Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
GRADES 9-12
Strand
1. The Nature of Science and Engineering
Substrand
1. The Practice of Science
Standard - Understand that…
1. Science is a way of knowing about the natural world that is characterized by empirical criteria, logical argument and skeptical review.
Benchmarks
9.1.1.1.1 Explain the implications of the assumption that the rules of the universe are the same everywhere and these rules can be discovered by careful and systematic investigation.
SE / TE: 35, 255
9.1.1.1.2 Understand that scientists conduct investigations for a variety of reasons: to discover new aspects of the natural world, to explain recently observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.
SE / TE: 2-3, 5, 8-9
9.1.1.1.3 Explain how the traditions and norms of science define the bounds of professional scientific practice and reveal instances of scientific error or misconduct. For example: The use of peer review, publications and presentations.
SE / TE: 2-3, 9, 487, 496
9.1.1.1.4 Explain how societal and scientific ethics impact research practices. For example: Research involving human subjects may be conducted only with the informed consent of the subjects.
Opportunities to address this standard can be found on the following pages: **SE / TE:** 5, 275, 595, 756, 799, 888
9.1.1.1.5 Identify sources of bias and how bias might influence the direction of research and the interpretation of data. For example: How funding of research can influence questions studied, procedures used, analysis of data, and communication of results.
Opportunities to address this standard can be found on the following pages: **SE / TE:** 9, 151, 236, 764
9.1.1.1.6 Describe how changes in scientific knowledge generally occur in incremental steps that include and build on earlier knowledge.
SE / TE: 3, 9, 29-33, 35, 236, 254-255, 282, 302, 314-316, 319, 470, 533, 897, 906

Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
9.1.1.1.7 Explain how scientific and technological innovations -as well as new evidence- can challenge portions of, or entire accepted theories and models including, but not limited to: cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, and the big bang theory.
SE / TE: 3, 5, 9, 29-33, 35, 236, 253-255, 282, 302, 308, 314-316, 319, 470, 533, 897, 906
Standard - Understand that…
2. Scientific inquiry uses multiple interrelated processes to investigate and explain the natural world.
Benchmarks
9.1.1.2.1 Formulate a testable hypothesis, design and conduct an experiment to test the hypothesis, analyze the data, consider alternative explanations and draw conclusions supported by evidence from the investigation.
SE / TE: 2-4, 8, 12, 28, 46, 68, 75-76, 86, 88, 97, 106, 124, 132, 144, 147, 170, 173, 179, 188, 190, 200, 212, 215, 232, 253, 262, 267, 282, 302, 324, 326, 344, 352, 362, 364, 369, 382, 387, 406, 409, 419, 430, 433, 435-436, 446, 450, 455, 468, 471, 478, 490, 494, 514, 532, 539, 544, 554, 559, 563, 578, 581, 590, 602, 615, 622, 627, 632, 644, 655, 664, 680, 702, 720, 725, 740, 766, 782, 808
9.1.1.2.2 Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.
SE / TE: 24, 204, 358-359, 549, 739
9.1.1.2.3 Identify the critical assumptions and logic used in a line of reasoning to judge the validity of a claim.
SE / TE: 3, 204, 260, 285, 307, 317, 319, 496
9.1.1.2.4 Use primary sources or scientific writings to identify and explain how different types of questions and their associated methodologies are used by scientists for investigations in different disciplines.
SE / TE: 10, 323, 405, 489, 643, 765, 840

SE = Student Edition **TE = Teacher's Edition**

Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
Substrand
2. The Practice of Engineering
Standard - Understand that…
1. Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
Benchmarks
9.1.2.1.1 Understand that engineering designs and products must be continually checked and critiqued for alternatives, risks, costs and benefits, so that subsequent designs are refined and improved. For example: If the price of an essential raw material changes, the product design may need to be changed.
SE / TE: 5, 9, 90, 162-163, 204, 248, 292, 476, 481, 526, 817
9.1.2.1.2 Recognize that risk analysis is used to determine the potential positive and negative consequences of using a new technology or design, including the evaluation of causes and effects of failures. For example: Risks and benefits associated with using lithium batteries.
SE / TE: 756, 801, 815-816, 910
9.1.2.1.3 Explain and give examples of how, in the design of a device or process, engineers consider how it is to be manufactured, operated, maintained, replaced and disposed of.
SE / TE: 5, 90, 292
Standard - Understand that…
2. Engineering design is an analytical and creative process of devising a product or solution to meet a need or solve a specific problem.
Benchmarks
9.1.2.2.1 Identify a problem and the associated constraints on possible design solutions. For example: Constraints can include time, money, scientific knowledge and available technology.
SE / TE: 5, 90, 292
9.1.2.2.2 Develop possible solutions to an engineering problem and evaluate them using conceptual, physical and mathematical models to determine the extent to which the solutions meet the design specifications. For example: Develop a prototype to test the quality, efficiency and productivity of a product.
Opportunities to address this standard can be found on the following pages: **SE / TE:** 90, 352

