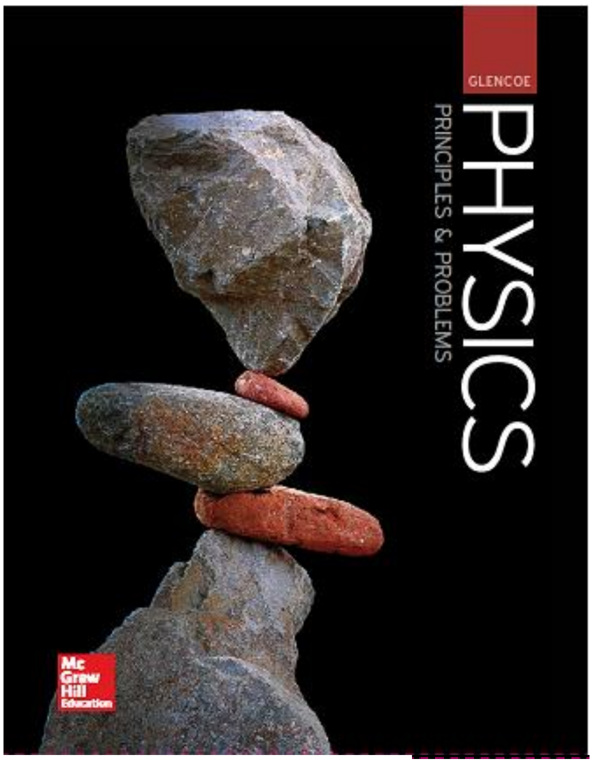
College- and Career-Readiness
Standards for Science
Physics



STANDARDS	PAGE REFERENCES
PHY.1 One-Dimensional Motion **Conceptual Understanding:** Linear motion of objects is described by displacement, velocity, and acceleration. These concepts should be introduced as computational and investigative phenomena.	
PHY.1 Students will investigate and understand how to analyze and interpret data.	
PHY.1.1 *Investigate and analyze evidence gained through observation or experimental design regarding the one-dimensional (1-D) motion of objects. Design and conduct experiments to generate and interpret graphical evidence of distance, velocity, and acceleration through motion.*	**Student Edition:** *Assessment* 118 #19 *Launch LAB* 88 *Mini LAB* 104 *Physics LAB* 102, 111 *Virtual Investigation* 96 **Teacher Edition:** AM 56, 62; CD 55, 62; QD 56, 59; TT 55

Codes used for Teacher Edition pages are the initial caps of headings on that page.

STANDARDS	PAGE REFERENCES
PHY.1.2 *Interpret and predict 1-D motion based on displacement vs. time, velocity vs. time, or acceleration vs. time graphs (e.g., free-falling objects).*	**Student Edition:** *Applying Concepts* 54-55 *Chapter 3 Assessment* 82-86 *Example Problem* 42, 44, 48, 65, 66, 70 *Mini LAB* 76 *Mixed Review* 55 #66 *Physics LAB* 64, 69, 77 *Practice Problems* 42, 45, 48, 66, 67, 70 *Section 1 Review* 67 #13 *Section 2 Review* 74 #39 *Section 3 Review* 45 *Standardized Test Practice* 57 #3, #5 **Teacher Edition:** AIE 26, 29; CU 26, 46; Re 46
PHY.1.3 *Use mathematical and computational analysis to solve problems using kinematic equations.*	**Student Edition:** *Example Problem* 72, 73 *Practice Problems* 72, 74 *Section 3 Review* 79 #48, #49 **Teacher Edition:** AIE 43
PHY.1.4 *Use graphical analysis to derive kinematic equations.*	**Student Edition:** *Chapter 3 Assessment* 83 #68
PHY.1.5 *Differentiate and give examples of motion concepts such as distance-displacement, speed-velocity, and acceleration.*	**Student Edition:** 37, 39, 46-47, 61-63 *Figure 4* 62 *Figure 5* 63 *Figure 9* 39 *Reading Check* 39 **Teacher Edition:** CD 38; IM 22, 54; R 56
PHY.1.6 *Design and mathematically/graphically analyze quantitative data to explore displacement, velocity, and acceleration of various objects. Use probe systems, video analysis, graphical analysis software, digital spreadsheets, and/or online simulations.*	These explorations can be used to explore and analyze data. **Student Edition:** *Physics LAB* 47, 64, 69, 77 *Virtual Investigation* 62 **Teacher Edition:** CT 46; E 30; PCA 43

