

Physics II Science Standards

Science and Engineering Process Standards (SEPS)

The Science and Engineering 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 Science and Engineering Process Standards from the Content Standards is intentional; the separation of the standards explicitly shows that what students are doing while 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.

Science and Engineering Process Standards	
SEPS.1 Posing questions (for science) and defining problems (for engineering)	A practice of science is posing and refining questions that lead to descriptions and explanations of how the natural and designed world(s) work and these questions can be scientifically tested. Engineering questions clarify problems to determine criteria for possible solutions and identify constraints to solve problems about the designed world.
SEPS.2 Developing and using models and tools	<p>A practice of both science and engineering is to use and construct conceptual models that illustrate ideas and explanations. Models are used to develop questions, predictions and explanations; analyze and identify flaws in systems; build and revise scientific explanations and proposed engineered systems; and communicate ideas. Measurements and observations are used to revise and improve models and designs. Models include, but are not limited to: diagrams, drawings, physical replicas, mathematical representations, analogies, and other technological models.</p> <p>Another practice of both science and engineering is to identify and correctly use tools to construct, obtain, and evaluate questions and problems. Utilize appropriate tools while identifying their limitations. Tools include, but are not limited to: pencil and paper, models, ruler, a protractor, a calculator, laboratory equipment, safety gear, a spreadsheet, experiment data collection software, and other technological tools.</p>
SEPS.3 Constructing and performing investigations	Scientists and engineers are constructing and performing investigations in the field or laboratory, working collaboratively as well as individually. Researching analogous problems in order to gain insight into possible solutions allows them to make conjectures about the form and meaning of the solution. A plan to a solution pathway is developed prior to constructing and performing investigations. Constructing investigations systematically encompasses identified variables and parameters generating quality data. While performing, scientists and engineers monitor and record progress. After performing, they evaluate to make changes to modify and repeat the investigation if necessary.

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SEPS.4 Analyzing and interpreting data	Investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists and engineers use a range of tools to identify the significant features in the data. They identify sources of error in the investigations and calculate the degree of certainty in the results. Advances in science and engineering makes analysis of proposed solutions more efficient and effective. They analyze their results by continually asking themselves questions; possible questions may be, but are not limited to: “Does this make sense?” “Could my results be duplicated?” and/or “Does the design solve the problem with the given constraints?”
SEPS.5 Using mathematics and computational thinking	In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions. Scientists and engineers understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)	Scientists and engineers use their results from the investigation in constructing descriptions and explanations, citing the interpretation of data, connecting the investigation to how the natural and designed world(s) work. They construct or design logical coherent explanations or solutions of phenomena that incorporate their understanding of science and/or engineering or a model that represents it, and are consistent with the available evidence.
SEPS.7 Engaging in argument from evidence	Scientists and engineers use reasoning and argument based on evidence to identify the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation, the process by which evidence-based conclusions and solutions are reached, to listen to, compare, and evaluate competing ideas and methods based on merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims.
SEPS.8 Obtaining, evaluating, and communicating information	Scientists and engineers need to be communicating clearly and articulating the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity. Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations, as well as, orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to obtain information that is used to evaluate the merit and validity of claims, methods, and designs.

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Literacy in Science/Technical Subjects: Grades 11-12 (11-12 LST)

The Indiana Academic Standards for Content Area Literacy (Science/Technical Subjects) indicate ways in which educators incorporate literacy skills into science at the 6-12 grade levels.

LEARNING OUTCOMES	LST.1: LEARNING OUTCOME FOR LITERACY IN SCIENCE/TECHNICAL SUBJECTS Read and comprehend science and technical texts independently and proficiently and write effectively for a variety of discipline-specific tasks, purposes, and
	GRADES 11-12
	11-12.LST.1.1: Read and comprehend science and technical texts within a range of complexity appropriate for grades 11-CCR independently and proficiently by the end of grade 12.
	11-12.LST.1.2: Write routinely over a variety of time frames for a range of discipline-specific tasks, purposes, and audiences.

KEY IDEAS AND TEXTUAL SUPPORT	LST.2: KEY IDEAS AND TEXTUAL SUPPORT (READING) Extract and construct meaning from science and technical texts using a variety of comprehension skills
	GRADES 11-12
	11-12.LST.2.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
	11-12.LST.2.2: 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.LST.2.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

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STRUCTURAL ELEMENTS AND ORGANIZATION	LST.3: STRUCTURAL ELEMENTS AND ORGANIZATION (READING) Build understanding of science and technical texts, using knowledge of structural organization and author’s purpose and message
	GRADES 11-12
	11-12.LST.3.1: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
	11-12.LST.3.2: Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
	11-12.LST.3.3: 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.