SE = Student Edition **TE = Teacher's Edition**

Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
Substrand
3. Interactions Among Science, Technology, Engineering, Mathematics, and Society
Standard - Understand that…
1. Natural and designed systems are made up of components that act within a system and interact with other systems.
Benchmarks
9.1.3.1.1 Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs. For example: A power plant or ecosystem.
SE / TE: 156-160, 374, 471, 478-480, 482, 823, 861
9.1.3.1.2 Identify properties of a system that are different from those of its parts but appear because of the interaction of those parts.
Opportunities to address this standard can be found on the following pages: **SE / TE:** 29, 173, 373, 471, 895
9.1.3.1.3 Describe how positive and/or negative feedback occur in systems. For example: The greenhouse effect.
SE / TE: 404, 441-443, 446-447, 900
Standard - Understand that…
2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in scientific inquiry and engineering design.
Benchmarks
9.1.3.2.1 Provide examples of how diverse cultures, including natives from all of the Americas, have contributed scientific and mathematical ideas and technological inventions. For example: Native American understanding of ecology; Lisa Meitner's contribution to understanding radioactivity; Tesla's ideas and inventions relating to electricity; Watson, Crick and Franklin's discovery of the structure of DNA; or how George Washington Carver's ideas changed land use.
SE / TE: 2, 29-30, 32-33, 35, 38, 97, 105, 130, 146, 235-236, 238, 252, 254, 282, 328, 331-332, 349, 390, 392, 469, 476, 492, 502, 519, 533-534, 623, 629, 645, 654, 671, 684, 720, 723, 726, 767, 740-741, 751, 754-755, 767-768, 770-773, 776, 795, 897, 899, 902, 904
9.1.3.2.2 Analyze possible careers in science and engineering in terms of education requirements, working practices and rewards.
SE / TE: 69, 180, 243, 254, 269, 333, 350, 441, 461, 498, 502, 560, 614, 705, 732, 754, 798, 815

Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
Substrand
3. Interactions Among Science, Technology, Engineering, Mathematics, and Society
Standard - Understand that…
3. Science and engineering operate in the context of society and both influence and are influenced by this context.
Benchmarks
9.1.3.3.1 Describe how values and constraints affect science and engineering. For example: Economic, environmental, social, political, ethical, health, safety and sustainability issues.
SE / TE: 5, 163, 204, 225, 236, 248, 275, 816
9.1.3.3.2 Communicate, justify and defend the procedures and results of a scientific inquiry or engineering design project using verbal, graphic, quantitative, virtual or written means.
SE / TE: 12, 28, 46, 55, 68, 75-76, 86, 88, 97, 106, 109, 124, 132, 144, 147, 170, 173, 179, 188, 190, 200, 212, 215, 232, 253, 262, 267, 282, 302, 324, 326, 344, 352, 362, 364, 369, 382, 387, 406, 409, 419, 430, 433, 435-436, 450, 455, 468, 471, 478, 490, 494, 514, 532, 539, 544, 554, 559, 563, 578, 581, 590, 602, 615, 622, 627, 632, 644, 655, 664, 680, 702, 720, 725, 740, 766, 782, 808
9.1.3.3.3 Describe how scientific investigations and engineering processes require multi-disciplinary contributions and efforts. For example: Nanotechnology, climate change, agriculture or biotechnology.
SE / TE: 90, 243, 292, 441-443, 476, 518, 611, 673, 709, 729, 745, 751, 793, 798-799, 817
Standard - Understand that…
4. Science, technology, engineering and mathematics rely on each other to enhance knowledge and understanding.
Benchmarks
9.1.3.4.1 Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics and new technologies.
SE / TE: 5, 9, 308
9.1.3.4.2 Determine and use appropriate safety procedures, tools, computers and measurement instruments in science and engineering contexts. For example: Consideration of chemical and biological hazards in the lab.
SE / TE: 12, 28, 46, 55, 68, 75-76, 86, 88, 97, 106, 109, 124, 132, 144, 147, 170, 173, 179, 188, 190, 200, 212, 215, 232, 253, 262, 267, 282, 302, 324, 326, 344, 352, 362, 364, 369, 382, 387, 406, 409, 419, 430, 433, 435-436, 450, 455, 468, 471, 478, 490, 494, 514, 532, 539, 544, 554, 559, 563, 578, 581, 590, 602, 615, 622, 627, 632, 644, 655, 664, 680, 702, 720, 725, 740, 766, 782, 808

