Physics

Institutions and Organizations seeking State Approval for programs which prepare and result in the recommendation of candidates for licensure as Science shall be required to demonstrate that they meet the following program standards. The Standards below are an adapted version of the 2003 standards of the National Science Teachers Association (NSTA), for the preparation of Science Teachers.

Standard 1: *Content Knowledge*

Teachers of science understand and can articulate the knowledge and practices of contemporary science. They can interrelate and interpret important concepts, ideas, and applications in their fields of licensure; and can conduct scientific investigations.

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
To show that they are prepared in content, teachers of chemistry must demonstrate that they: a. Understand and can successfully convey to students the major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields as recommended by the National Science Teachers Association.	**All secondary teachers should also be prepared to lead students to understand the <u>unifying concepts of science</u> including:** • Multiple ways we organize our perceptions of the world and how systems organize the studies and knowledge of science. • Nature of scientific evidence and the use of models for explanation. • Measurement as a way of		

b. Understand and can successfully convey to students the unifying concepts of science delineated by the National Science Education Standards. c. Understand and can successfully convey to students important personal and technological applications of science in their fields of licensure. d. Understand research and can successfully design, conduct, report and evaluate investigations in science. e. Understand and can successfully use mathematics to process and report data, and solve problems, in their field(s) of licensure.	knowing and organizing observations of constancy and change. • Evolution of natural systems and factors that result in evolution or equilibrium. • Interrelationships of form, function, and behaviors in living and nonliving systems. **All teachers of physics should be prepared lead students to understand the unifying concepts required of all teachers of science, and should in addition be prepared to lead students to understand:** • Energy, work, and power. • Motion, major forces, and momentum. • Newtonian principles and laws including engineering applications. • Conservation of mass, momentum, energy, and charge. • Physical properties of matter. • Kinetic-molecular motion and		

	atomic models. • Radioactivity, nuclear reactors, fission, and fusion. • Wave theory, sound, light, the electromagnetic spectrum and optics. • Electricity and magnetism • Fundamental processes of investigating in physics. • Applications of physics in environmental quality and to personal and community health. **In addition to the core competencies, teachers of physics as a primary field should be prepared to effectively lead students to understand:** • Thermodynamics and relationships between energy and matter. • Nuclear physics including matter-energy duality and reactivity. • Angular rotation and momentum, centripetal forces, and vector analysis.		

	• Quantum mechanics, space-time relationships, and special relativity. • Models of nuclear and subatomic structures and behavior. • Light behavior, including wave-particle duality and models. • Electrical phenomena including electric fields, vector analysis, energy, potential, capacitance, and inductance. • Issues related to physics such as disposal of nuclear waste, light pollution, shielding communication systems and weapons development. • Historical development and cosmological perspectives in physics including contributions of significant figures and underrepresented groups, and evolution of theories in physics. • How to design, conduct, and report research in physics. • Applications of physics and engineering in society, business, industry, and health fields.		

	All teachers of physics should be prepared to effectively apply concepts from other sciences and mathematics to the teaching of physics including concepts of: • Biology, including organization of life, bioenergetics, biomechanics, and cycles of matter. • Chemistry, including organization of matter and energy, electrochemistry, thermodynamics, and bonding. • Earth sciences or astronomy related to structure of the universe, energy, and interactions of matter. • Mathematical and statistical concepts and skills including statistics and the use of differential equations and calculus.		

Standard 2: Nature of Science

Teachers of science engage students effectively in studies of the history, philosophy, and practice of science. They enable students to distinguish science from non-science, understand the evolution and practice of science as a human endeavor, and critically analyze assertions made in the name of science.

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
To show they are prepared to teach the nature of science, teachers of science must demonstrate that they: a. Understand the historical and cultural development of science and the evolution of knowledge in their discipline. b. Understand the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world. c. Engage students successfully in studies of the nature of science including, when possible, the critical analysis of false or doubtful	All students of science, whether teacher candidates or not, should have knowledge of the nature of science as defined in this standard, and should have the skills needed to engage students in the critical analysis of scientific and pseudoscientific claims in an appropriate way. This requires explicit attention to the nature of science, as defined in this standard, as a part of the preparation of science teachers. Candidates should: • have multiple opportunities to study and analyze literature related to the history and nature of science, such as The Demon Haunted World (Sagan, 1996); Great Feuds in Science (Hellman, 1998) Facts, Fraud and Fantasy		