STANDARDS	PAGE REFERENCES
PHY.1.7 *Design different scenarios, and predict graph shapes for distance/time, velocity/time, and acceleration/time graphs.*	**Teacher Edition:** DI 39; PPA 229; R 39
PHY.1.8 *Given a 1D motion graph students should replicate the motion predicted by the graph.*	**Teacher Edition:** DI 39; TPK 38
PHY.2 Newton's Laws **Conceptual Understanding:** Motion and acceleration can be explained by analyzing the contact interaction of objects. This motion and acceleration can be predicted by analyzing the forces (i.e., normal, tension, gravitational, applied, and frictional) acting on the object and applying Newton's laws of motion.	
PHY.2 Students will develop an understanding of concepts related to Newtonian dynamics.	
PHY.2.1 *Identify forces acting on a system by applying Newton's laws mathematically and graphically (e.g., vector and scalar quantities).*	**Student Edition:** *Applying Practices* 95 *Chapter 4 Assessment* 116 #69 *Example Problem* 97, 101, 103, 110 *Practice Problems* 93, 96, 97, 101, 104, 110 *Virtual Investigation* 96 **Teacher Edition:** R 71
PHY.2.2 *Use models such as free-body diagrams to explain and predict the motion of an object according to Newton's law of motion, including circular motion.*	**Student Edition:** *Chapter 4 Assessment* 115 #58; 116 #69, 117 #86 *Example Problem* 97, 101, 103, 108, 110, 133, 134, 139, 140, 162 *Practice Problems* 93, 97, 101, 104, 108, 110, 133, 135, 139, 141, 162 *Section 1 Review* 99 #13-#14 *Section 2 Review* 105 #25 *Section 3 Review* 111 #35; 141 #42 **Teacher Edition:** A 56; CU 56; DI 54
PHY.2.3 *Use mathematical and graphical techniques to solve vector problems and find net forces acting on a body using free-body diagrams and/or online simulations.*	**Student Edition:** *Chapter 4 Assessment* 115 #58; 116 #69, 117 #86 *Example Problem* 97, 101, 103, 108, 110, 133, 134, 139, 140, 162 *Practice Problems* 93, 97, 101, 104, 108, 110, 133, 135, 139, 141, 162 *Section 1 Review* 99 #13-#14 *Section 2 Review* 105 #25 *Section 3 Review* 111 #35; 141 #42 **Teacher Edition:** A 56; CU 56; DI 54