SE = Student Edition **TE = Teacher's Edition**

Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
9.1.3.4.3 Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results.
SE / TE: 44-45, 64, 68, 99, 102, 109, 140, 168, 184, 186, 232, 260, 267, 289, 318, 398, 464, 484, 619-620, 698, 700, 766, 828, 834-842, 881
9.1.3.4.4 Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve data collection and analysis. For example: Use statistical analysis or error analysis to make judgments about the validity of results.
SE / TE: 487, 496
9.1.3.4.5 Demonstrate how unit consistency and dimensional analysis can guide the calculation of quantitative solutions and verification of results.
SE / TE: 38, 412
9.1.3.4.6 Analyze the strengths and limitations of physical, conceptual, mathematical and computer models used by scientists and engineers.
SE / TE: 76, 253, 302, 329-330, 334-335, 339, 443, 585, 645, 767, 769, 772-775, 779, 782, 808
Strand
2. Physical Science
Substrand
1. Matter
Standard - Understand that…
1. The structure of the atom determines chemical properties of elements.
Benchmarks
9.2.1.1.1 Describe the relative charges, masses, and locations of the protons, neutrons, and electrons in an atom of an element.
SE / TE: 331-335, 338, 340-343
9.2.1.1.2 Describe how experimental evidence led Dalton, Rutherford, Thompson, Chadwick and Bohr to develop increasingly accurate models of the atom.
SE / TE: 328, 331-332, 645, 767, 773, 795
9.2.1.1.3 Explain the arrangement of the elements on the Periodic Table, including the relationships among elements in a given column or row.
SE / TE: 335-336, 340-343

SE = Student Edition **TE = Teacher's Edition**

Minnesota Academic Standards – Science
9.2.1.1.4 Explain that isotopes of an element have different numbers of neutrons and that some are unstable and emit particles and/or radiation. For example: Some rock formations and building materials emit radioactive radon gas. Another example: The predictable rate of decay of radioactive isotopes makes it possible to estimate the age of some materials, and makes them useful in some medical procedures.
SE/TE: 333, 342, 788-789, 792, 798, 802-807, 810, 812-814, 816, 818, 824-828
Standard - Understand that…
2. Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.
Benchmarks
9.2.1.2.1 Describe the role of valence electrons in the formation of chemical bonds.
SE/TE: 330, 334, 650, 743
9.2.1.2.2 Explain how the rearrangement of atoms in a chemical reaction illustrates the law of conservation of mass.
Opportunities to address this standard can be found on the following pages: **SE/TE:** 154, 305
9.2.1.2.3 Describe a chemical reaction using words and symbolic equations. For example: The reaction of hydrogen gas with oxygen gas can be written: 2H2 + O2? 2H2O.
Opportunities to address this standard can be found on the following pages: **SE/TE:** 792-793, 795-796, 802, 828
9.2.1.2.4 Relate exothermic and endothermic chemical reactions to temperature and energy changes.
Opportunities to address this standard can be found on the following pages: **SE/TE:** 154, 159-160, 305, 683, 822
Substrand
2. Motion
Standard - Understand that…
2. Forces and object mass determine the motion of an object.
Benchmarks
9.2.2.2.1 Recognize that the inertia of an object causes it to resist changes in motion.
SE/TE: 33-34, 36-41, 43-44