assertions made in the name of science.	(Goran, 1979) and The Structure of Scientific Revolutions (Kuhn, 1962). • they should be required to analyze, discuss and debate topics and reports in the media related to the nature of science and scientific knowledge in courses and seminars throughout the program, not just in an educational context. Students should engage in active investigation and analysis of the conventions of science as reflected in papers and reports in science, across fields, in order to understand similarities and differences in methods and interpretations in science, and to identify strengths and weaknesses of findings. • demonstrate that they are effective by successfully engaging students in the study of the nature of science. Assessments with regard to understanding may include such possibilities as completion of independent study courses, seminars or assignments; projects; papers; summative readings; or case study analyses. Assessments		

	of effectiveness must include at least some demonstrably positive student outcomes in studies related to the nature of science as delineated by the standards in this cluster.		

<u>Standard 3: Inquiry</u>
Teachers of science engage students both in studies of various methods of scientific inquiry and in active learning through scientific inquiry. They encourage students, individually and collaboratively, to observe, ask questions, design inquiries, and collect and interpret data in order to develop concepts and relationships from empirical experiences.

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
To show that they are prepared to teach through inquiry, teachers of science must demonstrate that they: a. Understand the processes, tenets, and assumptions of multiple methods of inquiry leading to scientific knowledge. b. Engage students successfully in developmentally appropriate inquiries that	• Candidates in a science teacher preparation program should be provided with multiple opportunities to solve open-ended problems using appropriate scientific methods. These opportunities should be present in their science content courses, but also should be fundamental in their science methods preparation. Many candidates enter teaching because they want to impart knowledge: It is not easy for them to lead students		

require them to develop concepts and relationships from their observations, data, and inferences in a scientific manner.	by listening and questioning, and to allow students to infer proposed solutions to problems. Practice is essential. • The preparation of teachers for the elementary level, especially generalists, should require inquiry-based university science courses. Stalheim-Smith and Scharmann (1996) and Stoddart, Connell, Stofflett and Peck (1993) found that the use of constructivist teaching methodologies and learning cycles, methods that are generally inquiry-based, improved the learning of science by candidates in elementary education. Such courses also may increase the confidence level of generalists, who are often not confident in their ability to do science. • Secondary programs should also strongly emphasize inquiry and pay close attention to preparing teachers to effectively lead students in such activities. All programs should provide explicit instruction in the nature of inquiry as well as its		

	applications. Like the nature of science, inquiry is not learned well simply through practice. In general, the term "scientific method" (for the hypothetico-deductive method) should be avoided, since it may lead students to believe there is only one way to conduct scientific inquiries. Inductive studies have played a valuable role in science, as have mathematical and computer modeling. Hypotheses are not used formally by scientists in all research, nor are experiments per se the substance of all research. Candidates should study cases in which different approaches to inquiry are used in science, and should endeavor to communicate such differences to their students. • The role of the teacher is not just to engage students in inquiry in order to develop their conceptual knowledge and process skills, but also to increase their understanding of how scientific inquiries are conducted, and how decisions are made in science. In this		

	regard, the inquiry standards overlap and support the nature of science standards. • Inquiry demands skill in the analysis of data and assessment of results to reach reasonable and valid conclusions. Candidates must be able to demonstrate not only that they know and understand common and different modes of scientific inquiry, but also that they can and do effectively engage students in inquiries. They should be able to demonstrate their effectiveness through student data profiles or similar means that they are effective in conducting such activities.		

Standard 4: Issues
Teachers of science recognize that informed citizens must be prepared to make decisions and take action on contemporary science- and technology-related issues of interest to the general society. They require students to conduct inquiries into the factual basis of such issues and to assess possible actions and outcomes based upon their goals and values.

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
To show that they are prepared	• Science teacher preparation programs should give explicit		

to engage students in studies of issues related to science, teachers of science must demonstrate that they: a. Understand socially important issues related to science and technology in their field of licensure, as well as processes used to analyze and make decisions on such issues. b. Engage students successfully in the analysis of problems, including considerations of risks, costs, and benefits of alternative solutions; relating these to the knowledge, goals and values of the students.	attention to the study of socially important issues related to science and technology such as species preservation, land use, chemical pollution, weapons development, and cloning, to name but a few. Such issues may be introduced in science courses, but seldom do science courses provide for structured cost-benefit analyses or decision-making on these issues that considers all perspectives. Programs must ensure that candidates are prepared to lead students in learning how to dissect and analyze issues using data and information as resources. • The question of how to consider an issue is just as important as the issues considered. To that end, candidates will themselves need to learn how to explore issues with an open mind. Once this is accomplished, they will need to learn how to lead students to explore these issues with the goal of making an informed and justified decision. • To meet this standard,		

	candidates must demonstrate that they are aware of important issues and are knowledgeable of approaches to analyzing these issues. Candidates should access common sources of information (newspapers, magazines, televised reports) to relate their science instruction to contemporary issues and events. They must then demonstrate through student achievement that they are able to effectively lead them in the study of an important issue.		

