

Correlation to California Science Content Standards

Physics: A First Course

Student Text and Investigation Manual

Standard #: Subject	Topic	Standard	Benchmark	Volume One Student Text Page	Volume Two Investigation Manual Page
InqHS.01.a Investigation and Experimentation	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.	11 measurement 12 metric system 13 measuring time	computer spreadsheets and graphing software can be used throughout the curriculum for data analysis and presentation 1 collect accurate, precise data with electronic timer 2 using timers and photogates 7 collect precise data 27 how can photogate ensure consistent results? 44 using a timer and photogates 46 using a timer and photogates 61 collect and record resistance data 78 estimate the precision of measurements 86 use a timer and photogate to measure speed of rotor 93 use a timer and photogate to measure the period of a pendulum 96 use a timer and photogate to measure the natural frequency of an oscillator

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					150 using computer spreadsheets
InqHS.01.b Investigation and Experimentation	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Identify and communicate sources of unavoidable experimental error.	11 importance of units 11 communicating via measurement 11 measurement 12 metric system 13 measuring time	1 collect accurate, precise data with electronic timer 3 car launching technique is a possible source of error 4 car launching technique is a possible source of error 7 collect precise data 21 how close is your prediction to the actual measurement? 26 spotting the landing point of the marble is tricky 27 marble launching technique is a possible source of error 27 how can photogate ensure consistent results? 52 find a percentage 78 estimate the precision of measurements

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InqHS.01.c Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.	6 8 8 8 8 16 16 24	3 4 4 6 6 7 9 11 21 26 27 27 27 47
				what is a variable cause and effect relationships control and experimental variables dependent variables independent variables graphs and dependent variables graphs and independent variables importance of changing one variable at a time in an experiment	car launching technique is a possible source of error use photogate A to monitor repeatability car launching technique is a possible source of error reflecting on the experiment recognize and control variables construct explanations supported by evidence how do your observations support your answer? what experimental data support answer? how close is your prediction to the actual measurement? spotting the landing point of the marble is tricky practice your technique until it is repeatable identify and control variables marble launching technique is a possible source of error construct a reasonable explanation

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					52 find a percentage 60 propose a relationship between power and voltage 94 investigate variables and how they affect the period of a pendulum

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InqHS.01.d Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Formulate explanations by using logic and evidence.	8 cause and effect relationships	6 reflecting on the experiment 6 do results agree with hypothesis? 6 reflecting on the experiment 7 construct explanations supported by evidence 7 construct explanations supported by evidence 9 how do your observations support your answer? 9 how do your observations support your answer? 11 what experimental data support answer? 11 what experimental data support answer? 47 construct a reasonable explanation 47 construct a reasonable explanation 52 find a percentage 60 propose a relationship between power and voltage 60 propose a relationship between power and voltage 67 explain what happened

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InqHS.01.e Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.	19 26 34 35 41 43 61 62 68 86 89 96 118 141 143 144 145 153 179 193	mathematical descriptions interpreting distance/time graph mathematical model of acceleration Newton's second law equation average speed equation calculating weight momentum equation relating impulse and momentum conservation kinetic energy formula the work equation the power equation calculating mechanical advantage Hooke's law equation projectile motion problems calculating angular speed finding the circumference of a circle linear speed equation equation for law of universal gravitation the heat equation density formula	11 13 17 17 29 29 31 69 75 76 99 154	find formula for acceleration derive a formula calculate mechanical advantage derive a formula to use with ropes and pulleys find a mathematical name for the steepness ratio calculate the ratio calculate temperature of mixture calculate power used by the bulb derive a formula to calculate the charge calculate the number of electrons calculate natural frequency and period calculate gear ratio

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Standard #: Subject	Topic	Standard	Benchmark	Volume One Student Text Page	Volume Two Investigation Manual Page
				208 pressure and temperature relationship 308 equation for Ohm's law 342 equation for Coulomb's law 438 calculating wave speeds 439 equation for the speed of a wave 525 equation for the speed of light	
InqHS.01.f Investigation and Experimentation	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Distinguish between hypothesis and theory as scientific terms.	8 scientific method 8 formulating a hypothesis 22 scientific method in action	6 form a hypothesis 30 state a hypothesis about the water's energy 31 did result agree with hypothesis? 94 state a hypothesis about period of pendulum 96 state a hypothesis about the natural frequency of the oscillator

