Indiana Content Standards for Educators

SCIENCE–PHYSICS

Physics teachers are expected to have a broad and comprehensive understanding of the knowledge and skills needed for this educator license, and to use that knowledge to help students prepare for the challenges and opportunities of the twenty-first century. This requires the ability to identify, comprehend, analyze, synthesize, and evaluate the basic principles, fundamental concepts, and essential content defined in these standards, and to apply that knowledge to the tasks of planning and delivering effective instruction and assessment.

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Science – Physics
Educator Standards

Standard 1: The Nature and Processes of Science

Physics teachers have a broad and comprehensive understanding of the nature of science and the processes of scientific inquiry.

Standard 2: Central Concepts and Connections in Science

Physics teachers have a comprehensive understanding of the core ideas in other science disciplines and of the relationships between science, engineering, technology, and society.

Standard 3: Motion and Forces

Physics teachers have a broad and comprehensive understanding of motion, forces, and Newton's laws in one and two dimensions.

Standard 4: Energy and Momentum

Physics teachers have a broad and comprehensive understanding of the conservation of energy and momentum.

Standard 5: Thermodynamics and Kinetic Theory

Physics teachers have a broad and comprehensive understanding of the laws of thermodynamics and the kinetic theory of matter.

Standard 6: Electricity and Magnetism

Physics teachers have a broad and comprehensive understanding of electricity and magnetism.

Standard 7: Vibrations and Waves

Physics teachers have a broad and comprehensive understanding of vibrations and waves and the application of wave properties to sound and light.

Standard 8: Modern Physics

Physics teachers have a broad and comprehensive understanding of the fundamental ideas of modern physics.

Standard 9: Science Instruction and Assessment

Physics teachers have a broad and comprehensive understanding of content-specific instruction and assessment in science.

The Indiana Educator Standards for Science–Physics describe the knowledge and skills that teachers need to help students achieve the learning outcomes defined by the Indiana Revised Academic Standards for Science. Links to relevant portions of the Indiana Academic Standards can be found below.

Indiana Science Standards | Grade 5 | Grade 6 | Grade 7 | Grade 8 | Physics I

Standard 1: The Nature and Processes of Science

Physics teachers have a broad and comprehensive understanding of the nature of science and the processes of scientific inquiry, including:

1.1 the characteristics, assumptions, and goals of science

1.2 the tentative nature of scientific knowledge, which is subject to change as new evidence, new tools, or new ways of thinking become available

1.3 the formulation of testable hypotheses and the principles and procedures for designing and conducting scientific investigations

1.4 common tools, materials, and technology used in physics investigations

1.5 the collection, organization, analysis, interpretation, and communication of scientific data, including the use of technology

1.6 the safe execution of laboratory exercises and the safe storage and disposal of materials

1.7 the role and applications of mathematics in science

1.8 the characteristics and uses of various sources of scientific information and the evaluation of scientific information, claims, and arguments

1.9 the role of peer review and critical evaluation of the results of scientific investigations, models, and explanations

Standard 2: Central Concepts and Connections in Science

Physics teachers have a comprehensive understanding of the core ideas in other science disciplines and of the relationships between science, engineering, technology, and society, including:

2.1 the unifying concepts and processes that cut across the sciences and engineering

2.2 the basic concepts and major principles of chemistry

2.3 the basic concepts and major principles of Earth and space science

2.4 the basic concepts and major principles of life science

2.5 the basic characteristics, principles, and goals of the engineering, or technological, design process

2.6 the interconnections between the various disciplines of science

2.7 the interrelationships between science and technology

2.8 the social, cultural, and ethical aspects of science, engineering, and technology

2.9 the historical development of important ideas in science from different periods and cultures

Standard 3: Motion and Forces

Physics teachers have a broad and comprehensive understanding of motion, forces, and Newton's laws in one and two dimensions, including:

3.1 the representation of motion using graphs, motion maps, algebra, trigonometry, and calculus

3.2 the vector nature of force and motion in two dimensions

3.3 characteristics of the gravitational force, frictional forces, and elastic forces

3.4 applications of Newton's laws to a variety of situations on Earth and in space

3.5 torque and its application to static and dynamic systems

3.6 properties of fluids and applications of the principles of Archimedes, Pascal, and Bernoulli

Standard 4: Energy and Momentum

Physics teachers have a broad and comprehensive understanding of the conservation of energy and momentum, including:

