South Carolina PHYSICS 1

Foundations of Physics 2nd Edition c2016

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1: The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A.** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	**H.P.1A.1** Ask questions to: (1) generate hypotheses for scientific investigations, **IM:** Inv 5.1, p27 Inv 5.3, p32 Inv 6.2, p38 Inv 8.2, p57 Inv 10.3, p77 Inv 12.3, p91 Inv 20.1, p161 (2) refine models, explanations, or designs, or **IM:** Inv 1.1, Part 4f, p4 Inv 2.1, part5e, p9 Inv 3.2, p17-18 Inv 3.3 Part 4, p20 Inv 4.2, Part 4, 24 Inv 4.3, Part 4, p26 Inv 5.1, Part 3, p28 Inv 5.3, Part4a, p34 Inv 6.2, Part 2, p38 Inv 6.3, Part 3, p41 and Part 6, p43 Inv 7.2, p48-50 Inv 10.3, p78 Inv 13.1, Part3, p94 Inv 16.3, p138 Inv 23.2, p190 Engineering Design Challenges p255-275 (3) extend the results of investigations or challenge scientific arguments or claims. **IM:** Inv 8.2, Part4d, p59 Inv 11.2, Part3 #5, p85 Inv 13.1, p95 Inv 15.3, Part4ef, p117 Inv 23.3 Part6e, p196 Inv 24.2, Part3, p198 Inv 25.3, Part 3e, p211

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	**H.P.1A.2** Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships **SE:** Concept Reviews and Problems: Ch2 Rev, p55, #16 Ch3 Rev, p76, #6 Ch4 Rev, p97-8, #2, #6-10 Ch5 Rev, p115, #4, 116 #1, 12 Ch6 Rev, p138, #10 Ch7 Rev, p163, #17, p164 #7 Ch8 Rev, p179-180, #4, 12 Ch9 Rev, p197-198 #8, #11, #18, Prob #1, 5, 6, 10 Ch10 Rev, p221-222, #1, 4 Ch11 Rev, p242 #7, 9 Ch12 Rev, p541, #13 Ch13 Rev, p281, #4 Ch14 Rev, p305-306, #5, 10 Ch17 Rev, p374 #2, 3 Ch20 Rev, p438 Prob #2-4, 6 Ch21 Rev, p459, #21 Ch22 Rev, p476 Prob #1-5, 7 Ch23 Rev, p497, #5 Ch24 Rev, p518, #4, 5 Ch25 Rev, p541 #13 Ch26 Rev, p558 #2 Ch27 Rev, p585, #11, #16, 18 Ch28 Rev, p610-611, #15, 19 Also online Chapter Problem sets **IM:** Note: All investigations develop and use models to understand or represent phenomena, processes, and relationships

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H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	(2) test devices or solutions, or **IM:** Inv 1.1, 1.3, 2.2, 2.3, 3.2, 3.3, 4.2, 5.1, 6.2, 6.3, 7.2, 8.1, 8.2, 10.3, 13.1, 13.2, 14.3, 15.1, 17.1, 19.2, 20.1, 21.2, 22.2, 22.3, 23.1, 23.2, 23.3, 24.1, 24.2, 25.2, 27.2 Engineering Design Challenges p255, 262, 267, 272 (3) communicate ideas to others **IM:** Note: All investigations are expected collaborations between students in teams or groups. Also: Inv 5.1, p21, Part3bc Inv 6.2, p38, Part 3cd Inv 13.2, p98, Part 5cd Inv 18.1, p142, Inv 18.3, p147 Inv 20.1, p162 Part 6b Inv 21.2, p174, Part1f Inv 25.1, p204 Engineering Design Challenges p255, 262, 267, 272
		H.P.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information, **IM:** Inv 5.1, p27 Inv 5.3, p32 Inv 6.2, p38 Inv 8.2, p57 Inv 10.3, p77 Inv 12.3, p91 Inv 20.1, p161

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	(2) identify materials, procedures, and variables, **IM:** Inv 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.2, 6.3, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 9.1, 9.2, 9.3, 10.1, 10.2, 10.3, 11.1, 11.2, 12.1, 12.2, 12.3, 13.1, 13.2, 14.1, 14.3, 15.1, 17.3, 19.2, 20.1, 21.2, 22.2, 22.3, 23.1, 23.2, 23.3, 24.1, 24.2, 25.2, 27.2 (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data, and **IM:** Inv 1.1 - 11.2, 12.1 - 29.1 (4) record and represent data in an appropriate form. **IM:** Inv 1.1 - 11.2, 12.1 - 29.1 (5) Use appropriate safety procedures. **IM: Preface** Inv 1.1 - 11.2, 12.1 - 29.1
		H.P.1A.4 Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) (1) reveal patterns and construct meaning, **SE:** **Tables** Ch3 Rev, p75, #5 Ch7 Rev, p164, #7 Ch26 Rev, p559, #8 Ch28 Rev, p610, #1 Ch29 Rev, p634, #2, 13

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	**Graphs** Ch3 Rev, p78, #11, 12, 13, p79 Prob#6 Ch4 Rev, p97, #2, 6, Ch5 Rev, p116, #12 Ch10 Rev, p222, #8 Ch13 Rev Prob, p281-282, #1, 2, 6, 7, 10 Ch14 Rev Prob, p305-306, #6-9 Ch15 Rev Prob, p329-330, #4, 8-11 Ch24 Rev Prob, p517, #1, 2 Ch25 Rev p541-542, #12, 20 Prob #4 Ch26 Rev, p559, #15 Ch29 Rev, p635-636, #14, Prob #10 **IM: Tables** Inv 1.3, p5 Inv 3.2, p17 Inv 3.3, p19 Inv 5.2, p31 Inv 5.3, p33 Inv 6.1, p35 Inv 6.3, p40,42 Inv 7.1, p45-46 Inv 7.2, p50 Inv 8.1, p55 Inv 8.2, p59 **Graphs** Inv 3.1, p16 Inv 3.2, p18 Inv 3.3, p20 Inv 4.1, p22 Inv 4.2, p24 Inv 4.3, p26 Inv 5.1, p27 Inv 6.2, p38 Inv 6.3, p41 Inv 7.2, p50 Inv 8.3, p61 Inv 9.2, p65 Inv 10.3, p78 Inv 11.1 p80

