

**COLORADO**  
**Science Content Standards Grades 9-12**  
***Physics: Principles and Problems* © 2005**

STANDARDS	PAGE REFERENCES
<b>STANDARD 1:</b> <b>Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.</b> As students in grades 9-12 extend their knowledge, what they know and are able to do includes	
<ul style="list-style-type: none"> <li>asking questions and stating hypotheses, using prior scientific knowledge to help guide their development;</li> </ul>	SE: 8-10, 753 <i>Launch Lab</i> 31, 57, 313 <i>Physics Lab</i> 76-77, 218-219, 420-421, 532-533, 632-633, 714-715
<ul style="list-style-type: none"> <li>creating and defending a written plan of action for a scientific investigation;</li> </ul>	SE: 8-10, 15-17 <i>Physics Lab</i> 20-21, 160-161, 392-393, 532-533, 554-555, 660-661, 824-825
<ul style="list-style-type: none"> <li>selecting and using appropriate technologies to gather, process, and analyze data and to report information related to an investigation;</li> </ul>	SE: <i>Future Technology</i> 22 <i>How It Works</i> 740 <i>Physics Lab</i> 20-21, 48-49, 76-77, 246-247, 420-421, 790-791, 824-825
<ul style="list-style-type: none"> <li>identifying major sources of error or uncertainty within an investigation (<i>for example, particular measuring devices and experimental procedures</i>);</li> </ul>	SE: 11-13 <i>Physics Lab</i> 392-393, 420-421, 474-475, 532-533, 606-607, 737, 766-767
<ul style="list-style-type: none"> <li>constructing and revising scientific explanations and models, using evidence, logic, and experiments that include identifying and controlling variables;</li> </ul>	SE: 9-10, 175-178, 293-295, 748-759, 816-823 <i>MiniLab</i> 702, 813 <i>Physics Lab</i> 136-137, 332-333, 532-533
<ul style="list-style-type: none"> <li>communicating and evaluating scientific thinking that leads to particular conclusions;</li> </ul>	SE: 9-10, 323-325, 573-574, 648-651, 748-756, 760-761 <i>Problem-Solving Strategies</i> 123, 466, 728
<ul style="list-style-type: none"> <li>recognizing and analyzing alternative explanations and models; and</li> </ul>	SE: 153-156, 176, 184-185, 432, 486-488, 735, 737, 748-749, 760-761 TWE: CB 801
<ul style="list-style-type: none"> <li>explaining the difference between a scientific theory and a scientific hypothesis.</li> </ul>	SE: 8-10, 177-178, 352, 486-487, 748-749, 754-756, 776-777, 818-820 <i>Physics Lab</i> 532-533, 790-791
For students continuing their science education beyond the standards, what they know and are able to do <b>may</b> include	
<ul style="list-style-type: none"> <li>designing and completing an advanced scientific investigation—either individually or as part of a student team—that extends over several days or weeks; and</li> </ul>	SE: <i>Technology and Society</i> 220 TWE: A 450 C 357, 502, 574 PP 414, 549, 603, 729, 782
<ul style="list-style-type: none"> <li>continuing to practice and apply inquiry skills as they extend their understanding of science content through further study.</li> </ul>	SE: 74-75, 132, 157, 244-245, 363, 501, 552, 656, 709, 821