4.1 the interrelationships between force, work, energy, and power

4.2 conservation of energy and the work-energy theorem

4.3 the interrelationships among force, impulse, and momentum

4.4 the conservation of momentum in one and two dimensions

4.5 the conservation of rotational energy and angular momentum

Standard 5: Thermodynamics and Kinetic Theory

Physics teachers have a broad and comprehensive understanding of the laws of thermodynamics and the kinetic theory of matter, including:

5.1 heat and temperature, specific heat, phase changes, thermal expansion, and methods of heat transfer

5.2 the mechanical equivalence of heat, thermodynamic work, and the first law of thermodynamics

5.3 the kinetic theory of matter and the description of macroscopic quantities in terms of molecular interactions

5.4 heat engines, entropy, energy conversions and efficiency, and the second law of thermodynamics

Standard 6: Electricity and Magnetism

Physics teachers have a broad and comprehensive understanding of electricity and magnetism, including:

6.1 electric charge, electrostatics, the electric force, and Coulomb's law

6.2 the electric field and the motion of charged particles in an electric field

6.3 conservative fields, electrostatic potential energy, and electric potential

6.4 properties of the magnetic field, the motion of charged particles in magnetic fields, and magnetism in matter

6.5 Faraday's law, Lenz's law, and induced electric fields and electromotive force

6.6 Ohm's law, capacitance, resistivity and resistance, and the analysis of electric circuits using Kirchhoff's laws

6.7 qualitative aspects of the generation of electromagnetic waves and characteristics of the electromagnetic spectrum

6.8 basic characteristics of alternating current and the operation of devices such as electric motors, generators, and transformers

Standard 7: Vibrations and Waves

Physics teachers have a broad and comprehensive understanding of vibrations and waves and the application of wave properties to sound and light, including:

7.1 the application of force and energy principles to simple harmonic motion and oscillating systems

7.2 the properties of waves and the transfer of energy and momentum by transverse and longitudinal waves

7.3 the production, propagation, and properties of sound waves

7.4 the superposition principle, resonance, and the production of standing waves for various boundary conditions

7.5 the production, propagation, reflection, and refraction of light waves

7.6 geometric optics and image formation in thin lenses and mirrors

7.7 physical optics and the interference, diffraction, and polarization of light waves

Standard 8: Modern Physics

Physics teachers have a broad and comprehensive understanding of the fundamental ideas of modern physics, including:

8.1 energy of light quanta and the photoelectric effect

8.2 historic and contemporary models of the atom

8.3 the wave-particle duality, the uncertainty principle, and interactions between light and matter

8.4 fundamentals of the special theory of relativity

8.5 the structure of the nucleus, binding energy, stability, and nuclear reactions

Standard 9: Science Instruction and Assessment

Physics teachers have a broad and comprehensive understanding of content-specific instruction and assessment in science, including:

9.1 the Indiana Revised Academic Standards for Science

9.2 the National Science Education Standards, the NCATE/NSTA Standards for Science Teacher Preparation, the Common Core State Standards for Literacy: Science and Technical Subjects, and the ISTE National Educational Technology Standards

9.3 instructional strategies and resources for promoting students' development of conceptual understanding, inquiry skills, and scientific habits of mind

9.4 strategies and skills for planning and designing science instruction, including the use of techniques and approaches that meet the needs of diverse learners

9.5 instructional strategies and communication methods that encourage active inquiry, supportive interaction, and collaboration in the science classroom

9.6 strategies and resources for promoting students' reading, writing, and mathematics skills in science

9.7 strategies and skills for selecting, adapting, and using technological resources to enhance teaching and learning in science

9.8 procedures, resources, and guidelines for maintaining a safe science learning environment

9.9 strategies and skills for effectively assessing student understanding and mastery of essential science concepts and skills

Selected Bibliography of Standards and Sources Related to Science – Physics

State and National Standards and Curriculum Frameworks

1. Indiana Department of Education. (2010). *Indiana revised academic standards for science*. http://www.indianascience.org/files/standards_03_29_10.pdf
2. Council of Chief State School Officers (CCSSO)/National Governors Association (NGA). (2010). *Common core state standards for English language arts & literacy in history/social studies, science, and technical subjects*. http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf
3. National Research Council. (1996). *National science education standards*. Washington, DC: The National Academies Press. http://www.nap.edu/catalog/4962
4. National Science Teachers Association. (2003). *Standards for science teacher preparation*. http://www.ncate.org/ProgramStandards/NSTA/NSTAstandards.doc
5. American Association for the Advancement of Science. (1993). *Project 2061: Benchmarks for science literacy*. New York: Oxford University Press. http://www.project2061.org/publications/bsl/default.htm
6. International Society for Technology in Education (ISTE). (2008). *National educational technology standards for teachers*. http://www.iste.org/Libraries/PDFs/NETS_for_Teachers_2008_EN.sflb.ashx
7. National Research Council. (2010). *A framework for science education: Preliminary public draft*.