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	(2) support or refute hypotheses, explanations, claims, or designs, or **IM:** Inv 5.1, Part 3c, p28 Inv 5.3, Part 3c, p33, Part 3e, p34 Inv 6.2, Part 3cd, p33, p38 Inv 8.2, Part4a p59 Inv 9.3, Part2f, p67 Inv 10.3, Part 3bc, p78 Inv 12.3, Part4a, p92 Inv 20.1, Part 6cdefg, p163 Engineering Design Challenges p255, 262, 267, 272 (3) evaluate the strength of conclusions. **SE:** Ch22 Concept Rev, p475 #17 Ch27 Rev. Applying…p586 #2,4 **IM:** Inv 3.2, p17 , Part2c Inv 9.3, p66, Part2fg Inv 15.1, p112, Part #5, Inv 16.3, p128, Part5a Inv 20.1, p163, Part6h, Inv 25.3, p211, Part 3bcd, Inv 28.1, p231, Part 3bcd, 4bcde Engineering Design Challenges p255, 262, 267, 272

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	**H.P.1A.5** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, **SE:** Chapter Review Problems Ch2 Rev, p56 Ch3 Rev, p76Ch4 Rev, p97-98 Ch5 Rev, p116 Ch6 Rev, p137-138 Ch7 Rev, p163-164 Ch8 Rev, p180 Ch9 Rev, p197-198 Ch10 Rev, p221-222 Ch11 Rev, p241-242 Ch12 Rev, p261 Ch13 Rev, p281-282 Ch14 Rev, p305-306 Ch15 Rev, p329-330 Ch18 Rev, p397 Ch19 Rev, p417-418 Ch20 Rev, p437-438 Ch21 Rev, p460 Ch23 Rev, p497 Ch25 Rev, p542 Ch26 Rev, p560 Ch27 Rev, p586 Also online Chapter Problem Sets **IM:** Inv 2.1, 2.3, 3.1, 3.2, 4.1, 4.2, 4.3, 5.2, 5.3, 6.1, 6.2, 6.3, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 9.1, 9.3,10.1, 10.2, 10.3, 11.1, 11, 2, 12.1, 12.2, 13.1, 13.2, 13.3, 14.1, 14.3, 16.1, 17.1, 17.3, 18.2, 19.3, 20.1, 20.2, 20.3, 21.2. 23.1, 23.2, 23.3, 24.2, 25.3, 26.1, 27.1, 27.3, 28.3

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	(2) express relationships between variables for models, and **SE**: Chapter Review Problems Ch2 Rev, p56 Ch3 Rev, p76 Ch4 Rev, p97-98 Ch5 Rev, p116 Ch6 Rev, p137-138 Ch7 Rev, p163-164 Ch8 Rev, p180 Ch9 Rev, p197-198 Ch10 Rev, p221-222 Ch11 Rev, p241-242 Ch12 Rev, p261 Ch13 Rev, p281-282 Ch14 Rev, p305-306 Ch15 Rev, p329-330 Ch18 Rev, p397 Ch19 Rev, p417-418 Ch20 Rev, p437-438 Ch21 Rev, p460 Ch23 Rev, p497 Ch25 Rev, p542 Ch26 Rev, p560 Ch27 Rev, p586 Also online Chapter Problem Sets **IM:** Inv 2.2, p10 Inv 3.1, Part4d, p16 Inv 3.2, Part4fh, p18 Inv 3.3, Part4e, p20 Inv 4.2, Part2e, p23; Part 3a, p24 Inv 4.3, Part2e, p26 Inv 5.2, Part4e, p31 Inv 6.1, Part 2d, p36 Inv 7.2, Part4b, p55 Inv 10.1, Part4c, p71 Inv 10.3, Part2c, p78

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	Inv 12.3, Part1a, p91 Inv 13.1, Part3-4 Inv 23.3, Part 4 p194 (3) use grade-level appropriate statistics to analyze data. **IM:** Inv 3.1, Part 4d, p16 Inv 3.2, Part 2c, p17, Part 4, p18 Inv 3.3, Part 4, p20 Inv 4.1, Part 4, p22 Inv 4.2, Part 2, p23; Part 4, #6, p24 Inv 4.3, Part 3, p26 Inv 5.1, Part 3b, p28 Inv 5.2, Part 4a, p31 Inv 6.1, Part3b, p36 Inv 6.2, Part3f, p39 Inv 6.3, Part3c, p41; Part6c, p43 Inv 8.1, Part5 #9ab, p54-56 Inv 9.3, Part 2g, p67 Inv 11.1, Part2 #7, p80 Inv 11.2, Part3 #5, p84 Inv 13.1, Part53, p95 Inv 15.1 Part4abc, p111 Inv 25.3, Part2f, p210
		H.P.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence and models **SE: Applying Your Knowledge**. Ch4, p98 Ch7, p164 Ch8, p180 Ch9, p198 Ch11, p242 Ch13, p282 Ch15, p330 Ch17, p376 Ch26, p560 **IM: All investigations**

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	(2) conclusions from scientific investigations, **IM:** Analyzing results… p 8, 17, 59 Reflecting on… p 28, 90, 92, 100, 103, 231 Applying… p 36, 88, 95, 105, 153, 187 (3) predictions based on observations and measurements, or **IM:** Inv 4.3, p27, Part2ef Inv 6.2, p38, Part2bc, Part3b Inv 6.3, p Part6 Inv 7.2, p50, Part5#3, Part6b Inv 7.3, p51-52, Part4a, Part5#1a Inv 8.1, p54-56, Part 4c.Part6abd Inv 8.2, p57, Part 4abf Inv 10.2, p74, Part2de Inv 10.3, p77-78, Part4, Part5 Inv 13.1, p95, Part5ce Inv 17.1, p130 Part2d, p132 Part5f Inv 17.3, p141, Part2 #5a, Part4 Inv 19.2, p153 Part2 #8, Part3 #4, Part6, #5, Part8#2 Inv 20.1, p161, Part3b (4) data communicated in graphs, tables, or diagrams. **IM: All investigations**