Minnesota Academic Standards – Science
9.2.2.2.2 Explain and calculate the acceleration of an object subjected to a set of forces in one dimension (F=ma).
SE/TE: 87-89, 99, 101-102, 104-105
9.2.2.2.3 Demonstrate that whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted by the second object back on the first object.
SE/TE: 106-114, 116-122, 131, 853-854
9.2.2.2.4 Use the law of gravitation to describe and calculate the attraction between massive objects based on the distance between them. For example: Calculate the weight of a person on different planets in the solar system.
SE/TE: 237-241, 255-261, 867-868
Substrand
3. Energy
Standard - Understand that…
2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.
Benchmarks
9.2.3.2.1 Identify the energy forms and explain the transfers of energy involved in the operation of common devices. For example: Light bulbs, electric motors, automobiles or bicycles.
SE/TE: 144, 147-154, 158-169, 652, 693-694, 743-746, 749, 758, 761
9.2.3.2.2 Calculate and explain the energy, work and power involved in energy transfers in a mechanical system. For example: Compare walking and running up or down steps.
SE/TE: 145-152, 155-160, 164-169
9.2.3.2.3 Describe how energy is transferred through sound waves and how pitch and loudness are related to wave properties of amplitude and wavelength.
SE/TE: 361, 503, 514-515, 520, 528
9.2.3.2.4 Explain and calculate current, voltage and resistance, and describe energy transfers in simple electric circuits.
SE/TE: 680-685, 695-701, 704-707, 709-719
9.2.3.2.5 Describe how an electric current produces a magnetic force, and how this interaction is used in motors and electromagnets to produce mechanical energy.
SE/TE: 726-732, 734-739, 746, 758, 761

Minnesota Academic Standards – Science
9.2.3.2.6 Use the idea that small amounts of matter are transformed into large amounts of energy in nuclear reactions to compare fission and fusion in terms of beginning and end products and the amount of energy released. For example: The fusion of hydrogen produces energy in the sun. Another example: The use of chain reactions in nuclear reactors.
SE / TE: 808, 821, 823, 825, 827-828, 889-890
9.2.3.2.7 Describe the properties and uses of forms of electromagnetic radiation from radio frequencies through gamma radiation. For example: Compare the energy of microwaves and X-rays.
SE / TE: 436-440, 445-446, 536, 547, 549, 756, 785-807
Substrand
4. Human Interaction with Physical Systems
Standard - Understand that…
1. There are benefits, costs and risks to different means of generating and using energy.
Benchmarks
9.2.4.1.1 Compare local and global environmental and economic advantages and disadvantages of generating electricity using various sources or energy. For example: Fossil fuels, nuclear fission, wind, sun or tidal energy.
SE / TE: 161-164, 166, 169, 813-816
9.2.4.1.2 Describe the trade-offs involved when technological developments impact the way we use energy, natural resources, or synthetic materials. For example: Fluorescent light bulbs use less energy, but contain toxic mercury
SE / TE: 816, 829

Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
PHYSICS
Strand
1. The Nature of Science and Engineering
Substrand
3. Interactions Among Science, Technology, Engineering, Mathematics, and Society
Standard - Understand that…
3. Developments in physics affect society and societal concerns affect the field of physics.
Benchmarks
9P.1.3.3.1 Describe changes in society that have resulted from significant discoveries and advances in technology in physics. For example: Transistors, generators, radio/television, or microwave ovens.
SE/TE: 651-652, 657, 720, 730-731, 743-746, 749-751
Standard - Understand that…
4. Physical and mathematical models are used to describe physical systems.
9P.1.3.4.1 Use significant figures and an understanding of accuracy and precision in scientific measurements to determine and express the uncertainty of a result.
SE/TE: 54, 797, 834, 879
Strand
2. Physical Science
Substrand
2. Motion
Standard - Understand that…
1. Forces and inertia determine the motion of objects.
Benchmarks
9P.2.2.1.1 Use vectors and free-body diagrams to describe force, position, velocity and acceleration of objects in two-dimensional space.
SE/TE: 90-91, 98

Prentice Hall Conceptual Physics © 2009
Correlated to:
Minnesota Academic Standards – Science
(Grades 9-12)