STANDARDS	PAGE REFERENCES
<b>STANDARD 2:</b> <b>Physical Science: Students know and understand common properties, forms, and changes in matter and energy. (Focus: Physics and Chemistry)</b>	
<b>2.1 Students know that matter has characteristic properties, which are related to its composition and structure.</b> <b>As students in grades 9-12 extend their knowledge, what they know and are able to do includes</b>	
<ul style="list-style-type: none"> <li>examining, describing, measuring, classifying, and predicting common properties of substances (<i>for example, electrical charge, chemical reactivity, acidity, electrical conductivity, radioactivity, relationships in the periodic table</i>);</li> </ul>	SE: 317-321, 323-325, 360-363, 802-804, 809-810 <i>Launch Lab</i> 341 <i>Physics Lab</i> 332-333, 364-365 TWE: PP 350
<ul style="list-style-type: none"> <li>describing and explaining properties and composition of samples of matter using models (<i>for example, atomic and molecular structure, the periodic table</i>);</li> </ul>	SE: 314-315, 349-350, 360-363, 404-405, 754-756 <i>MiniLab</i> 389 TWE: CB 321 IM 361
<ul style="list-style-type: none"> <li>separating substances based on their chemical and physical properties (<i>for example, color, solubility, chemical reactivity, melting point, boiling point</i>); and</li> </ul>	SE: 815-816 TWE: PP 782
<ul style="list-style-type: none"> <li>using word and chemical equations to relate observed changes in matter to its composition and structure.</li> </ul>	SE: 811-812, 814, 821
<b>2.2 Students know that energy appears in different forms, and can move (be transferred) and change (be transformed).</b> <b>As students in grades 9-12 extend their knowledge, what they know and are able to do includes</b>	
<ul style="list-style-type: none"> <li>identifying, measuring, calculating, and analyzing quantitative relationships involved with energy forms (<i>for example, heat transfer in a system involving mass, specific heat, and change in temperature of matter</i>); and</li> </ul>	SE: 317-321, 324-325, 344-345, 376-380, 754-756, 802-805 <i>Physics Lab</i> 332-333
<ul style="list-style-type: none"> <li>identifying, measuring, calculating, and analyzing qualitative and quantitative relationships associated with energy transfer or energy transformation (<i>for example, changes in temperature, velocity, potential energy, kinetic energy, conduction, convection, radiation, voltage, current</i>).</li> </ul>	SE: 258-259, 286-292, 314-318, 323-324, 593-599, 672-678, 709-712, 776-777 <i>Physics Lab</i> 332-333, 580-581
<b>2.3 Students understand that interactions can produce changes in a system, although the total quantities of matter and energy remain unchanged.</b> <b>As students in grades 9-12 extend their knowledge, what they know and are able to do includes</b>	
<ul style="list-style-type: none"> <li>identifying, describing, and explaining physical and chemical changes involving the conservation of matter and energy (<i>for example, oscillating pendulum/spring, chemical reactions, nuclear reactions</i>);</li> </ul>	SE: 293-295, 807-809, 811-812 <i>Launch Lab</i> 285 <i>Physics Lab</i> 302-303 TWE: CB 287, 298