STANDARDS	PAGE REFERENCES
PHY.2.4 *Use vectors and mathematical analysis to explore the 2D motion of objects. (i.e. projectile and circular motion).*	**Student Edition:** *Chapter 5 Assessment* 144 #62 *Example Problem* 124, 128, 133, 139, 140, 155, 157, 162 *Practice Problems* 124, 129, 133, 139, 141, 156, 157, 162 *Section 1 Review* 129 **Teacher Edition:** AM 73; CT 72; QD 70, 88; R 71
PHY.2.5 *Use mathematical and computational analysis to derive simple equations of motion for various systems using Newton's second law (e.g. net force equations).*	**Student Edition:** *Example Problem* 97, 101, 103, 162 *Practice Problems* 97, 101, 104, 162 **Teacher Edition:** AIE 61
PHY.2.6 *Use mathematical and computational analysis to explore forces (e.g., friction, force applied, normal, and tension).*	**Student Edition:** *Chapter 4 Assessment* 117 #84 *Chapter 5 Assessment* 145-146 *Example Problem* 108, 110, 133, 134, 139, 140, 162 *Mastering Problems* 115 *Physics Challenge* 104 *Practice Problems* 108, 110, 133, 135, 139, 141, 162 *Section 2 Review* 135 *Section 3 Review* 111 #36-#38; 141 **Teacher Edition:** AIE 75, 76, 79; CU 76; PCA 160; UF 61
PHY.2.7 *Analyze real-world applications to draw conclusions about Newton's three laws of motion using online simulations, probe systems, and/or laboratory experiences.*	**Student Edition:** *Launch LAB* 88 *Mini LAB* 137,138, 153 *Physics LAB* 102, 104, 111, 131, 138, 154, 161 **Teacher Edition:** AM 62; CD 62, 76; QD 75, 88; R 76
PHY.2.8 *Design an experiment to determine the forces acting on a stationary object on an inclined plane. Test your conclusions.*	This lab can lead to a situation where students design their own experiment. **Student Edition:** *Physics LAB* 138
PHY.2.9 *Draw diagrams of forces applied to an object, and predict the angle of incline that will result in unbalanced forces acting on the object.*	This is a challenge problem where information is given and can be used by students to try a prediction problem. **Student Edition:** *Practice Problems* 141 #40

STANDARDS	PAGE REFERENCES
PHY.2.10 *Apply the effects of the universal gravitation law to generate a digital/physical graph, and interpret the forces between two masses, acceleration due to gravity, and planetary motion (e.g., situations where g is constant, as in falling bodies).*	**Student Edition:** *Mini LAB* 190 *Virtual Investigation* 184 **Teacher Edition:** AIE 110; QD 106
PHY.2.11 *Explain centripetal acceleration while undergoing uniform circular motion to explore Kepler's third law using online simulations, models, and/or probe systems.*	**Student Edition:** *Concepts in Motion* 180
PHY.3 Work and Energy **Conceptual Understanding:** Work and energy are synonymous. When investigating mechanical energy, energy is the ability to do work. The rate at which work is done is called power. Efficiency is the ratio of power input to the output of the system. In closed systems, energy is conserved.	
PHY.3 Students will develop an understanding of concepts related to work and energy.	
PHY.3.1 *Use mathematical and computational analysis to qualitatively and quantitatively analyze the concept of work, energy, and power to explain and apply the conservation of energy.*	**Student Edition:** *Chapter 10 Assessment* 284-286 *Chapter 11 Assessment* 312-316 *Example Problem* 268, 269, 272, 297, 304-305, 308 *Mini LAB* 266, 302, 334 *Physics Challenge* 309 *Physics LAB* 271, 306 *Practice Problems* 268, 269, 272, 294, 298, 305, 309 *Problem-Solving Strategies* 304 *Section 1 Review* 273 *Virtual Investigation* 303 **Teacher Edition:** AIE 159, 160, 175, 179, 181; CU 161; PCA 178
PHY.3.2 *Use mathematical and computational analysis to explore conservation of momentum and impulse.*	**Student Edition:** *Applying Practices* 244 *Chapter 9 Assessment* 256-260 *Concepts in Motion* 245 *Example Problem* 238, 242, 246, 248, 250 *Mini LAB* 247, 249 *Physics Challenge* 252 *Physics LAB* 247 *Practice Problems* 239, 243, 246, 249, 251 *Section 1 Review* 243 *Section 2 Review* 253 **Teacher Edition:** AIE 143, 146; AM 144; DI 147; IMT 142; UF 148