Minnesota Academic Standards – Science
9P.2.2.1.2 Apply Newton's three laws of motion to calculate and analyze the effect of forces and momentum on motion.
SE/TE: 33-34, 40-45, 88-89, 93, 95, 97-105, 108-123, 125-143
9P.2.2.1.3 Use gravitational force to explain the motion of objects near Earth and in the universe.
SE/TE: 14, 36-37, 43, 232-261, 263, 265-281
Standard - Understand that…
2. When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.
Benchmarks
9P.2.2.2.1 Explain and calculate the work, power, potential energy and kinetic energy involved in objects moving under the influence of gravity and other mechanical forces.
SE/TE: 145-152, 164-169, 207, 281, 379
9P.2.2.2.2 Describe and calculate the change in velocity for objects when forces are applied perpendicular to the direction of motion. For example: Objects in orbit
SE/TE: 175, 234-236, 256, 266, 302
9P.2.2.2.3 Use conservation of momentum and energy to analyze the elastic collision of two solid objects in one-dimensional motion.
SE/TE: 132-134, 137, 139
Substrand
3. Energy
Standard - Understand that…
1. Sound waves are generated from mechanical oscillations of objects and travel through a medium.
Benchmarks
9P.2.3.1.1 Analyze the frequency, period and amplitude of an oscillatory system. For example: An ideal pendulum, a vibrating string, or a vibrating spring-and-mass system.
SE/TE: 491-493, 507-508, 510
9P.2.3.1.2 Describe how vibration of physical objects sets up transverse and longitudinal waves in gases, liquids and solid materials.
SE/TE: 497, 507-508

Minnesota Academic Standards – Science
9P.2.3.1.3 Explain how wave properties, such as interference, resonance, refraction and reflection, affect sound waves.
SE / TE: 521-523, 527-531, 583-584, 586
9P.2.3.1.4 Describe the Doppler effect changes that occur in an observed sound as a result of the motion of a source of the sound relative to a receiver.
SE / TE: 501-503, 508, 511
Standard - Understand that…
2. Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.
Benchmarks
9P.2.3.2.1 Explain why currents flow when free charges are placed in an electrical field, and how that forms the basis for electrical circuits.
SE / TE: 726-729, 734-735
9P.2.3.2.2 Explain and calculate the relationship of current, voltage, resistance and power in series and parallel circuits. For example: Determine the voltage between two points in a series circuit with two resistors.
SE / TE: 705-707, 710-719, 886
9P.2.3.2.3 Describe how moving electric charges produce magnetic forces and moving magnets produce electric forces.
SE / TE: 726-729, 734-739
9P.2.3.2.4 Use the interplay of electric and magnetic forces to explain how motors, generators, and transformers work.
SE / TE: 730-731, 734, 736, 738, 743-749, 758, 761-762
Standard - Understand that…
3. Magnetic and electric fields interact to produce electromagnetic waves.
Benchmarks
9P.2.3.3.1 Describe the nature of the magnetic and electrical fields in a propagating electromagnetic wave.
SE / TE: 753-755, 757, 759

Minnesota Academic Standards – Science
9P.2.3.3.2 Quantitatively relate the speed of light in a medium to its frequency and wave-length in that medium, and in free space.
SE / TE: 495, 513, 534-536, 549, 551, 601, 878, 880
9P.2.3.3.3 Use Snell's Law to explain the refraction and total internal reflection of light in transparent media, such as lenses and fiber optics.
SE / TE: 881, 904
9P.2.3.3.4 Use properties of light, including reflection, refraction, interference, Doppler effect and the photoelectric effect, to explain phenomena and describe applications.
SE / TE: 502-503, 578-601, 610-612, 628-641
9P.2.3.3.5 Compare the wave model and particle model in explaining properties of light.
SE / TE: 533, 547-548, 622, 766, 767-771, 778-781
9P.2.3.3.6 Compare the wavelength, frequency and energy of different kinds of waves in the electromagnetic spectrum and describe their applications.
SE / TE: 536, 548, 552, 555-556, 590
Standard - Understand that…
4. Heat is energy transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.
Benchmarks
9P.2.3.4.1 Describe and calculate the quantity of heat transferred between solids and/or liquids, using specific heat, density and temperatures.
SE / TE: 411-414, 423-426, 876
9P.2.3.4.2 Explain the role of gravity, pressure and density in the convection of heat by a fluid.
SE / TE: 433-436, 444-445, 541, 733
9P.2.3.4.3 Compare the rate at which objects at different temperatures will transfer thermal energy by electromagnetic radiation.
SE / TE: 436-438, 444-446
http://education.state.mn.us/mdeprod/groups/Standards/documents/Publication/013906.pdf