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	**H.P.1A.7** Construct and analyze scientific arguments to support claims, explanations, or designs using evidence and valid reasoning from observations, data, or informational texts. **SE:** Ch11 Rev, p242 #9, Applying #1, 2 **IM:** Inv 13.2, p98, Part5 abcd, Inv 29.2, 240-241 Engineering Design Challenges p255, 262, 267, 272
		H.P.1A.8 Obtain and evaluate scientific information to (1) answer questions **SE:** Ch9 Rev, p198, #6 Ch11 Rev, p242 #1, 2 Ch15 Rev, p330, #2 Ch16 Rev, p350, #1 Ch17 Rev, p376, #1, 4 Ch21 Rev, p460, #2 Ch24 Rev, p518, #1 Ch25 Rev, p542, #1 Ch28 Rev, p612, #3 Ch29 Rev, p636, #3 **IM:** Inv 15.2, , p118 Part5b Inv 29.2, 240-241 Inv 29.3, 242-243 Engineering Design Challenges p255, 262, 267, 272 (2) explain or describe phenomena, **SE:** Ch11 Rev, p242 #2 Ch13 Rev, p282, #1 Ch14 Rev, p306, #2 Ch15 Rev, p330, #2

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	Ch16 Rev, p350, #2, 3 Ch17 Rev, p376, #5 Ch18 Rev, p398, #4 Ch19 Rev, p418, #1, 2 Ch21 Rev, p460, #2 Ch27 Rev, p586, #2, 3 Ch29 Rev, p636 #3 **IM:** Inv 29.2, 240-241 (3) develop models, **SE:** Ch11 Rev, p242, #2 Ch16 Rev, p350, #4 Ch18 Rev, p398, #2, 4 Ch19 Rev, p418, #1 Ch21 Rev, p460, #1 Ch24 Rev, p518, #2 Ch29 Rev, p636 #1, 2 **IM:** Inv 15.3, p119 Part 5f Inv 29.3, 242-243 Engineering Design Challenges p255, 262, 267, 272 (4) evaluate hypotheses, explanations, claims, or designs, or **SE:** Ch10 Rev, p222, #4 Ch12 Rev, p262, #1 Ch17 Rev, p376, #1 Ch18 Rev, p398, #3 Ch19 Rev, p418, #2 Ch20 Rev, p438, #1, 2 Ch25 Rev, p542, #1 Ch26 Rev, p560, #1 Ch27 Rev, p586, #2, 3 **IM:** Engineering Design Challenges p255, 262, 267, 272

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1A. (cont.)** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers. **SE: Sections 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	(5) identify and/or fill gaps in knowledge. **SE:** Ch11 Rev, p242, #1 Ch12 Rev, p262, #2 Ch16 Rev, p350, #2 Ch17 Rev, p586, #1 **IM:** Engineering Design Challenges p255, 262, 267, 272
		H.P.1A.8 Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or **SE:** Ch11 Rev, p242, #1 Ch15 Rev, p330, #2 Ch16 Rev, p350, #4 **IM:** Inv 18.1, p142 Inv 25.1, p204 See Also Teacher Guide Appendix B: Literary Selections (2) reporting the results of student experimental investigations. **IM:** All investigations have a recommended digital or printable reporting format. Also Engineering Design Log p244

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1B. Conceptual Understanding:** Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology. **SE: Sections 1.1, 10.3, 11.1, 11.1, 11.3, 13.1, 14.1, 15.1, 17.3, 18.2, 19.3, 24.3, 29.1, 29.2** Also Chapter Connections: Biomimicry p27-28 Nanotechnology, p53 Slow Motion Photography, p73 Anti-lock Brakes p94-95 Biomechanics, p113-114 Design of Structures, p134-135 Robot Navigation, p160-161 Satellite Moon, p177-178 Bicycle Physics, p195-196 Jet Engines, p257-258 Quartz Crystals, p279-280 Freak Waves, p302-303 Color Printing, p347-348 Holography, p394-395 Hybrid Gas Electric Cars, p414-415 Projector Technologies p456-457 Magnetic Resonance Imaging p473, 474 Magnetic Levitation, p494-495 Energy Efficient Buildings, p556-557 The Laser, p607-608	**H.P.1B.1** Construct devices or design solutions using scientific knowledge to solve specific problems or needs: (1) ask questions to identify problems or needs, **IM:** Engineering Design Challenges p255, 262, 267, 272 (2) ask questions about the criteria and constraints of the device or solutions, **IM:** Engineering Design Challenges p255, 262, 267, 272 (3) generate and communicate ideas for possible devices or solutions, **IM:** Engineering Design Challenges p255, 262, 267, 272 (4) build and test devices or solutions, **IM:** Inv 6.2, p38, Part2 Inv 6.3, p43, Part3b, Part 6b Inv 7.2, p50, Part 5 Inv 8.1, p56, Part 6 Inv 13.1, p95, Part 5 Inv 13.2, p98, Part 5ab Engineering Design Challenges p255, 262, 267, 272 (5) determine if the devices or solutions solved the problem and refine the design if needed, and **IM:** Inv 6.3, p43, Part 6cde Inv 7.2, p50, Part 6 Inv 8.1, p56, Part 6 Inv 13.2, p98, Part5d Engineering Design Challenges p255, 262, 267, 272

Science and Engineering Practices	Conceptual Understanding	Performance Indicators
H.P.1 (cont.): The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.	**H.P.1B. Conceptual Understanding (cont.):** Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.	(6) communicate the results. **IM:** Engineering Design Log p244 Engineering Design Challenges p255, 262, 267, 272
Interactions and Forces	**Conceptual Understanding**	**Performance Indicators**
Standard H.P.2: The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2A:** The linear motion of an object can be described by its displacement, velocity, and acceleration. **SE: Sections 3.1, 3.2, 3.3, 4.1, 4.2, 5.2, 7.1, 11.2, 12.1, 12.2, 12.3**	**H.P.2A.1** Plan and conduct controlled scientific investigations on the straight-line motion of an object to include an interpretation of the object's displacement, time of motion, constant velocity, average velocity, and constant acceleration. **IM:** Inv 3.1, p14 Inv 3.2, p17 Inv 3.3, p19 Inv 4.1, p21 Inv 4.2, p23 Inv 4.3, p25 Inv 5.1, p27 Inv 5.2, p29 Inv 5.3, p32 Inv 10.2, p73 Inv 11.1, p80 Inv 12.1,p87
		H.P.2A.2 Construct explanations for an object's change in motion using one-dimensional vector addition. **SE:** Ch7 Rev, p163, Prob #1-#14 Also online Ch7 Problem set **IM:** Inv 7.1, p44-46

