# Active Physics 3rd Ed. Correlation to the Minnesota Academic Standards, Grades 9-12

## The Nature of Science and Engineering

| Standard/Benchmark | Location/Page where Standard is found |
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| **1. The Practice of Science** | |
| **1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.** | |
| 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 | Throughout, for example: p. 831-834 |
| 9.1.1.1.2 Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories. | Throughout, for example: p. 820-823 |
| 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. | Throughout, for example: p. 795-800, 807. |
| 9.1.1.1.4 Explain how societal and scientific ethics impact research practices. | Throughout, for example: p. 795-800, 807. |
| 9.1.1.1.5 Identify sources of bias and explain how bias might influence the direction of research and the interpretation of data. | p. 22-33 |
| 9.1.1.1.6 Describe how changes in scientific knowledge generally occur in incremental steps that include and build on earlier knowledge. | p. 134-135, 795-797, 810, 820-823, 831-834, 848-849, 857-858, |

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| 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. | p. 134-135, 795-797, 810, 820-823, 831-834, 848-849, 857-858, |
| **2. Scientific inquiry uses multiple interrelated processes to investigate and explain the natural world.** | |
| 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. | Throughout, especially "What do you think?" For example, p. 8, 16, 22, 30 |
| 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 | Throughout, for example: p. 174-176 |
| 9.1.1.2.3 Identify the critical assumptions and logic used in a line of reasoning to judge the validity of a claim. | Throughout, for example, p. 134-138 |
| 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. | n/a |
| **2. The Practice of Engineering** | |
| **1. Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.** | |
| 9.1.2.1.1 Understand that engineering designs and products are often continually checked and critiqued for alternatives, risks, costs and benefits, so that subsequent designs are refined and improved. | Throughout, in Chapter Mini-Challenge, and Chapter Challenge. Examples: p 75-76, 120-121, 196-197, 248-249 |
| 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. | Chapter challenge, for example: p. 255-256, 302-303, 336-337 |
| 9.1.2.1.3 Explain and give examples of how, in the design of a device, engineers consider how it is to be manufactured, operated, maintained, replaced and disposed of | Chapter challenge, for example: p. 255-256, 302-303, 336-337 |

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| **2. Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.** | |
| 9.1.2.2.1 Identify a problem and the associated constraints on possible design solutions. | Chapter challenge, for example: p. 255-256, 302-303, 336-337 |
| 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. | Chapter challenge, for example: p. 255-256, 302-303, 336-337 |
| **3. Interactions Among Science, Technology, Engineering, Mathematics, and Society** | |
| **1. Natural and designed systems are made up of components that act within a system and interact with other systems.** | |
| 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. | Throughout, for example: p. 220-233, 234-245. |
| 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. | Throughout, for example: p. 220-233, 234-245. |
| 9.1.3.1.3 Describe how positive and/or negative feedback occur in systems. | p. 633-638, 644, 656 |
| **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.** | |
| 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. | "Physics at Work," p. 123, 251, 339, 475, 589, 705, 783, 897, 993 |
| 9.1.3.2.2 Analyze possible careers in science and engineering in terms of education requirements, working practices and rewards. | "Physics at Work," p. 123, 251, 339, 475, 589, 705, 783, 897, 993 |
| **3. Science and engineering operate in the context of society and both influence and are influenced by this context.** | |

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| 9.1.3.3.1 Describe how values and constraints affect science and engineering. | Throughout, for example: p. 220-233, 234-245. |
| 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. | Throughout, for example: p. 220-233, 234-245. |
| 9.1.3.3.3 Describe how scientific investigations and engineering processes require multi-disciplinary contributions and efforts. | Throughout, for example: p. 220-233, 234-245. |
| **4. Science, technology, engineering and mathematics rely on each other to enhance knowledge and understanding.** | |
| 9.1.3.4.1 Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics and new technologies. | p. 134-135, 795-797, 810, 820-823, 831-834, 848-849, 857-858, |
| 9.1.3.4.2 Determine and use appropriate safety procedures, tools, computers and measurement instruments in science and engineering contexts. | Throughout, for example: p. 22-33 |
| 9.1.3.4.3 Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results. | Throughout, for example: p. 75-89 |
| 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. | Throughout, for example: p. 22-33 |
| 9.1.3.4.5 Demonstrate how unit consistency and dimensional analysis can guide the calculation of quantitative solutions and verification of results. | p. 283-284, 285-286, 626, 634, 740 |
| 9.1.3.4.6 Analyze the strengths and limitations of physical, conceptual, mathematical and computer models used by scientists and engineers. | **Throughout, for example, p. 846-849, 866-867, 184-189, 98-101** |