Sources on Science–Physics Content

8. Hodapp, T., Hein, J., & Hein, W. (2009). Preparing high-school physics teachers. *Physics today*, *February, 2009*, 40–45.
9. The American Association of Physics Teachers. (2009) *The Role, Education, Qualifications, and Professional Development of Secondary School Physics Teachers*. http://www.aapt.org/Resources/upload/Secondary-School-Physics-Teacher-Role_booklet.pdf
10. American Association for the Advancement of Science and the National Science Teachers Association. *Atlas of science literacy*. Volume 1 (2001) and Volume 2 (2007). Washington, DC: American Association for the Advancement of Science.
11. American Association of Physics Teachers. (2006). *Physics first, an informational guide for teachers, school administrators, parents, scientist, and the public.* http://www.aapt.org/aboutaapt/ennouncer/upload/physicsfirst.pdf
12. Tiberghien, A., Jossem, E. L., & Barojas, J. (1998). *Connecting research in physics education with teacher education*. International Commission on Physics Education. http://www.physics.ohio-state.edu/~jossem/ICPE/TOC.html

Sources on Student Learning and Pedagogical Methodology

13. Committee on Science Learning, Kindergarten Through Eighth Grade, National Research Council. (2007). *Taking science to school: Learning and teaching science in grades K–8*. (R. A. Duschl, H. A. Schweingruber, & A. W. Shouse, Eds.). Washington, DC: The National Academies Press.

14. Finkelstein, N., Adams, W., Keller, C., Perkins, K., & Wieman, C. (2006). High-tech tools for teaching physics: The Physics Education Technology Project. *Journal of online teaching and learning.* http://jolt.merlot.org/vol2no3/finkelstein.pdf

15. Committee on High School Science Laboratories: Role and Vision, National Research Council. (2006). *America's lab report: Investigations in high school science*. (S. R. Singer, M. L. Hilton, & H. A. Schweingruber, Eds.). Washington, DC: The National Academies Press.

16. Bransford, J. D., & Donovan, M. S. (2005). Scientific inquiry and how people learn. In M. S. Donovan & J. D. Bransford (Eds.), *How students learn: History, mathematics, and science in the classroom.* Washington, DC: The National Academies Press.

17. Weiss, I. R., Knapp, M. S., Hollweg, K. S., & Burrill, G. (Eds.). (2001). *Investigating the influence of standards: A framework for research in mathematics, science, and technology education*. Washington, DC: The National Academies Press.

18. Redish, E. F., & Steinberg, R. N. (1999). Teaching physics: Figuring out what works. *Physics Today, 52*, 24–30. http://www.physics.umd.edu/perg/qm/qmcourse/NewModel/research/whatwork/index.htm

19. Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher, 30*, 141–58.

20. Arons, A. B. (1990). *A guide to introductory physics teaching*. New York: Wiley.

Indiana Educator Standards for Science–Physics	Indiana Revised Academic Standards for Science	Indiana Core Standards for Science	National Science Education Standards	NCATE/NSTA Standards for Science Teacher Preparation	Common Core State Standards for Literacy: Science and Technical Subjects	ISTE National Educational Technology Standards
Standard 1: The Nature and Processes of Science Physics teachers have a broad and comprehensive understanding of the nature of science and the processes of scientific inquiry.	Gr. 5–8 Process Standards, Physics I, ICP Nature of Science Standard		Gr. 5–8, CS – A; Gr. 5–8, CS – E; Gr. 5–8, CS – G; Gr. 9–12, CS – A; Gr. 9–12, CS – E; Gr. 9–12, CS – G	Teachers of Physics; C.5.a.3, C.5.a.10, C.5.b.21–22; Standard 1 – B.4.33–34; Standard 1 – C.1.2–3; Standard 9 – Safety and Welfare	Reading Gr. 6–8, 1–10; Reading Gr. 9–10, 1–10; Reading Gr. 11–12, 1–10	
Standard 2: Central Concepts and Connections in Science Physics teachers have a comprehensive understanding of the core ideas in other science disciplines and of the relationships between science, engineering, technology, and society.	Gr. 5–8 Process Standards, Physics I Nature of Science Standard, ICP Nature of Science Standard, 5.1, 6.1, 7.1, 8.1, 5.2, 6.2, 7.2, 8.2, 5.3, 6.3, 7.3, 8.3, 5.4, 6.4, 7.4, 8.4	5.1, 6.1, 7.1, 8.1, 5.2, 6.2, 7.2, 8.2, 5.3, 6.3, 7.3, 8.3, 5.4, 6.4, 7.4, 8.4	Gr. 5–8, CS – E; Gr. 5–8, CS – F; Gr. 9–12, CS – E; Gr. 9–12, CS – F	C.5.a.11, C.5.b.19–22; Standard 4 – Issues; Standard 1 – B.4.29, 31		