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2A (cont.):** The linear motion of an object can be described by its displacement, velocity, and acceleration. **SE: Sections 3.1, 3.2, 3.3, 4.1, 4.2, 5.2, 7.1, 11.2, 12.1, 12.2, 12.3**	**H.P.2A.3** Use mathematical and computational thinking to apply formulas related to an object's displacement, constant velocity, average velocity and constant acceleration. Interpret the meaning of the sign of displacement, velocity, and acceleration. **SE:** Ch6 Rev, p137, #6 Ch7 Rev, p163 #2-4 Ch8 Rev, p179 #2, p180 #3, 5, 10. Ch12 Rev, p260, #9d, 19c, p262, #4, 6 Ch13 Rev, p282, #6 Ch15 Rev, p329, #5 Ch18 Rev, p397 Prob #4,5 Also online Chapter 6, 7, 8, 12, 13, 15, 18 Problem Sets **IM:** Inv 3.1, p14 Inv 3.2, p17 Inv 3.3, p19 Inv 4.1, p21 Inv 4.2, p23 Inv 4.3, p25 Inv 5.1, p27 Inv 5.2, p29 Inv 5.3, p32 Inv 10.2, p73 Inv 11.1, p80 Inv 12.1, p87
		H.P.2A.4 Develop and use models to represent an object's displacement, velocity, and acceleration (including vector diagrams, data tables, motion graphs, dot motion diagrams, and mathematical formulas). **SE:** Ch3 Rev, p78, #5, 11, 12, 13, p79 Prob#6 Ch4 Rev, p96, #4, p97, #2, 6, Ch5 Rev, p116, #12 Ch7 Rev, p163, Prob #7-14 Also online Chapter 3, 4, 5, 6, 7, Problem sets.

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2A (cont.):** The linear motion of an object can be described by its displacement, velocity, and acceleration. **SE: Sections 3.1, 3.2, 3.3, 4.1, 4.2, 5.2, 7.1, 11.2, 12.1, 12.2, 12.3**	**IM:** Inv 3.1, p14 Inv 3.2, p17 Inv 3.3, p19 Inv 4.1, p21 Inv 4.2, p23 Inv 4.3, p25 Inv 5.1, p27 Inv 5.2, p29 Inv 5.3, p32 Inv 10.2, p73 Inv 11.1, p80 Inv 12.1,p87
		H.P.2A.5 Construct explanations for what is meant by "constant" velocity and "constant" acceleration (including writing descriptions of the object's motion and calculating the sign and magnitude of the slope of the line on a position-time and velocity-time graph). **SE:** Ch3 Rev, p76, #9, 10, 14, 15 Ch4 Rev, p96, #7, 9 Ch5 Rev, p115,#14, p116, #1 Ch6 Rev, p138, #3 Ch7 Rev, p163, Prob #21 Also online Chapter 3, 4, 5, 6, 7, Problem sets **IM:** Inv 3.1, p14 Inv 3.3, p19 Inv 4.1, p21 Inv 4.3, p25 Inv 5.2, p29 Inv 7.2, p48

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2A (cont.):** The linear motion of an object can be described by its displacement, velocity, and acceleration. **SE: Sections 3.1, 3.2, 3.3, 4.1, 4.2, 5.2, 7.1, 11.2, 12.1, 12.2, 12.3**	**H.P.2A.6** Obtain information to communicate the similarities and differences between distance and displacement; speed and velocity; constant velocity and instantaneous velocity; constant velocity and average velocity; and velocity and acceleration. **SE:** Ch3 Rev, p76, #3 Ch4 Rev Concepts, p96, #1, 7, 9 Ch7 Rev, p163, #2-4 Also online Chapter 3, 4, 7, Problem sets **IM:** Inv 3.3, p19 Inv 5.2, p29 Inv 7.2, p48 Inv 10.2, p7
	H.P.2B: The interactions among objects and their subsequent motion can be explained and predicted by analyzing the forces acting on the objects and applying Newton's laws of motion. **SE: 8.1, 8.2, 8.3, 9.1, 9.2, 9.3, 12.1, 12.2, 12.3**	**H.P.2B.1** Plan and conduct controlled scientific investigations involving the motion of an object to determine the relationships among the net force on the object, its mass, and its acceleration (Newton's second law of motion, Fnet = ma) and analyze collected data to construct an explanation of the object's motion using Newton's second law of motion. **IM:** Inv 5.2, p29-31 Inv 6.2, p37-38 Also Engineering Design Challenge p255
		H.P.2B.2 Use a free-body diagram to represent the forces on an object. **SE:** Ch6 Rev, p137, #7abc, p138, #10a Also online Chapter 6 Problem set **IM:** Inv 5.1, p34, Part4 Inv 8.2, p58, Part2c Inv 9.1, p63, Part3a

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2B (cont.):** The interactions among objects and their subsequent motion can be explained and predicted by analyzing the forces acting on the objects and applying Newton's laws of motion. **SE: 8.1, 8.2, 8.3, 9.1, 9.2, 9.3, 12.1, 12.2, 12.3**	**H.P.2B.3** Use Newton's Third Law of Motion to construct explanations of everyday phenomena (such as a hammer hitting a nail, the thrust of a rocket engine, the lift of an airplane wing, or a book at rest on a table) and identify the force pairs in each given situation involving two objects and compare the size and direction of each force. **SE:** Ch5 Rev Concepts, p115, #1, 4, p116 #16, 17, Prob #1, 12 Also online Chapter 5 Problem set **IM:** Inv 5.3, p32-34 Inv 12.1, p87, Part3a Inv 12.2, p89
		H.P.2B.4 Use mathematical and computational thinking to derive the relationship between impulse and Newton's Second Law of Motion. **SE:** Ch12 Rev, p261, #7a **IM:** Inv 12.1, p87 Inv 12.2, p89
		H.P.2B.5 Plan and conduct controlled scientific investigations to support the Law of Conservation of Momentum in the context of two objects moving linearly (p=mv). **IM:** Inv 12.1, p87 Inv 12.2, p89
		H.P.2B.6 Construct scientific arguments to defend the use of the conservation of linear momentum in the investigation of traffic accidents in which the initial motions of the objects are used to determine the final motions of the objects **IM:** Inv 12.1, p 88, Part 5ac