SYNTHESIS AND CONNECTION OF IDEAS	LST.4: SYNTHESIS AND CONNECTION OF IDEAS (READING) Build understanding of science and technical texts by synthesizing and connecting ideas and evaluating specific claims
	GRADES 11-12
	11-12.LST.4.1: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., <i>quantitative data, video, multimedia</i>) in order to address a question or solve a problem.
	11-12.LST.4.2: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
	11-12.LST.4.3: Synthesize information from a range of sources (e.g., <i>texts, experiments, simulations</i>) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

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WRITING GENRES	LST.5: WRITING GENRES (WRITING) Write for different purposes and to specific audiences or people
	GRADES 11-12
	11-12.LST.5.1: Write arguments focused on discipline-specific content.
	11-12.LST.5.2: Write informative texts, including scientific procedures/experiments or technical processes that include precise descriptions and conclusions drawn from data and research.

THE WRITING PROCESS	LST.6: THE WRITING PROCESS (WRITING) Produce coherent and legible documents by planning, drafting, revising, editing, and collaborating with others
	GRADES 11-12
	11-12.LST.6.1: Plan and develop; draft; revise using appropriate reference materials; rewrite; try a new approach, focusing on addressing what is most significant for a specific purpose and audience; and edit to produce and strengthen writing that is clear and coherent.
	11-12.LST.6.2: Use technology to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

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THE RESEARCH PROCESS	<p>LST.7: THE RESEARCH PROCESS (WRITING) Build knowledge about the research process and the topic under study by conducting short or more sustained research</p>
	<p>GRADES 11-12</p>
	<p>11-12.LST.7.1: Conduct short as well as more sustained research assignments and tasks to answer a question (including a self-generated question), test a hypothesis, or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.</p>
	<p>11-12.LST.7.2: Gather relevant information from multiple types of authoritative sources, using advanced searches effectively; annotate sources; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; synthesize and integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation (e.g., <i>APA or CSE</i>).</p>
	<p>11-12.LST.7.3: Draw evidence from informational texts to support analysis, reflection, and research.</p>

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Content Standards

For the high school science courses, the content standards are organized around the core ideas in each particular course. Within each core idea are indicators which serve as the more detailed expectations within each of the content areas.

Indiana Physics II	
Standard 1: Energy and Momentum in Two Dimensions	PII.1.1 For a system consisting of a single object with a net external force applied, qualitatively and quantitatively predict changes in its linear momentum using the impulse-momentum theorem and in its translational kinetic energy using the work-energy theorem.
	PII.1.2 For a system consisting of a two objects with no net external forces applied, qualitatively and quantitatively analyze a two dimensional interaction (i.e. collision or separation) to show that the total linear momentum of the system remains constant.
	PII.1.3 For a system consisting of two objects moving in two dimensions with no net external forces applied, apply the principles of conservation of linear momentum and of mechanical energy to quantitatively predict changes in the linear momentum, velocity, and kinetic energy after the interaction between the two objects.
	PII.1.4 Classify interactions between two objects moving in two dimensions as elastic, inelastic, and completely inelastic.
Standard 2: Temperature and Thermal Energy Transfer	PII.2.1 Develop graphical and mathematical representations that describe the relationship among the temperature, thermal energy, and thermal energy transfer (i.e. heat) in the kinetic molecular theory and apply those representations to qualitatively and quantitatively describe how changing the temperature of a substance affects the motion of the molecules.
	PII.2.2 Describe the process of the transfer of thermal energy (i.e. heat) that occurs during the heating cycle of a substance from solid to gas and relate the changes in molecular motion to temperature changes that are observed.
	PII.2.3 Cite evidence from everyday life to describe the transfer of thermal energy by conduction, convection, and radiation.
	PII.2.4 Develop graphical and mathematical representations that describe the relationship among the volume, temperature, and number of molecules of an ideal gas in a closed system and the pressure exerted by the system and apply those representations to qualitatively and quantitatively describe how changing any of those variables affects the others.