Standard 5: General Skills of Teaching

Teachers of science create a community of diverse learners who construct meaning from their science experiences and possess a disposition for further exploration and learning. They use, and can justify, a variety of classroom arrangements, groupings, actions, strategies, and methodologies.

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
To show that they are prepared to create a community of diverse learners, teachers of science must demonstrate that they:	• The standards under the general teaching cluster are largely skills based and must be demonstrated by data from		

a. Vary their teaching actions, strategies, and methods to promote the development of multiple student skills and levels of understanding. b. Successfully promote the learning of science by students with different abilities, needs, interests, and backgrounds. c. Successfully organize and engage students in collaborative learning using different student group learning strategies. d. Successfully use technological tools, including but not limited to computer technology, to access resources, collect and process data, and facilitate the learning of science. e. Understand and build effectively upon the prior beliefs, knowledge, experiences, and interests of students. f. Create and maintain a psychologically and	the classroom. Not all of the standards require demonstrations of student achievement or performance, but where effectiveness must be demonstrated, data from students should be used. • Programs should provide candidates with ample opportunities to work with students using well-defined indicators of effective pedagogy. Candidates must go beyond demonstrating that they can create varied plans for instruction (as in a methods course) and actually implement a unit that has appropriate variety. • Not all schools have diversity in terms of racial or ethnic makeup, but almost all have variations in socio-economic status, gender and learning styles. Candidates should be able to show how they have considered such differences in their planning and teaching. These considerations may be directed at a group or at individuals. For example, demonstrating the ability to make appropriate provisions for a student who does not		

socially safe and supportive learning environment.	speak English well, or who has a defined disability might be acceptable evidence of adapting instruction. • The ability to use structured collaborative learning effectively is an important part of Standard 15. This includes, but goes beyond, setting up effective lab groups. Strategies such as Teams-Games-Tournament (TGT) and Student Teams, Achievement Division (STAD) are examples of alternative ways to organize instruction, where students teach each other (Slavin, 1996). • Technology use is the emphasis of standard 16, as opposed to teaching about technology in contrast with science. The availability of technology in schools may limit the ability of some candidates to demonstrate their performance with students. If a teacher preparation program is situated in an area where computer technology is not common in the schools, it may be necessary to purchase laptops and lab ware for use in		

	the schools. • Pretesting and preconceptions surveys are excellent ways for candidates to determine the prior conceptual knowledge of their students. Candidates should also be able to show how they used prior conceptions and variations in the knowledge of their students to plan instruction in relation to the target concept. • The cooperating teacher, using a rubric designed by the program, may assess classroom atmosphere. The candidate may also collect student feedback using an instrument of his or her own design.		

<u>Standard 6: Curriculum</u>
Teachers of science plan and implement an active, coherent, and effective curriculum that is consistent with the goals and recommendations of the National Science Education Standards. They begin with the end in mind and effectively incorporate contemporary practices and resources into their planning and teaching.

Elements	Indicators	Map to Field Experience / Map to Curriculum and	Assessment Strategies

		Course Experiences	
To show that they are prepared to plan and implement an effective science curriculum, teachers of science must demonstrate that they: a. Understand the curricular recommendations of the National Science Education Standards, and can identify, access, and/or create resources and activities for science education that are consistent with the standards. b. Plan and implement internally consistent units of study that address the diverse goals of the National Science Education Standards and the needs and abilities of students.	• Teacher candidates should engage in planning and implementing lessons and units of instruction early and often, and should be held responsible for demonstrating such planning throughout the program. With little experience in teaching, candidates may find such planning difficult and time-consuming. There is a tendency among novices to fall back upon activities for their own sake, rather than to deliberately plan a lesson or a unit with concern for how it might be made more effective. Practice		

	in implementing units that have been designed to portray the National Science Education Standards and that have been field-tested may offer an opportunity to practice inquiry based teaching in a supportive context with a high probability of success. • Resource units or collections of related materials are one way candidates can be shown to be familiar with a wide variety of materials in relation to a particular topic. Lesson plans and unit plans are generally required in most programs and can be used as data to verify		

	that the program addresses the standards. • Candidates can be asked to formally assess the internal consistency of their plans using program criteria and may create a reflective narrative to explain that assessment. This assessment may then be returned as part of a portfolio or as an independent assessment and may be used by the program to verify candidate skills in relation to standard 20.		