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2B (cont.):** The interactions among objects and their subsequent motion can be explained and predicted by analyzing the forces acting on the objects and applying Newton's laws of motion. **SE: 8.1, 8.2, 8.3, 9.1, 9.2, 9.3, 12.1, 12.2, 12.3**	**H.P.2B.7** Apply physics principles to design a device that minimizes the force on an object during a collision and construct an explanation for the design. **IM:** Engineering Design Challenge Ch3, p255
		H.P.2B.8 Develop and use models (such as a computer simulation, drawing, or demonstration) and Newton's Second Law of Motion to construct explanations for why an object moving at a constant speed in a circle is accelerating. **SE:** Ch8 Rev, p180, #12, 13, Prob #7 Also online Newtons 2nd Law video demo Also online Chapter 8 Problem set **IM:** Inv 8.1, p53 Inv 8.2, p57
		H.P.2B.9 Construct explanations for the practical applications of torque (such as a see-saw, bolt, wrench, and hinged door). **SE:** Ch9 Rev Concepts, p196, #4-#7, Prob #1, 2 Also online Chapter 9 Problem set **IM:** Inv 9.1, p62
		H.P.2B.10 Obtain information to communicate physical situations in which Newton's Second Law of Motion does not apply. **SE:** Ch18.3, p388 **IM:** Inv 18.3, p137

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2C:** The contact interactions among objects and their subsequent motion can be explained and predicted by analyzing the normal, tension, applied, and frictional forces acting on the objects and by applying Newton's Laws of Motion. **SE: Sections 6.1, 6.2, 6.3, 8.3, 10.1**	**H.P.2C.1** Use a free-body diagram to represent the normal, tension (or elastic), applied, and frictional forces on an object. **SE:** Ch5 Rev, p116, #1ab,#12 Ch6 Rev Prob, p137, #7c, 8 Ch7 Rev Concept, #17b Ch10 Rev Prob, p221, #2ab, Prob p222, #4 Ch12 Rev Concept, p260, #7, 9, Prob #11 Also online Chapter 6 Problem set **IM:** Inv 5.3, p34, Part 4c Inv 8.2,p58, Part 2c
		H.P.2C.2 Plan and conduct controlled scientific investigations to determine the variables that could affect the kinetic frictional force on an object. **IM:** Inv 3.3, p19, Part 1 Inv 4.3, p26, Part4b Inv 5.2, p29, Part 4 Inv 6.2, p37, Part 1, p38 Part2, 3 Inv 8.2, p58 , Part 2 Inv 10.1, p71, Part5d Inv 10.2, p76, Part5b Inv 11.1, p80 , Intro Inv 13.3, p,101 Part 5 Inv 23.2, p192, Part7g
		H.P.2C.3 Obtain and evaluate information to compare kinetic and static friction. **SE:** Ch6 Rev Concept, p137, #10, Prob p138, #10c **IM:** Inv 6.2, p37

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2C (cont.):** The contact interactions among objects and their subsequent motion can be explained and predicted by analyzing the normal, tension, applied, and frictional forces acting on the objects and by applying Newton's Laws of Motion. **SE: Sections 6.1, 6.2, 6.3, 8.3, 10.1**	**H.P.2C.4** Analyze and interpret data on force and displacement to determine the spring (or elastic) constant of an elastic material (Hooke's Law, F=-kx), including constructing an appropriate graph in order to draw a line-of-best-fit whose calculated slope will yield the spring constant, *k*. **SE:** Ch6 Rev Prob, p138, #9 **IM:** Inv 6.3, p40-43
		H.P.2C.5 Use mathematical and computational thinking to apply Fnet = ma to analyze problems involving contact interactions and gravity **SE:** Ch6 Rev Concept, p137, #4, 6, 9, Prob #4 , 5, 10b Ch7 Rev, p163, #20, p164, #10ab,11-14 Ch10 Rev Prob, p221,#1, 2b, 3a Also online Chapter 6, 7,10 Problem sets **IM:** Inv 3.3, p19-20 Inv 4.3, p25-26 Inv 6.2, p37-39 Inv 6.3, p40-43
	H.P.2D: The non-contact (at a distance) interactions among objects and their subsequent motion can be explained and predicted by analyzing the gravitational, electric, and magnetic forces acting on the objects and applying Newton's laws of motion. These non-contact forces can be represented as fields. **SE: Sections 8.3, 18.1, 21.1, 21.2, 21.3, 22.1, 22.2, 22.3, 23.1, 23.2, 23.3, 29.3**	**H.P.2D.1** Develop and use models (such as computer s, demonstrations, diagrams, and drawings) to explain how neutral objects can become charged and how objects mutually repel or attract each other and include the concept of conservation of charge in the explanation. **SE:** Ch21 Rev, p459, #21 Ch22 Rev, p467, #1-5, 7 Also online Paramagnetism simulation **IM:** Inv 21.1, p170 Inv 21.3, p176 Inv 22.1, p179 Inv 22.2, p180

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2D (cont.):** The non-contact (at a distance) interactions among objects and their subsequent motion can be explained and predicted by analyzing the gravitational, electric, and magnetic forces acting on the objects and applying Newton's laws of motion. These non-contact forces can be represented as fields. **SE: Sections 8.3, 18.1, 21.1, 21.2, 21.3, 22.1, 22.2, 22.3, 23.1, 23.2, 23.3, 29.3**	**H.P.2D.2** Use mathematical and computational thinking to predict the relationships among the masses of two objects, the attractive gravitational force between them, and the distance between them (Newton's Law of Universal Gravitation, $F=Gm_1m_2/r^2$). **SE:** Ch8 Rev, p180, #8 Also online Chapter 8 Problem set **IM:** Inv 8.3, p60
		H.P.2D.3 Obtain information to communicate how long-term gravitational interactions govern the evolution and maintenance of large-scale structures in the universe (such as the solar system and galaxies) and the patterns of motion within them. **SE:** Ch30.1, p638-641 Also Chapter 30 Connection: Hadron Collider
		H.P.2D.4 Use mathematical and computational thinking to predict the relationships among the charges of two particles, the attractive or repulsive electrical force between them, and the distance between them (Coulomb's Law. $F=kq_1q_2/r^2$). **SE:** Ch21.2 , p460, #1-4 Also online Chapter 21 Problem set **IM:** Inv 21.2, p173
		H.P.2D.5 Construct explanations for how the non-contact forces of gravity, electricity, and magnetism can be modeled as fields by sketching field diagrams for two given charges, two massive objects, or a bar magnet and use these diagrams to qualitatively interpret the direction and magnitude of the force at a particular location in the field. **SE:** Ch22 Rev Prob, p476, #1 Also online Chapter 22 Problem set