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	<p>PII.2.5 Describe the slope of the graphical representation of pressure vs. the product of: the number of particles, temperature of the gas, and inverse of the volume of the gas in terms of the ideal gas constant.</p>
	<p>PII.2.6 Using PV graphs, qualitatively and quantitatively determine how changes in the pressure, volume, or temperature of an ideal gas allow the gas to do work and classify the work as either done on or done by the gas.</p>

Standard 3: Fluids	<p>PII.3.1 For a static, incompressible fluid, develop and apply graphical and mathematical representations that describe the relationship between the density and the pressure exerted at various positions in the fluid, and apply those representations to qualitatively and quantitatively describe how changing the depth or density affects the pressure.</p>
	<p>PII.3.2 Qualitatively and quantitatively determine how the density of fluid or volume of fluid displaced is related to the force due to buoyancy acting on either a floating or submerged object as described by Archimedes' principle of buoyancy.</p>
	<p>PII.3.3 Develop and apply the principle of constant volume flow rate to determine the relationship between cross-sectional area of a pipe and the velocity of an incompressible fluid flowing through a pipe.</p>
	<p>PII.3.4 Develop and apply Bernoulli's principle and continuity equations to predict changes in the speed and pressure of a moving incompressible fluid.</p>
	<p>PII.3.5 Describe how a change in the pressure of a static fluid in an enclosed container is transmitted equally in all directions (Pascal's Principle) and apply Pascal's Principle to determine the mechanical advantage of a hydraulic system.</p>

Standard 4: Electricity	<p>PII.4.1 Describe the methods of charging an object (i.e. contact, induction, and polarization) and apply the principle of conservation of charge to determine the charges on each object after charge is transferred between two objects by contact.</p>
	<p>PII.4.2 For a single isolated charge, develop and apply graphical and mathematical representations that describe the relationship between the amount of charge, the distance from the charge and the strength of the electric field created by the charge and apply those representations to qualitatively and quantitatively describe how changing either the amount of charge or distance from the charge affects the strength of the electric field.</p>
	<p>PII.4.3 Using Coulomb's law, pictorially and mathematically describe the force on a stationary charge due to other stationary charges. Understand that these forces are equal and opposite as described by Newton's third law and compare and contrast the strength of this force to the force due to gravity.</p>

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Standard 4: Simple and Complex Circuits	<p>PII.4.4 For a single isolated charge, develop graphical and mathematical representations that describe the relationship between the amount of charge, the distance from the charge and the electric potential created by the charge and apply those representations to qualitatively and quantitatively describe how changing either the amount of charge or distance from the charge affects the electric potential.</p>
	<p>PII.4.5 Map electric fields and equipotential lines, showing the electric field lines are perpendicular to the equipotential lines, and draw conclusions about the motion of a charged particle either between or along equipotential lines due the electric field.</p>
	<p>PII.4.6 Distinguish between electric potential energy and electric potential (i.e. voltage).</p>
	<p>PII.4.7 Apply conservation of energy to determine changes in the electric potential energy, translational kinetic energy, and speed of a single charged object (i.e. a point particle) placed in a uniform electric field.</p>

Standard 5: Simple and Complex Circuits	<p>PII.5.1 Relate the idea of electric potential energy to electric potential (i.e. voltage) in the context of electric circuits.</p>
	<p>PII.5.2 Develop graphical and mathematical representations that describe the relationship between the between the amount of current passing through an ohmic device and the amount of voltage (i.e. EMF) applied across the device according to Ohm’s Law. Apply those representations to qualitatively and quantitatively describe how changing the current affects the voltage and vice versa for an ohmic device of known resistance.</p>
	<p>PII.5.3 Describe the slope of the graphical representation of current vs. voltage or voltage vs. current in terms of the resistance of the device.</p>
	<p>PII.5.4 Define and describe a device as ohmic or non-ohmic based on the relationship between the current passing through the device and the voltage across the device based on the shape of the curve of a current vs. voltage or voltage vs. current graphical representation.</p>
	<p>PII.5.5 Explain and analyze simple arrangements of electrical components in series and parallel DC circuits in terms of current, resistance, voltage and power. Use Ohm’s and Kirchhoff’s laws to analyze DC circuits.</p>

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Standard 6: Magnetism	PII.6.1 Describe the magnetic properties of ferromagnetic, paramagnetic, and diamagnetic materials on a macroscopic scale and atomic scale.
	PII.6.2 Develop and apply a mathematical representation that describes the relationship between the magnetic field created by a long straight wire carrying an electric current, the magnitude of the current, and the distance to the wire.
	PII.6.3 Describe the motion of a charged or uncharged particle through a uniform magnetic field.
	PII.6.4 Determine the magnitude of the magnetic force acting on a charged particle moving through a uniform magnetic field and apply the right hand rule to determine the direction of either the magnetic force or the magnetic field.
	PII.6.5 Describe the practical uses of magnetism in motors, electronic devices, mass spectroscopy, MRIs, and other applications.