Standards 7: Science in the Community

Teachers of science relate their discipline to their local and regional communities, involving stakeholders and using the individual, institutional, and natural resources of the community in their teaching. They actively engage students in science-related studies or activities related to locally important issues.

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
To show that they are prepared to relate science to the community, teachers of science must demonstrate that they: a. Identify ways to relate science to the community, involve stakeholders, and use community resources to promote the learning of science. b. Involve students successfully in activities that relate science to resources and stakeholders in the community or to the resolution of issues important to the community.	• To meet this standard, candidates must know the community in which they teach. Programs should provide candidates with the background and tools they need to learn about the community. This could include a community survey or visits to a community website that provides demographic and resource information about the community. Candidates should also know how to obtain information from their students that might help them to understand their needs, and might lead to guest speakers from the students' families. • A good resource for finding out about the community is the local newspaper. News media may report on issues relevant to science and technology, which then may be used as the focus of discussion and cost-benefit analysis. It may be desirable for candidates to create and maintain a resource list for topics in their field and arrange to either take		

	students to the field or have guest speakers come in. The Internet can also be a useful tool for finding resources in some communities. • It is not always necessary for candidates to arrange for guest speakers or a field trip in order to make use of community resources. Students, alone or in small study groups, may be asked to investigate questions, collect data, visit sites¸ attend presentations, or interview people after school or on weekends.		

Standards 8: Assessment ***Teachers of science construct and use effective assessment strategies to determine the backgrounds and achievements of learners and facilitate their intellectual, social, and personal development. They assess students fairly and equitably, and require that students engage in ongoing self-assessment.***			
Elements	**Indicators**	**Map to Field Experience / Map to Curriculum and Course Experiences**	**Assessment Strategies**
To show that they are prepared to use assessment effectively, teachers of science must demonstrate that they:	• An important tenet of education is that the mode of assessment often drives methods of instruction rather than the other way around. The very nature of a		

a. Use multiple assessment tools and strategies to achieve important goals for instruction that are aligned with methods of instruction and the needs of students. b. Use the results of multiple assessments to guide and modify instruction, the classroom environment, or the assessment process. c. Use the results of assessments as vehicles for students to analyze their own learning, engaging students in reflective self-analysis of their own work.	performance based teacher preparation program requires candidates to pay far more attention to determining the results of instruction than has been necessary in the past. • Multiple assessment tools should be aligned with the multiple purposes of instruction. Candidates should be called upon to justify their selection of assessment tools in relation to the purposes of the instruction. For example, it is clearly inconsistent to use a multiple-choice quiz to assess the result of an open inquiry. Variety of assessments does not just include different kinds of traditional and nontraditional assessments, but also assessments to measure different dimensions of learning—cognitive, affective and psychomotor knowledge and skills—and dispositions of students. • It would be expected that candidates should show at least some disposition to use assessments to guide and change instruction. These assessments may be formal or informal, formative or		

	summative. A supervisor may note this occurring and assistant the candidate in reflecting upon this change. Alternatively, candidates may use pretests or may collect data formatively to determine whether further instruction on a concept or in a skill is needed. Some teachers have found it effective to asks students at the end of each class period to write something they have learned that day; they have then used the student response to guide their work the next day and clear up misconceptions or misunderstandings. • It is also important that teachers be able to involve students in self-analysis. Too often assessment is something done to students. It takes little effort for candidates to include items that require student reflection on tests, projects, or activities they have completed. Conferencing with students using data from their assessments may also be a way of involving students in self assessment as long as the students themselves are doing		

	the assessing: such conferences would not meet standard 25 if it is just another form of teacher assessment.		

Standard 9: Safety and Welfare

Teachers of science organize safe and effective learning environments that promote the success of students and the welfare of all living things. They require and promote knowledge and respect for safety, and oversee the welfare of all living things used in the classroom or found in the field.