Interactions and Forces	Conceptual Understanding	Performance Indicators
Standard H.P.2 (cont.): The student will demonstrate an understanding of how the interactions among objects and their subsequent motion can be explained and predicted using the concept of forces.	**H.P.2D (cont.):** The non-contact (at a distance) interactions among objects and their subsequent motion can be explained and predicted by analyzing the gravitational, electric, and magnetic forces acting on the objects and applying Newton's laws of motion. These non-contact forces can be represented as fields. **SE: Sections 8.3, 18.1, 21.1, 21.2, 21.3, 22.1, 22.2, 22.3, 23.1, 23.2, 23.3, 29.3**	**IM:** Inv 21.1, p172, Part3e Inv 22.1, p181, Part3, Part4 Inv 22.3, p184, Part5c
		H.P.2D.6 Use a free-body diagram to represent the gravitational force on an object. **IM:** Inv 8.2, p, Part2cd
		H.P.2D.7 Use a free-body diagram to represent the electrical force on a charge. **IM:** Inv 21.1, p172, Part3e
		H.P.2D.8 Develop and use models (such as computer simulations, drawings, or demonstrations) to explain the relationship between moving charged particles (current) and magnetic forces and fields. **SE:** Ch23 Rev Prob p498, #8, 9, Applying #1 Also online Electromagnetic Induction simulation **IM:** Inv 23.1, p186 Inv 23.2, p193, Part2, Part5
		H.P.2D.9 Use Newton's Law of Universal Gravitation and Newton's second law of motion to explain why all objects near Earth's surface have the same acceleration. **IM:** Inv 4.3, p26, Part3 Inv 6.1, p36, Part2,3 Inv 8.3, p60, Part1
		H.P.2D.10 Use mathematical and computational thinking to apply F_{net} = ma to analyze problems involving non-contact interactions, including objects in free fall. **SE:** Ch4 Rev Prob, p97, #5, 6, p98, #11, 12, 13 Ch5 Rev Prob, p116, #7-9 Also online Chapter 4, 5, Problem sets **IM:** Inv 4.3, p26, Part3

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3: The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3A:** Work and energy are equivalent to each other. Work is defined as the product of displacement and the force causing that displacement; this results in the transfer of mechanical energy. Therefore, in the case of mechanical energy, energy is seen as the ability to do work. This is called the work-energy principle. The rate at which work is done (or energy is transformed) is called power. For machines that do useful work for humans, the ratio of useful power output is the efficiency of the machine. For all energies and in all instances, energy in a closed system remains constant. **SE: Sections 10.1, 10.2, 10.3, 11.2, 12.1, 12.2, 12.3**	**H.P.3A.1** Use mathematical and computational thinking to determine the work done by a constant force (W = Fd). **SE:** Ch10 Rev Prob, p221, #1,, p222, #5, 6, p222 Applying #3 Also online Chapter 10 Problem set **IM:** Inv 10.2, p75, Parts3-4 Inv 11.2, p83-84, Parts2-5
		H.P.3A.2 Use mathematical and computational thinking to analyze problems dealing with the work done on or by an object and its change in energy. **SE:** Ch10 Rev Prob, p222, #7, 8abcde Also online Chapter 10 Problem set **IM:** Inv 10.2, p75, Part5 Inv 11.2, p83-85, Parts2-5
		H.P.3A.3 Obtain information to communicate how energy is conserved in elastic and inelastic collisions. **SE:** Ch12 Rev p262, Applying #2 Ch12 Connection: Jet Engines p257-258 **IM:** Inv 12.1, p87-88
		H.P.3A.4 Plan and conduct controlled scientific investigations to determine the power output of the human body. **IM:** Inv 11.2, p83-85
		H.P.3A.5 Obtain and communicate information to describe the efficiency of everyday machines (such as automobiles, hair dryers, refrigerators, and washing machines). **SE:** Ch11 Rev Prob , p241, #1 **IM:** Inv10.1, p68-72 Inv11.1, p80-82

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3B:** Mechanical energy refers to a combination of motion (kinetic energy) and stored energy (potential energy). When only conservative forces act on an object and when no mass is converted to energy, mechanical energy is conserved. Gravitational and electrical potential energy can be modeled as energy stored in the fields created by massive objects or charged particles. **SE: Sections 4.1, 5.2, 7.1, 8.1, 8.2, 8.3, 10.2, 11.3, 12.2** Also Chapter Connections: Hydroelectric Power p218-219 Energy from Tides Connection p238-239	**H.P.3B.1** Develop and use models (such as computer simulations, drawings, bar graphs, and diagrams) to exemplify the transformation of mechanical energy in simple systems and those with periodic motion and on which only conservative forces act. **SE:** Ch10 Rev, p221, #1, p222 #4, 8 Ch11 Rev p241, #15 Ch13 Rev Prob, p281, #4, p282, #6, Applying #1 Also online Pendulum simulation Also online Chapter 10, 11, 13 Problem sets **IM:** Inv 10.2, p73-76 Inv 11.3, p86
		H.P.3B.2 Use mathematical and computational thinking to argue the validity of the conservation of mechanical energy in simple systems and those with periodic motion and on which only conservative forces act ($KE = \frac{1}{2} mv^2$, $PE_g = mgh$, $PE_e = \frac{1}{2} kx^2$). **SE:** Ch10 Rev Concepts , p222, #7, 8, 9, 10 Ch11 Rev Prob, p242, #5, 7 Also online Chapter 10, 11, 13 Problem sets **IM:** Inv 10.3, p77-79 Inv 11.1, p80-82 Inv 11.3, p86
		H.P.3B.3 Use drawings or diagrams to identify positions of relative high and low potential energy in a gravitational and electrical field (with the source of the field being positive as well as negative and the charge experiencing the field being positive as well as negative). **SE:** See online Chapter 22 Problem set **IM:** Inv 22.3, p184-185