Standard 7: Electromagnetic Induction	PII.7.1 Given the magnitude and direction of a uniform magnetic field, calculate the flux through a specified area in terms of the field magnitude and the size and orientation of the area with respect to the field.
	PII.7.2 Develop graphical and mathematical representations that describe the relationship between the rate of change of magnetic flux and the amount of voltage induced in a simple loop circuit according to Faraday's Law of Induction and apply those representations to qualitatively and quantitatively describe how changing the voltage across the device affects the current through the device.
	PII.7.3 Apply Ohm's Law, Faraday's Law, and Lenz's Law to determine the amount and direction of current induced by a changing magnetic flux in a loop of wire or simple loop circuit.

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Standard 8: Geometric Optics	<p>PII.8.1 Develop graphical, mathematical, and pictorial representations (e.g. ray diagrams) that describe the relationships between the focal length, the image distance and the object distance for planar, converging, and diverging mirrors and apply those representations to qualitatively and quantitatively describe how changing the object distance affects the image distance.</p>
	<p>PII.8.2 Develop graphical, mathematical, and pictorial representations (e.g. ray diagrams) that describe the relationship between the angles of incidence and refraction of monochromatic light passed between two different media and apply those representations to qualitatively and quantitatively describe how changing the angle of incidence affects the angle of refraction.</p>
	<p>PII.8.3 Develop graphical, mathematical, and pictorial representations (e.g. ray diagrams) that describe the relationships between the focal length, the image distance, and the object distance for both converging and diverging lenses and apply those representations to qualitatively and quantitatively describe how changing the object distance affects the image distance.</p>
	<p>PII.8.4 Describe an image as real or virtual for both a curved mirror and lens system based on the position of the image relative to the optical device.</p>

Standard 9: Particle and Wave Nature of Light	<p>PII.9.1 Develop the relationship among frequency, wavelength, and energy for electromagnetic waves across the entire spectrum.</p>
	<p>PII.9.2 Explain how electromagnetic waves interact with matter both as particles (i.e. photons) and as waves and be able to apply the most appropriate model to any particular scenario.</p>
	<p>PII.9.3 Develop graphical and mathematical representations that describe the relationship between the frequency of a photon and the kinetic energy of an electron emitted through the photoelectric effect and apply those representations to qualitatively and quantitatively describe how changing the frequency or intensity of light affect the current produced in the photoelectric effect.</p>
	<p>PII.9.4 Describe the slope of the graphical representation of the kinetic energy of a photoelectron vs. frequency in terms of Planck's constant.</p>
	<p>PII.9.5 Develop graphical and mathematical representations that describe the relationship between the wavelength of monochromatic light, spacing between slits, distance to screen, and interference pattern produced for a double-slit scenario and apply those representations to qualitatively and quantitatively describe how changing any of the independent variables affects the position of the bright fringes.</p>

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	<p>PII.9.6 Develop graphical and mathematical representations that describe the relationship between the angle between two polarizing filters and the intensity of light passed through the filters from an unpolarized light source and apply those representations to qualitatively and quantitatively describe how changing the angle between polarizing filters affects the intensity of light passing through both filters.</p>
Standard 10: Modern Physics	<p>PII.10.1 Describe the Standard Model and explain the composition and decay of subatomic particles using the Standard Model and Feynman diagrams.</p>
	<p>PII.10.2 Explain the stability of the nucleus considering the electromagnetic repulsion in the nucleus and how forces govern binding energy and radioactive decay for different elements.</p>
	<p>PII.10.3 Qualitatively compare and contrast how particle interactions, fission, and fusion can convert matter into energy and energy into matter, and calculate the relative amounts of matter and energy in such processes.</p>
	<p>PII.10.4 Apply the conservation of mass, conservation of charge, and conservation of linear momentum principles to describe the results of a radioactive particle undergoing either alpha or beta decay.</p>
	<p>PII.10.5 Know and describe how a particle accelerator functions and how current high energy particle physics experiments are being used to develop the Standard Model.</p>