STANDARDS	PAGE REFERENCES
PHY.3.3 *Through real-world applications, draw conclusions about mechanical potential energy and kinetic energy using online simulations and/or laboratory experiences.*	**Student Edition:** *Launch LAB* 262 *Mini LAB* 302 *Virtual Investigation* 303 **Teacher Edition:** PCA 178
PHY.3.4 *Design and conduct investigations to compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions using probe systems, online simulations, and/or laboratory experiences.*	Using the information on the following pages, the teacher can introduce the concepts of conservation of momentum and kinetic energy, then have students design and conduct investigations. **Student Edition:** 306-307
PHY.3.5 *Investigate, collect data, and summarize the principles of thermodynamics by exploring how heat energy is transferred from higher temperature to lower temperature until equilibrium is reached.*	**Student Edition:** *Virtual Investigation* 338
PHY.3.6 Enrichment*: Design, conduct, and communicate investigations that explore how temperature and thermal energy relate to molecular motion and states of matter.*	This lab explores temperature and thermal energy as it relates to molecular motion. **Teacher Edition:** QD 205
PHY.3.7 Enrichment: *Use mathematical and computational analysis to analyze problems involving specific heat and heat capacity.*	**Student Edition:** *Applying Practices* 327 *Example Problem* 328 *Practice Problem* 328
PHY.3.8 Enrichment: *Research to compare the first and second laws of thermodynamics as related to heat engines, refrigerators, and thermal efficiency.*	The information on the following pages can be used for researching the information in this standard. **Student Edition:** 335-336
PHY.3.9 *Explore the kinetic theory in terms of kinetic energy of ideal gases using digital resources.*	The information on the following pages can be used to introduce the concepts in this standard **Student Edition:** 360 *Video* 351
PHY.3.10 Enrichment: *Research the efficiency of everyday machines (e.g., automobiles, hair dryers, refrigerators, and washing machines).*	**Student Edition:** *Writing in Physics* 288 #99

STANDARDS	PAGE REFERENCES
PHY.3.11 Enrichment: *Use an engineering design process to design and build a themed Rube Goldberg-type machine that has six or more steps and complete a desired task (e.g., pop a balloon, fill a bottle, shoot a projectile, or raise an object 35 cm) within an allotted time. Include a poster that demonstrates the calculations of the energy transformation or efficiency of the machine.**	This standard falls outside the scope of *Physics Principles & Problems* © 2017.
PHY.4 Waves **Conceptual Understanding:** Wave properties are the transfer of energy from one place to another. The investigation of these interactions must include simple harmonic motion, sound, and electromagnetic radiation.	
PHY.4 Students will investigate and explore wave properties.	
PHY.4.1 *Analyze the characteristics and properties of simple harmonic motions, sound, and light.*	**Student Edition:** *Applying Practices* 388 *Concepts in Motion* 384 *Figure 1* 382 *Figure 2* 383, 411 *Figure 3* 384 *Figure 9* 389 *Figure 10* 390 **Teacher Edition:** B 244; CU 242; PCA 255; QD 254; R 230, 240; UA 240
PHY.4.2 *Describe and model through digital or physical means the characteristics and properties of mechanical waves by simulating and investigating properties of simple harmonic motion.*	**Student Edition:** *Mini LAB* 413 *Physics LAB* 386, 411 *Section 2 Review* 427 #24 **Teacher Edition:** CD 228; QD 229; R 229
PHY.4.3 *Use mathematical and computational analysis to explore wave characteristics (e.g., velocity, period, frequency, amplitude, phase, and wavelength).*	**Student Edition:** *Example Problem* 387, 392, 424 *Practice Problems* 387, 393, 424, 455 **Teacher Edition:** AIE 230, 246; CU 242; TPK 232
PHY.4.4 *Investigate and communicate the relationship between the energy of a wave in terms of amplitude and frequency using probe systems, online simulations, and/or laboratory experiences.*	**Teacher Edition:** B 240