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3C:** When there is a temperature difference between two objects, an interaction occurs in the form of a transfer of thermal energy (heat) from the hotter object to the cooler object. Thermal energy is the total internal kinetic energy of the molecules and/or atoms of a system and is related to temperature, which is the average kinetic energy of the particles of a system. Energy always flows from hot to cold through the processes of conduction, convection, or radiation. **SE: Sections 8.1, 9.2, 25.2, 25.3, 26.1, 26.2** **Also** Ch 25 Connection Refrigeration p236-237 Ch 26 Connection Energy Efficient Buildings p556-557	**H.P.3C.1** Plan and conduct controlled scientific investigations to determine the variables that affect the rate of heat transfer between two objects. **IM:** Inv 25.3, p209-211 Inv 26.1, ,p212-214 Inv 26.2 ,p215-216 Inv 26.3, p217-220
		H.P.3C.2 Analyze and interpret data to describe the thermal conductivity of different materials. **IM:** Inv 26.1, ,p212-214
		H.P.3C.3 Develop and use models (such as a drawing or a small-scale greenhouse) to exemplify the energy balance of the Earth (including conduction, convection, and radiation). **SE:** Ch26 Rev, p560, Applying #1 **IM:** Inv 26.2 ,p215-216 Inv 26.3, p217-220
	H.P.3D: Sound is a mechanical, longitudinal wave that is the result of vibrations (kinetic energy) that transfer energy through a medium. **SE: Sections 13.1, 13.2, 13.3, 14.1, 14.2, 14.3, 15.1, 15.2, 15.3**	**H.P.3D.1** Develop and use models (such as drawings) to exemplify the interaction of mechanical waves with different boundaries (sound wave interference) including the formation of standing waves and two-source interference patterns. **SE:** Ch14 Rev, p 305, Prob #5, #6, p306 #7, #8, #9, #10 Also online Chapter 14 Problem Set **IM:** Inv 15.2, p113-115 Part 1, Part 2
		H.P.3D.2 Use the principle of superposition to explain everyday examples of resonance (including musical instruments and the human voice). **SE:** Ch14 Rev, p 305 Prob #6, 328 Ch15 Rev, p328 Concept #5, #11, #17, 328 Problem #1

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3D (cont.):** Sound is a mechanical, longitudinal wave that is the result of vibrations (kinetic energy) that transfer energy through a medium. **SE: Sections 13.1, 13.2, 13.3, 14.1, 14.2, 14.3, 15.1, 15.2, 15.3**	**IM:** Inv 15.2 p 114, Part 2b (interference in a concert hall relating to superposition), p115, Part4ab (superposition of sound generator and tuning fork – beats)
		H.P.3D.3 Develop and use models to explain what happens to the observed frequency of a sound wave when the relative positions of an observer and wave source changes (Doppler effect). **SE:** Ch15.2, p315 Ch15 Rev, p329, #5, p330 #10 Also online Chapter 15 Problem set
		H.P.3D.4 Use mathematical and computational thinking to analyze problems that relate the frequency, period, amplitude, wavelength, velocity, and energy of sound waves. **SE:** Ch13 Rev, p281, Prob #3, #4, #5, p282, #6, #7, #8, #9, #10, #11 Ch14 Rev, p305, Prob 31, #2, #3, #4, #5b, p306 #7, #8, #9, #10 Ch15 Rev , p328, #1, #2, #3 Also online Chapter 13,14,15 Problem sets **IM:** Inv 13.1 , p95, Part 5c Inv 13.2, p97, Part 4a Inv 13.3, p Inv 14.1 , p, Part Inv 14.2, p Inv 14.3, p Inv 15.1 , p, Part Inv 15.2, p Inv 15.3, p

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3E:** During electric circuit interactions, electrical energy (energy stored in a battery or energy transmitted by a current) is transformed into other forms of energy and transferred to circuit devices and the surroundings. Charged particles and magnets create fields that store energy. Magnetic fields exert forces on moving charged particles. Changing the magnetic fields cause electrons in wires to move, creating current. **SE: Sections 19.1, 19.2, 19.3, 20.1, 20.2, 20.3, 21.1, 21.2, 21.3, 22.1, 22.2, 22.3, 23.1, 23.2, 23.3, 24.1, 24.2, 24.3**	**H.P.3E.1** Plan and conduct controlled scientific investigations to determine the relationship between the current and potential drop (voltage) across an Ohmic resistor. Analyze and interpret data to verify Ohm's law, including constructing an appropriate graph in order to draw a line-of-best-fit whose calculated slope will yield *R*, the resistance of the resistor. **IM:** Inv 19.2, p152-155 Inv 19.3, p156-159 Inv 20.1, p160-163
		H.P.3E.2 Develop and use models (such as circuit drawings and mathematical representations) to explain how an electric circuit works by tracing the path of the electrons and including concepts of energy transformation, transfer, and the conservation of energy and electric charge. **SE:** Ch19 Rev, p417 Concept #3, #4, p418, #9 Ch20 Rev, p437, Concept #7, p438 Prob #2, #3, #4,#6, Applying #3 Ch21 Rev, p459, #21 **IM:** Inv 19.1, p1501-51 Inv 19.2, p152-154
		H.P.3E.3 Use mathematical and computational thinking to analyze problems dealing with current, electric potential, resistance, and electric charge. **SE:** Ch19 Rev, p417, Prob #1-4, p481 #5-8 Ch20 Rev, p438 Prob #1-#9 Ch21 Rev, p459, Concept #23, p460Prob1-6. Also online Chapter 19, 20, 21 Problem sets **IM:** Inv 19.3, p 158, Part3cd, p159, Part5d Inv 20.1, p161, Part4#1a, p163, Part6ah Inv 20.2, p165, Part3hi Inv 21.2, p175, Part2c Inv 24.2, p200, Part3bfg

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3E (cont.):** During electric circuit interactions, electrical energy (energy stored in a battery or energy transmitted by a current) is transformed into other forms of energy and transferred to circuit devices and the surroundings. Charged particles and magnets create fields that store energy. Magnetic fields exert forces on moving charged particles. Changing the magnetic fields cause electrons in wires to move, creating current. **SE: Sections 19.1, 19.2, 19.3, 20.1, 20.2, 20.3, 21.1, 21.2, 21.3, 22.1, 22.2, 22.3, 23.1, 23.2, 23.3, 24.1, 24.2, 24.3**	**H.P.3E.4** Use mathematical and computational thinking to analyze problems dealing with the power output of electric devices. **SE:** Ch20 Rev, p438 Concept #15, Prob #7, #8, #9 **IM:** Inv 11.2, p84 Part2 Inv 20.3, p167-169
		H.P.3E.5 Plan and conduct controlled scientific investigations to determine how connecting resistors in series and in parallel affects the power (brightness) of light bulbs. **IM:** Inv 20.1, p160-163
		H.P.3E.6 Obtain and communicate information about the relationship between magnetism and electric currents to explain the role of magnets and coils of wire in microphones, speakers, generators, and motors. **SE:** Ch23 Connection MagLev Trains, p494-495 **IM:** Inv 23.1, p186-187 Inv 23.2, p188-192 Inv 23.3, p193-196
		H.P.3E.7 Design a simple motor and construct an explanation of how this motor transforms electrical energy into mechanical energy and work. **IM:** Inv23.1, p186-187 Inv23.2, p188-192 Or Engineering DC p272 Inv23.3, p193-196