## Physics

| **Standard/Benchmark** | **Location/Page where Standard is found** |
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| **1. The Nature of Science and Engineering** | |
| **3. Interactions Among Science, Technology, Engineering, Mathematics, and Society** | |
| **3. Developments in physics affect society and societal concerns affect the field of physics.** | |
| 9P.1.3.3.1 Describe changes in society that have resulted from significant discoveries and advances in technology in physics.<br>*For example:* Transistors, generators, radio/television, or microwave ovens. | Throughout, especially Chapter 6, p. 593-708 |
| **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. | p. 164-165, 246 |
| **2. Physical Science** | |
| **2. Motion** | |
| **1. Forces and inertia determine the motion of objects.** | |
| 9P.2.2.1.1 Use vectors and free-body diagrams to describe force, position, velocity and acceleration of objects in two-dimensional space. | p. 167, 200-206, 408-409 |
| 9P.2.2.1.2 Apply Newton's three laws of motion to calculate and analyze the effect of forces and momentum on motion. | p. 132-144, 157-173, 198-209, 266-276, 292-301 |
| 9P.2.2.1.3 Use gravitational force to explain the motion of objects near Earth and in the universe. | p. 382-391 |
| **2. When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constan** | |
| 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. | **Various, including Sections 2.8-2.9, p. 220-245. Also, Sections 3.3, 4.2, 4.3, 4.8, 4.9, 6.8, 6.9, 8.8, 9.5** |

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| 9P.2.2.2.2 Describe and calculate the change in velocity for objects when forces are applied perpendicular to the direction of motion. | p. 190-192, 215-216 |
| 9P.2.2.2.3 Use conservation of momentum and conservation of energy to analyze an elastic collision of two solid objects in one-dimensional motion. | p. 277-291, p. 304-333. |
| **3. Energy** | |
| **1. Sound waves are generated from mechanical oscillations of objects and travel through a medium.** | |
| 9P.2.3.1.1 Analyze the frequency, period and amplitude of an oscillatory system. | p. 492-507 |
| 9P.2.3.1.2 Describe how vibration of physical objects sets up transverse and/or longitudinal waves in gases, liquids and solid materials. | p. 421, 493-497, 500, 543, 584, 770-773 |
| 9P.2.3.1.3 Explain how interference, resonance, refraction and reflection affect sound waves. | p. 840-843, 847, 484-487, 518-523 |
| 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. | p. 44-45, 118, 122 |
| **2. Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.** | |
| 9P.2.3.2.1 Explain why currents flow when free charges are placed in an electric field, and how that forms the basis for electric circuits. | p. 767-769 |
| 9P.2.3.2.2 Explain and calculate the relationship of current, voltage, resistance and power in series and parallel circuits. | p. 598-661 |
| 9P.2.3.2.3 Describe how moving electric charges produce magnetic forces and moving magnets produce electric forces. | p. 714-733 |

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| 9P.2.3.2.4 Use the interplay of electric and magnetic forces to explain how motors, generators, and transformers work. | p. 734-755 and Chapter 7 Challenge p. 710-711, 744-745, 780-781 |
| **3. Magnetic and electric fields interact to produce electromagnetic waves.** | |
| 9P.2.3.3.1 Describe the nature of the magnetic and electric fields in a propagating electromagnetic wave. | p. 765-777 |
| 9P.2.3.3.2 Explain and calculate how the speed of light and its wavelength change when the medium changes. | p. 561-563 |
| 9P.2.3.3.3 Explain the refraction and/or total internal reflection of light in transparent media, such as lenses and optical fibers. | p. 558-576 |
| 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. | p. 530-583 and Chapter 5 Challenge, p. 480-481, 586-587 |
| 9P.2.3.3.5 Compare the wave model and particle model in explaining properties of light | p. 840-852 |
| 9P.2.3.3.6 Compare the wavelength, frequency and energy of waves in different regions of the electromagnetic spectrum and describe their applications. | p. 765-777 |
| **4. Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.** | |
| 9P.2.3.4.1 Describe and calculate the quantity of heat transferred between solids and/or liquids, using specific heat, mass and change in temperature. | p. 664-699 |
| 9P.2.3.4.2 Explain the role of gravity, pressure and density in the convection of heat by a fluid. | p. 694-695 |

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| 9P.2.3.4.3 Compare the rate at which objects at different temperatures will transfer thermal energy by electromagnetic radiation. | p. 695 |