STANDARDS	PAGE REFERENCES
PHY.4.5 *Design, investigate, and collect data on standing waves and waves in specific media (e.g., stretched string, water surface, and air) using online simulations, probe systems, and/or laboratory experiences.*	**Student Edition:** *Concepts in Motion* 397 *Physics LAB* 421 **Teacher Edition:** DI 233; PPA 232; QD 246
PHY.4.6 *Explore and explain the Doppler effect as it relates to a moving source and to a moving observer using online simulations, probe systems, and/or real-world experiences.*	**Student Edition:** *Concepts in Motion* 414 *Virtual Investigation* 415 **Teacher Edition:** E 242; QD 242; R 262
PHY.4.7 *Explain the laws of reflection and refraction, and apply Snell's law to describe the relationship between the angles of incidence and refraction.*	**Student Edition:** 465-466 *Concepts in Motion* 465, 493 *Example Problems* 467, 494 *Figure 2* 493 *Physics LAB* 469, 495 *Practice Problems* 467, 494 *Virtual Investigation* 493 **Teacher Edition:** CD 286; IM 286; QD 288; UM 270
PHY.4.8 *Use ray diagrams and the thin lens equations to solve real-world problems involving object distance from lenses, using a lens bench, online simulations, and/or laboratory experiences.*	**Student Edition:** *Example Problem* 505 *Physics LAB* 502 *Practice Problems* 505 **Teacher Edition:** AIE 271; E 293
PHY.4.9 *Research the different bands of electromagnetic radiation, including characteristics, properties, and similarities/differences.*	**Student Edition:** 710-713 *Figure 7* 712 *Physics Challenge* 713 *Section 2 Review* 719 #24, #30 **Teacher Edition:** CB 422; CT 422; R 411; RC 412; Re 414
PHY.4.10 Enrichment: *Research the ways absorption and emission spectra are used to study astronomy and the formation of the universe.*	**Student Edition:** *Connection to Astronomy* 729, 756 **Teacher Edition:** AP 422; PPA 413
PHY.4.11 Enrichment: *Research digital nonfictional text to defend the wave-particle duality of light (i.e., wave model of light and particle model of light).*	Information provided in the chapter below can be used to defend the wave-particle duality. **Student Edition:** Chapter 27

STANDARDS	PAGE REFERENCES
PHY.4.12 Enrichment: *Research uses of the electromagnetic spectrum or photoelectric effect.*	**Teacher Edition:** DI 414; PPA 425
PHY.5 Electricity and Magnetism **Conceptual Understanding:** In electrical interactions, electrical energy (whether battery or circuit energy) is transformed into other forms of energy. Charged particles and magnetic fields are similar in that they store energy. Magnetic fields exert forces on moving charged particles. Changing magnetic fields cause electrons in wires to move and thus create a current.	
PHY.5 Students will investigate the key components of electricity and magnetism.	
PHY.5.1 *Analyze and explain electricity and the relationship between electricity and magnetism.*	**Student Edition:** 655-656, 710-712 *Figure 5* 710 *Figure 6* 711 *Physics LAB* 655
PHY.5.2 *Explore the characteristics of static charge and how a static charge is generated using simulations.*	**Student Edition:** *Concepts in Motion* 555 *Launch LAB* 546 *Mini LAB* 556 *Physics LAB* 550, 551, 556 **Teacher Edition:** AM 319; DI 319; QD 323; R 318
PHY.5.3 *Use mathematical and computational analysis to analyze problems dealing with electric field, electric potential, current, voltage, and resistance as related to Ohm's law.*	**Student Edition:** *Chapter 22 Assessment* 617 #65 *Example Problem* 572, 573, 581, 607 *Practice Problem* 572, 573, 580, 581, 607 *Section 1 Review* 576 #17 **Teacher Edition:** AIE 332, 333, 337, 349
PHY.5.4 *Develop and use models (e.g., circuit drawing and mathematical representation) to explain how electric circuits work by tracing the path of electrons, including concepts of energy transformation, transfer, conservation of energy, electric charge, and resistance using online simulations, probe systems, and/or laboratory experiences.*	**Student Edition:** *Launch LAB* 622 *Mini LAB* 606 *Physics LAB* 608, 611, 636 *Practice Problems* 603 *Section 1 Review* 608 #20 *Virtual Investigation* 604 **Teacher Edition:** AM 349, 368; CU 349; E 368; QD 368