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
To show that they are prepared, teachers of science must demonstrate that they: a. Understand the legal and ethical responsibilities of science teachers for the welfare of their students, the proper treatment of animals, and the maintenance and disposal of materials. b. Know and practice safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials used in science	• Teacher preparation programs must ensure that candidates possess the knowledge needed to maintain a safe environment for all students. This includes knowledge of how to avoid or control hazardous materials or organisms, how to prepare and/or store materials properly, and how to clean up spills and dispose of chemicals safely. • Candidates must know how to check and use safety equipment properly and the hazards of improperly shielded equipment, and must be able to avoid risks from fire hazards		

instruction. c. Know and follow emergency procedures, maintain safety equipment, and ensure safety procedures appropriate for the activities and the abilities of students. d. Treat all living organisms used in the classroom or found in the field in a safe, humane, and ethical manner and respect legal restrictions on their collection, keeping, and use.	and biological contaminants. • It is also important that candidates actually behave in a safe manner, model ethical and safe behavior, and ensure that students behave safely at all times. They must give proper safety instruction and causations, and must label materials and equipment in such a way as to maintain safety. • In addition to safety concerns, candidates who may keep or use animals in the classroom or field should be knowledgeable of their care. They should know and comply with laws and professional standards for classroom treatment of animals and should be aware of regulations controlling the use of sentient, usually vertebrate, animals. They should be able to properly maintain the environment of the animals and dispose of wastes, respond to the illness of the animals and ensure that they have the food, water, space, shelter and care needed for their well-being. • Where candidates may use		

	viruses, microorganisms, or other living things potentially harmful to students, candidates should know how to clean up the classroom and dispose of materials in order to maintain safety for students and anyone who may encounter such materials. Chemical hazards or biohazards must be dealt with according to rules and regulations that apply to all laboratories. • Candidates should know and respect restrictions on collecting and using plants and animals, or parts of plants and animals, from the wild. They should be aware of the potential hazards of common plants as well as animals. • Finally, they should know the common emergency precautions, responses, and reporting procedures that they are to follow in the event problems arise. • Both knowledge and behaviors are essential components in demonstrating that this standard is met. Safety readings, tests, artifacts, projects, classroom safety		

	evaluations, and so forth may be used to demonstrate knowledge and attention to safety matters. Reviews of regulations related to the collection and use of living things and general guidelines for safety and use of living things may also contribute to evidence of preparation. Actual performance in the classroom might be demonstrated by completion of a safety and ethical behaviors rubric or checklist by cooperating teachers.		

Standard 10: Professional Growth

Teachers of science strive continuously to grow and change, personally and professionally, to meet the diverse needs of their students, school, community, and profession. They have a desire and disposition for growth and betterment. To show their disposition for growth, teachers of science must demonstrate that they:

Elements	Indicators	Map to Field Experience / Map to Curriculum and Course Experiences	Assessment Strategies
a. Engage actively and continuously in opportunities for professional learning and	• Programs must help candidates the professional community as science educators. • Science teaching is a		

leadership that reach beyond minimum job requirements. b. Reflect constantly upon their teaching and identify ways and means through which they may grow professionally. c. Use information from students, supervisors, colleagues and others to improve their teaching and facilitate their professional growth. d. Interact effectively with colleagues, parents, and students; mentor new colleagues; and foster positive relationships with the community.	composite profession requiring knowledge and skills in both science and education. Ideally, these skills come together in the preparation program. • Associations and activities related to science teaching are abundant. Participation in such activities at the local, state and national levels should be encouraged, some being required. • They are a resource for improving one's teaching, but also they provide the opportunity for constructive interaction with others in the same field. • Teacher preparation programs should keep records of such activity so that they may then try to increase the activity of their candidates year by year. • The best teachers tend to be goal-focused, but flexible and reflective. These characteristics allow them to relate to students and to modify and improve their practices. • Candidates in teacher preparation programs must demonstrate the ability to		

	reflect, but also to respond positively to constructive feedback from others. Few teacher educators are unfamiliar with candidates who enter their programs with preset ideas that they refuse to change, even when students do not respond well to them. It is imperative that such individuals not be allowed to continue on into teaching. • The ability to get along with others is crucial in education, certainly with students, but also with other stakeholders such as teachers, administrators, support staff and parents. • Dispositional factors can be assessed through the behaviors of candidates; candidates should be held accountable for behaviors that are contrary to the expectations of the profession as determined by the faculty and reflected in these standards. • Carefully constructed criteria are needed and may be used as a source of data for candidate preparation and practice by the program.		