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<ul style="list-style-type: none"> <li>observing, measuring, and calculating quantities to demonstrate conservation of matter and energy in chemical changes (<i>for example, acid-base, precipitation, oxidation-reduction reactions</i>), and physical interactions of matter (<i>for example, force, work, power</i>);</li> </ul>	SE: 258-259, 293-294 <i>Launch Lab</i> 285 <i>Physics Lab</i> 302-303 <i>Problem-Solving Strategies</i> 295 TWE: CB 298
<ul style="list-style-type: none"> <li>describing and predicting chemical changes (<i>for example, combustion, simple chemical reactions</i>), and physical interactions of matter (<i>for example, velocity, force, work, power</i>), using word or symbolic equations; and</li> </ul>	SE: 286-289, 293-294, 297-298, 319-321, 326, 569-570 <i>Problem-Solving Strategies</i> 295
<ul style="list-style-type: none"> <li>describing and explaining physical interactions of matter using conceptual models (<i>for example, conservation laws of matter and energy, particle model for gaseous behavior</i>).</li> </ul>	SE: 172-177, 182-185, 293-295, 342 <i>Extreme Physics</i> 78 <i>Launch Lab</i> 171 <i>Physics Lab</i> 186-187
For students continuing their science education beyond the standards, what they know and are able to do <b>may</b> include	
<ul style="list-style-type: none"> <li>relating their prior knowledge and understanding of properties of matter to observable characteristics of materials and emerging technologies (<i>for example, semiconductors, superconductors, photovoltaics, ceramics</i>);</li> </ul>	SE: 347-348, 350, 359-363, 777-781, 809-811 <i>Extreme Physics</i> 366 <i>Technology and Society</i> 394, 608 TWE: RLC 345
<ul style="list-style-type: none"> <li>modeling quantitative aspects of chemical and physical interactions (<i>for example, rates of reactions, stoichiometry, electromagnetic phenomena, statics and dynamics, electrochemistry</i>);</li> </ul>	SE: 352-355, 360-363, 376-379, 407-409, 549-552, 564-568 <i>Physics Lab</i> 364-365, 790-791, 824-825
<ul style="list-style-type: none"> <li>applying knowledge and understanding of chemical and physical interactions to explore factors that influence or govern change (<i>for example, equilibrium constants, kinetics, thermodynamics</i>); and</li> </ul>	SE: 352, 357-358, 360-363, 382-384, 546-550, 569-571, 760-765 <i>Physics Lab</i> 392-393, 606-607
<ul style="list-style-type: none"> <li>distinguishing among different types of constancy (<i>for example, static and dynamic equilibrium, symmetry, uniform/accelerated motion</i>) and different types of change (<i>for example, qualitative and quantitative trends, cyclic change, chaotic systems</i>).</li> </ul>	SE: 66-68, 211-215, 258-260, 286-290, 317-318, 323-329, 360-363 <i>Physics Lab</i> 218-219, 392-393 <i>Technology and Society</i> 220
<b>STANDARD 5:</b> <b>Students know and understand interrelationships among science, technology, and human activity and how they can affect the world.</b> As students in grades 9-12 extend their knowledge, what they know and are able to do includes	
<ul style="list-style-type: none"> <li>analyzing benefits, limitations, costs, and consequences involved in using technology or resources (<i>for example, X-rays, agricultural chemicals, natural gas reserves</i>);</li> </ul>	SE: 331, 775 <i>Technology and Society</i> 220, 394, 608, 716 TWE: CD 327 EX 814 RLP 779

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<ul style="list-style-type: none"> <li>analyzing how the introduction of a new technology has affected or could affect human activity (<i>for example, invention of the telescope, applications of modern telecommunications</i>);</li> </ul>	SE: <i>Extreme Physics</i> 792 <i>Future Technology</i> 22, 162, 826 <i>How It Works</i> 582, 688, 740 <i>Technology and Society</i> 394, 608, 716
<ul style="list-style-type: none"> <li>demonstrating the interrelationships between science and technology (<i>for example, building a bridge, designing a better running shoe</i>); and</li> </ul>	SE: <i>Extreme Physics</i> 792 <i>Technology and Society</i> 220, 304, 450, 608 TWE: CB 158 PP 232 RLC 289, 319 RLP 238
<ul style="list-style-type: none"> <li>explaining the use of technology in an occupation.</li> </ul>	SE: 3 TWE: RLC 180, 214, 289, 319, 345, 360
For students continuing their science education beyond the standards, what they know and are able to do <b>may</b> include	
<ul style="list-style-type: none"> <li>applying their knowledge and understanding of chemical and physical interactions to explain present and anticipated technologies (<i>for example, lasers, ultrasound, superconducting materials, photocopy machines</i>); and</li> </ul>	SE: <i>Extreme Physics</i> 662, 792 <i>Future Technology</i> 22, 476, 556, 768, 826 <i>How It Works</i> 688, 740 <i>Technology and Society</i> 394, 608
<ul style="list-style-type: none"> <li>exploring the scientific and technological aspects of contemporary problems (<i>for example, issues related to nutrition, air quality, natural resources</i>).</li> </ul>	SE: 552-553, 812-813 <i>Future Technology</i> 826 <i>Physics Lab</i> 714-715 <i>Technology and Society</i> 220, 394, 608
<b>STANDARD 6:</b> <b>Students understand that science involves a particular way of knowing and understand common connections among scientific disciplines.</b> As students in grades 9-12 extend their knowledge, what they know and are able to do includes	
<ul style="list-style-type: none"> <li>evaluating print and visual media for scientific evidence, bias, or opinion;</li> </ul>	SE: 9-10 TWE: PP 16
<ul style="list-style-type: none"> <li>explaining that the scientific way of knowing uses a critique and consensus process (<i>for example, peer review, openness to criticism, logical arguments, skepticism</i>);</li> </ul>	SE: 11, 437-438, 726-729, 760-761 <i>Extreme Physics</i> 506 TWE: CB 177, 184
<ul style="list-style-type: none"> <li>using graphs, equations, or other models to analyze systems involving change and constancy (<i>for example, comparing the geologic time scale to shorter time frames</i>);</li> </ul>	SE: 43-47, 58-66, 147-151, 179-185, 241-242, 344-346, 756, 811-813 <i>MiniLab</i> 8 <i>Physics Lab</i> 108-109
<ul style="list-style-type: none"> <li>analyzing and comparing models of cyclic change as used within and among scientific disciplines (<i>for example, water cycle, circular motion, sound waves, weather cycles</i>);</li> </ul>	SE: 154-155, 179-185, 378-380, 382-385, 415-419, 439 <i>Helping Struggling Students</i> 754 <i>Physics Lab</i> 392-393 TWE: CB 757
<ul style="list-style-type: none"> <li>identifying and predicting cause-effect relationships within a system (<i>for example, the effect of temperature on gas volume, effect of carbon dioxide level on the greenhouse effect, effects of changing nutrients at the base of a food pyramid</i>);</li> </ul>	SE: 344-346, 404-406, 648-649, 756 <i>Extreme Physics</i> 506 <i>Physics Lab</i> 606-607 <i>Technology and Society</i> 220 TWE: EX 358