Indiana Educator Standards for Science–Physics	Indiana Revised Academic Standards for Science	Indiana Core Standards for Science	National Science Education Standards	NCATE/NSTA Standards for Science Teacher Preparation	Common Core State Standards for Literacy: Science and Technical Subjects	ISTE National Educational Technology Standards
Standard 3: Motion and Forces Physics teachers have a broad and comprehensive understanding of motion, forces, and Newton's laws in one and two dimensions.	P.1, 5.1, 6.1, 7.1, ICP.1, ICP.2.1	P.1, 5.1, 7.1	Gr. 5–8, CS – B; Gr. 9–12, CS – B	A.3.17, C.5.a.2, C.5.a.3		
Standard 4: Energy and Momentum Physics teachers have a broad and comprehensive understanding of the conservation of energy and momentum.	P.2.1, 6.1, 7.1, ICP.2.2–2.4	P.2, 6.1, 7.1	Gr. 5–8, CS – B; Gr. 9–12, CS – B	A.3.16, A.3.18, A.3.20, B.2.11, B.2.12, B.2.14, C.5.a.1, C.5.a.4, C.5.b.14		
Standard 5: Thermodynamics and Kinetic Theory Physics teachers have a broad and comprehensive understanding of the laws of thermodynamics and the kinetic theory of matter.	P.3, 6.1, ICP.3, ICP.4.1, ICP.4.2	P.3, 6.1, 7.1	Gr. 5–8, CS – B; Gr. 9–12, CS – B	A.3.20, B.2.12, B.2.13, C5.a.5, C5.a.6, C5.b.12		

Indiana Educator Standards for Science–Physics	Indiana Revised Academic Standards for Science	Indiana Core Standards for Science	National Science Education Standards	NCATE/NSTA Standards for Science Teacher Preparation	Common Core State Standards for Literacy: Science and Technical Subjects	ISTE National Educational Technology Standards
Standard 6: Electricity and Magnetism Physics teachers have a broad and comprehensive understanding of electricity and magnetism.	P.4, P.6.2, P.6.3, 7.1.5, ICP.6	P.4, 6.1, 7.1	Gr. 5–8, CS – B; Gr. 9–12, CS – B	A.3.19, B10, C5.a.4, C5.a.9, C5.b.18		
Standard 7: Vibrations and Waves Physics teachers have a broad and comprehensive understanding of vibrations and waves and the application of wave properties to sound and light.	P.5, P.6.1, P.6.3, 7.1, ICP.4.4, ICP.4.5	P.5, P.6, 6.1, 7.1	Gr. 5–8, CS – B; Gr. 9–12, CS – B	A.3.20, C5.a.8		
Standard 8: Modern Physics Physics teachers have a broad and comprehensive understanding of the fundamental ideas of modern physics.	P.6.3, P.7, 8.1.3, ICP.4.3, ICP.7	P.7, 6.1, 7.1	Gr. 5–8, CS – B; Gr. 9–12, CS – B	A.3.15, B.2.18, C5.a.6, C5.a.7, C5.b.13, C5.b.15, C5.b.16		

Indiana Educator Standards for Science–Physics	Indiana Revised Academic Standards for Science	Indiana Core Standards for Science	National Science Education Standards	NCATE/NSTA Standards for Science Teacher Preparation	Common Core State Standards for Literacy: Science and Technical Subjects	ISTE National Educational Technology Standards
Standard 9: Science Instruction and Assessment Physics teachers have a broad and comprehensive understanding of content-specific instruction and assessment in science.			Teaching Standards A – E, Assessment Standards A – E	Standard 5 – General Skills of Teaching, Standard 6 – Curriculum, Standard 8 – Assessment, Standard 9 – Safety and Welfare	Reading Gr. 6–8, 1–10; Reading Gr. 9–10, 1–10; Reading Gr. 11–12, 1–10; Writing Gr. 6–8, 1–10; Writing Gr. 9–10, 1–10; Writing Gr. 11–12, 1–10	1a–1d, 2a–2d, 3a–3d, 4a–4b