illustrates the Law of Conservation of Energy and the Law of Conservation of Momentum. Apply these laws to analyze elastic and completely inelastic collisions.

P.2.4 Describe and quantify energy in its different mechanical forms (e.g., kinetic, gravitational potential, elastic potential) and recognize that these forms of energy can be transformed one into another and into non-mechanical forms of energy (e.g., thermal, chemical, nuclear and electromagnetic).

Standard 3: Temperature and Thermal Energy Transfer

Core Standard

Describe and distinguish the concepts of temperature and thermal energy. Use the kinetic-molecular theory to explain some thermal properties of gases and phase changes of solids, liquids and gases.

P.3.1 Describe temperature, thermal energy and thermal energy transfer in terms of the kinetic molecular model. Expand the concept of conservation of mechanical energy to include thermal energy.

P.3.2 Describe the kinetic molecular model, use it to derive the ideal gas law and show how it explains the relationship between the temperature of an object and the average kinetic energy of its molecules.

P.3.3 Use the kinetic theory to explain that the transfer of heat occurs during a change of state.

P.3.4 Use examples from everyday life to describe the transfer of thermal energy by conduction, convection and radiation.

Standard 4: Electricity and Magnetism

Core Standard

Understand the interplay of electricity and magnetism. Apply this understanding to electrostatic problems and basic electrical circuits.

P.4.1 Using Coulomb's law, describe and determine the force on a stationary charge due to other stationary charges. Know that this force is many times greater than the gravitational force.

P.4.2 Define electric field and describe the motion of a charged particle in a simple electric field.

P.4.3 Describe electric potential energy and electric potential (i.e., voltage). Use voltage to explain the motion of electrical charges and the resulting electric currents in conductors.

P.4.4 Explain and analyze simple arrangements of electrical components in series and parallel circuits in terms of current, resistance, voltage and power. Use Ohm's and Kirchhoff's laws to analyze circuits.

P.4.5 Describe the magnetic forces and fields produced by and acting on moving charges and magnetic materials.

Standard 5: Vibrations, Waves

Core Standard

Apply Newton's laws and the concepts of kinetic and potential energy to describe and explain the motion of vibrating objects.

P.5.1 Identify properties of objects that vibrate by using Newton's laws to describe and explain the vibrational motion resulting from restoring forces, such as Hooke's Law in the case of spring or gravity in the case of a small amplitude pendulum.

P.5.2 Describe how vibrating objects can generate transverse and/or longitudinal waves so that energy is transmitted without the transfer of energy. Distinguish longitudinal waves from transverse waves.

P.5.3 Describe and analyze propagating waves in terms of their fundamental characteristics such as wave speed, wavelength, frequency or period, and amplitude.

P.5.4 Describe and explain the behavior of waves such as transmission, reflection, interference and polarizations. Qualitatively describe and explain the production and properties of standing waves.

Standard 6: Light and Optics

Core Standard

Understand the geometric nature of light propagation and its wave nature as observed in the propagation of light through space and its interactions with and in matter.

P.6.1 Understand the geometric nature of light in reflection and refraction and in image formation by lenses and mirrors. Use that geometric nature to graphically predict the formation of images by lens and mirrors.

P.6.2 Describe the electromagnetic spectrum (i.e., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays and gamma rays) in terms of frequency, wavelength and energy. Recognize that all these waves travel in a vacuum at the same speed.

P.6.3 Understand that electromagnetic waves are produced by the acceleration of charged particles. Describe how electromagnetic waves interact with matter both as packets (i.e., photons) and as waves. Show qualitatively how wave theory helps explain polarization and diffraction.

Standard 7: Modern Physics

Core Standard

Understand how our knowledge of physics has changed during the last hundred years, particularly in the areas of atomic and nuclear physics, quantum theory and relativity. Describe the structure of the atom and the reactions that occur in its nucleus.

P.7.1 Explain that electrons, protons and neutrons are parts of the atom and that the nuclei of atoms are composed of protons and neutrons, which experience forces of attraction and repulsion consistent with their charges and masses. Distinguish elements from isotopes.

P.7.2 Explain that the stability of the nucleus, containing only positive or neutral particles, indicates the existence of a new force that is only evident within the nucleus, as it holds the particles together despite the strong repulsive electrical force.

P.7.3 Distinguish fission from fusion processes. Describe how the binding energies of protons and neutrons determine the stability and instability of nuclei.

P.7.4 Describe qualitatively how nuclear reactions (i.e, fission and fusion) convert very small amounts of matter into large amounts of energy.

P.7.5 Understand that fission results from large, less stable nuclei decomposing to form smaller, more stable nuclei. Understand that fusion results from small nuclei at high temperatures and pressures combining to form larger, more stable nuclei and releasing thermonuclear energy.