STANDARDS	PAGE REFERENCES
PHY.5.5 *Design and conduct an investigation of magnetic poles, magnetic flux and magnetic field using online simulations, probe systems, and/or laboratory experiences.*	The following pages reference investigations. **Student Edition:** *Applying Practices* 653 *Launch LAB* 648 *Mini LAB* 653 *Physics LAB* 656 **Teacher Edition:** QD 376
PHY.5.6 *Use schematic diagrams to analyze the current flow in series and parallel electric circuits, given the component resistances and the imposed electric potential.*	**Student Edition:** *Example Problem* 632, 638 *Mini LAB* 631 *Physics LAB* 626, 631 *Practice Problems* 633, 638 *Section 1 Review* 634 #24 **Teacher Edition:** AIE 367; CU 364; D 362; PPA 360; R 360
PHY.5.7 *Analyze and communicate the relationship between magnetic fields and electrical current by induction, generators, and electric motors (e.g., microphones, speakers, generators, and motors) using Ampere's and Faraday's laws.*	**Student Edition:** 661-662, 680-683 *Concepts in Motion* 663, 680 *Figure 6* 681 *Figure 19* 663 *Launch LAB* 389 *Mini LAB* 682 **Teacher Edition:** CB 392; PCA 396; R 392
PHY.5.8 Enrichment: *Design and construct a simple motor to develop an explanation of how the motor transforms electrical energy into mechanical energy and work.*	In this lab, the students make a generator, which can be used as impetus to design a motor. **Student Edition:** *Mini LAB* 682
PHY.5.9 Enrichment: *Design and draw a schematic of a circuit that will turn on/off a light from two locations in a room like those found in most homes.*	Students can design and draw a circuit using the follow reference. **Student Edition:** *Problem-Solving Strategies* 603

STANDARDS	PAGE REFERENCES
PHY.6 Nuclear Energy **Conceptual Understanding:** Nuclear energy is energy stored in the nucleus of the atom. The energy holding atoms together is called binding energy. The binding energy is a huge amount of energy. So, at the subatomic scale, the conservation of energy becomes the conservation of mass-energy.	
PHY.6 Students will demonstrate an understanding of the basic principles of nuclear energy.	
PHY.6.1 *Analyze and explain the concepts of nuclear physics.*	**Student Edition:** 804-805, 807, 808-817 *Concepts in Motion* 815 *Example Problem* 806 *Figure 4* 804 *Figure 12* 815 *Figure 14* 816 *Figure 15* 817 *Going Further* 828 *Practice Problems* 806 *Section 1 Review* 807 *Virtual Investigation* 813 **Teacher Edition:** CD 465; CT 464, 470; CU 471; D 466; RWP 470; UM 470
PHY.6.2 *Explore the mass number and atomic number of the nucleus of an isotope of a given chemical element.*	**Student Edition:** 803 *Figure 3* 803 *Practice Problems* 804 **Teacher Edition:** A 465; E 466; IM 464; R 464
PHY.6.3 *Investigate the conservation of mass and the conservation of charge by writing and balancing nuclear decay equations for alpha and beta decay.*	**Student Edition:** 809, 813 *Concepts in Motion* 809 *Example Problem* 811, 812 *Figure 8* 810 *Mastering Problems* 830 *Personal Tutor* 813 *Practice Problems* 811, 812 *Section 2 Review* 817 #30-#31, #34 *Table 1* 809 **Teacher Edition:** AIE 469; UF 469

STANDARDS	PAGE REFERENCES
PHY.6.4 *Simulate the process of nuclear decay using online simulations and/or laboratory experiences and using mathematical computations determine the half-life of radioactive isotopes.*	**Student Edition:** *Mini LAB* 811 *Virtual Investigation* 813