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<ul style="list-style-type: none"> <li>identifying and describing the dynamics of natural systems (<i>for example, weather systems, ecological systems, body systems, systems at dynamic equilibrium</i>);</li> </ul>	SE: 172-173, 175-176 <i>Applying Physics</i> 725 <i>Extreme Physics</i> 188, 422, 506 <i>Launch Lab</i> 171 <i>Meteorology Connection</i> 217 <i>Physics Lab</i> 186-187
<ul style="list-style-type: none"> <li>identifying and testing a model to analyze systems involving change and constancy (<i>for example, a mathematical expression for gas behavior; constructing a closed ecosystem such as an aquarium</i>);</li> </ul>	SE: 9, 33, 439, 723, 748-756, 818-820 <i>Launch Lab</i> 171, 431 <i>Physics Lab</i> 186-187, 738-739
<ul style="list-style-type: none"> <li>explaining an exponential model (<i>for example, pH scale, population growth, Richter scale</i>); and</li> </ul>	SE: 18, 810
<ul style="list-style-type: none"> <li>refining a hypothesis based on an accumulation of data over time (<i>for example, Alvarez's theory on dinosaur extinction</i>).</li> </ul>	SE: 172-176, 179-185 <i>Physics Lab</i> 186-187
For students continuing their science education beyond the standards, what they know and are able to <b>may</b> include	
<ul style="list-style-type: none"> <li>relating small-scale phenomena to large-scale properties (<i>for example, intermolecular forces related to physical properties</i>); and</li> </ul>	SE: 314-315, 328-329, 350, 359-360, 439, 726-731, 761-765, 779-781 TWE: CB 291
<ul style="list-style-type: none"> <li>tracing the development of an invention, theory, or discovery to demonstrate the dynamic nature of science.</li> </ul>	SE: 723-731, 747-759, 761-765, 776-789, 802-813 <i>Extreme Physics</i> 50, 662 <i>Future Technology</i> 22 <i>Technology and Society</i> 394, 450

### Codes Used for TWE pages

A	Activity
C	Challenge
CB	Content Background
CD	Concept Development
EX	Extension
IM	Identifying Misconceptions
PP	Physics Project
RLC	Real-Life Careers
RLP	Real-Life Physics