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3F:** During radiant energy interactions, energy can be transferred over long distances without a medium. Radiation can be modeled as an electromagnetic wave or as a stream of discrete packets of energy (photons); all radiation travels at the same speed in a vacuum (speed of light). This electromagnetic radiation is a major source of energy for life on Earth. **SE: Sections 16.1, 16.2, 16.3, 17.1, 17.2, 17.3, 18.1, 18.2, 18.3**	**H.P.3F.1** Construct scientific arguments that support the wave model of light and the particle model of light. **IM:** Inv 16.1, p121-122 Inv 16.3, p126-128 Inv 18.2 , p143-145, Part4
		H.P.3F.2 Plan and conduct controlled scientific investigations to determine the interaction between the visible light portion of the electromagnetic spectrum and various objects (including mirrors, lenses, barriers with two slits, and diffraction gratings) and to construct explanations of the behavior of light (reflection, refraction, transmission, interference) in these instances using models (including ray diagrams). **IM:** Inv 16.1, p120-122 Inv 16.2, p124, Part6 Inv 17.1, p129-133 Inv 17.2, p134-137 Inv 17.3, p138-141 Inv 18.1, p142 Inv 18.3, p143-146
		H.P.3F.3 Use drawings to exemplify the behavior of light passing from one transparent medium to another and construct explanations for this behavior. **IM:** Inv 17.1, p129-133 Inv 17.2, p134-137 Inv 17.3, p138-141

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3F (cont.):** During radiant energy interactions, energy can be transferred over long distances without a medium. Radiation can be modeled as an electromagnetic wave or as a stream of discrete packets of energy (photons); all radiation travels at the same speed in a vacuum (speed of light). This electromagnetic radiation is a major source of energy for life on Earth. **SE: Sections 16.1, 16.2, 16.3, 17.1, 17.2, 17.3, 18.1, 18.2, 18.3**	**H.P.3F.4** Use mathematical and computational thinking to analyze problems that relate the frequency, period, amplitude, wavelength, velocity, and energy of light. **SE:** Ch18 Rev , p **IM:** Inv 18.1, p142 Inv18.2, p142-145
		H.P.3F.5 Obtain information to communicate the similarities and differences among the different bands of the electromagnetic spectrum (including radio waves, microwaves, infrared, visible light, ultraviolet, and gamma rays) and give examples of devices or phenomena from each band. **IM:** Inv 18.1, p142
		H.P.3F.6 Obtain information to construct explanations on how waves are used to produce, transmit, and capture signals and store and interpret information (including ultrasound imaging, telescopes, cell phones, and bar code scanners). **SE:** Ch22 Connection, p473-474

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3G:** Nuclear energy is energy stored in an atom's nucleus; this energy holds the atom together and is called binding energy. Binding energy is a reflection of the equivalence of mass and energy; the mass of any nucleus is always less than the sum of the masses of the individual constituent nucleons that comprise it. Binding energy is also a measure of the strong nuclear force that exists in the nucleus and is responsible for overcoming the repulsive forces among protons. The strong and weak nuclear forces, gravity, and the electromagnetic force are the fundamental forces in nature. Strong and weak nuclear forces determine nuclear sizes, stability, and rates of radioactive decay. At the subatomic scale, the conservation of energy becomes the conservation of mass-energy. **SE: Sections 28.1, 28.2, 28.3, 29.1, 29.2, 29.3**	**H.P.3G.1** Develop and use models to represent the basic structure of an atom (including protons, neutrons, electrons, and the nucleus). **SE:** Ch21 Rev, p459,Concept #5, 13 Ch28 Rev, p **IM:** Inv28.1, p229-232 Inv28.2, p233-234
		H.P.3G.2 Develop and use models (such as drawings, diagrams, computer simulations, and demonstrations) to communicate the similarities and differences between fusion and fission. Give examples of fusion and fission reactions and include the concept of conservation of mass-energy. **SE:** Ch29 Rev, p635, Concept #18, Prob #8 Also online Nuclear Power Plant simulation **IM:** Inv29.3, p242-243
		H.P.3G.3 Construct scientific arguments to support claims for or against the viability of fusion and fission as sources of usable energy. **SE:** Ch29 Rev, p634, Concept#11, 12, 13 **IM:** Inv29.3, p242-243

Interactions and Energy	Conceptual Understanding	Performance Indicators
H.P.3 (cont.): The student will demonstrate an understanding of how the interactions among objects can be explained and predicted using the concept of the conservation of energy.	**H.P.3G (cont.):** Nuclear energy is energy stored in an atom's nucleus; this energy holds the atom together and is called binding energy. Binding energy is a reflection of the equivalence of mass and energy; the mass of any nucleus is always less than the sum of the masses of the individual constituent nucleons that comprise it. Binding energy is also a measure of the strong nuclear force that exists in the nucleus and is responsible for overcoming the repulsive forces among protons. The strong and weak nuclear forces, gravity, and the electromagnetic force are the fundamental forces in nature. Strong and weak nuclear forces determine nuclear sizes, stability, and rates of radioactive decay. At the subatomic scale, the conservation of energy becomes the conservation of mass-energy. **SE: Sections 28.1, 28.2, 28.3, 29.1, 29.2, 29.3**	**H.P.3G.4** Use mathematical and computational thinking to predict the products of radioactive decay (including alpha, beta, and gamma decay). **SE:** Ch29 Rev, p634, Concept #2, p635, #6, 7 p636 Prob #9, #10 **IM:** Inv29.1, p238-239 Inv29.2, p240-241
		H.P.3G.5 Obtain information to communicate how radioactive decay processes have practical applications (such as food preservation, cancer treatments, fossil and rock dating, and as radioisotopic medical tracers). **SE:** Ch29 Rev, p634 Conc #8, #9 Also Chapter Connection Nuclear Power p635-636 **IM:** Inv 29.2 p240-241, Part 3, 4, 5.