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InqHS.01.g Investigation and Experimentation	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Recognize the usefulness and limitations of models and theories as scientific representations of reality.	10 what is a model 16 constructing graphs 16 steps to follow for graph construction 19 mathematical models 19 mathematical descriptions 25 constructing a graph 26 interpreting distance/time graph 34 mathematical model of acceleration 35 Newton's second law equation 41 average speed equation 43 calculating weight 46 motion graphs 48 motion graphs 61 momentum equation 62 relating impulse and momentum conservation 68 kinetic energy formula 86 the work equation 89 the power equation 96 calculating mechanical advantage 112 using a graph to find force vector components	4 construct a graph 11 find formula for acceleration 11 create a graph 13 derive a formula 15 graph speed vs. height 17 derive a formula to use with ropes and pulleys 17 calculate mechanical advantage 20 graph work done vs. deflection of rubber band 21 graph speed vs. rubber band deflection 25 graph friction vs. mass 27 graph launch angle vs. range 29 calculate the ratio 29 find a mathematical name for the steepness ratio 29 graph acceleration vs. steepness ratio 31 calculate temperature of mixture 45 make a graph of efficiency vs. speed 50 graph time vs. temperature

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				118	Hooke's law equation	52	construct a graph
				141	projectile motion problems	69	calculate power used by the bulb
				143	calculating angular speed	75	graph current vs. time for the capacitor
				144	finding the circumference of a circle	75	derive a formula to calculate the charge
				145	linear speed equation	76	calculate the number of electrons
				153	equation for law of universal gravitation	86	graph voltage vs. speed
				179	the heat equation	94	sketch harmonic motion graphs
				193	density formula	99	calculate natural frequency and period
				208	pressure and temperature relationship	154	calculate gear ratio
				308	equation for Ohm's law		
				342	equation for Coulomb's law		
				419	harmonic motion graphs		
				420	finding the amplitude on a harmonic motion graph		
				438	calculating wave speeds		
				439	equation for the speed of a wave		
				525	equation for the speed of light		

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InqHS.01.j Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Recognize the issues of statistical variability and the need for controlled tests.	4 6 8 8 8 16 16 24	6 27 71 94
				what is analysis what is a variable control and experimental variables dependent variables independent variables graphs and dependent variables graphs and independent variables importance of changing one variable at a time in an experiment	recognize and control variables identify and control variables find the average of the three times investigate variables and how they affect the period of a pendulum

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InqHS.01.k Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Recognize the cumulative nature of scientific evidence.	23 23 28 167 218 218 219 219 219 230 231 231 232	science helps us learn about natural world science helps us learn about natural world Newton's idea of force history of atomic theory contributions of John Dalton atomic theory contributions of Rutherford contributions of J. J. Thomson development of atom models contributions of Bohr Pauli's contributions contributions of Schrödinger contributions of Heisenberg	6 15 21 30 45 47 96	predict fastest car predict speed of car predict speed of car predict temperature of mixture predict how many bounces the car will make suggest a design modification make predictions about natural frequency

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InqHS.01.l Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Analyze situations and solve problems that require combining and applying concepts from more than one area of science.	104 connection to life science: prosthetic legs and technology 186 connection to chemistry: extraordinary materials 212 connection to life science: deep water submarine 234 indirect evidence and archaeology 254 energy in the ocean 274 cook or chemist? 312 electric circuits in your body 354 connection to earth science: lightning 374 What is an MRI scanner? 408 space weather is magnetic 492 northern lights 516 retinal implants	48 connection to chemistry 89 connection to earth science: gravitational fields 111 connection to life science: photoreceptors in the eye 167 building a sundial: earth science connection

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InqHS.01.m Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources...	104 122 247 247 254 255 255 335	112 157 157 161
				prosthetic legs and technology maglev train technology burning gasoline and low efficiency sources of electrical power in the United States generating electricity from the ocean's energy energy in the ocean impact of generating electricity on the environment using hybrid cars	research how computer monitors and televisions make colros research electricity generation methods compare economic and environmental impact of using different energy sources making a model maglev train

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InqHS.01.n Investigation and Experimentatio n	Standard	Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop questions and perform investigations.	Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent and that the theory is sometimes wrong.		<p>3 car launching technique is a possible source of error</p> <p>4 use photogate A to monitor repeatability</p> <p>4 car launching technique is a possible source of error</p> <p>6 do results agree with hypothesis?</p> <p>21 how close is your prediction to the actual measurement?</p> <p>26 spotting the landing point of the marble is tricky</p> <p>27 practice your technique until it is repeatable</p> <p>27 marble launching technique is a possible source of error</p> <p>31 did result agree with hypothesis?</p>

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PhysHS.01.a Physics	Motion and Forces	Newton's law predicts the motion of most objects.	Students know how to solve problems that involve constant speed and average speed.	18 56 speed units calculate speed from distance/time graph	3 find the speed of the car 7 measure the speed 9 why did the speed change? 10 find speed of car 21 measure speed of car 25 calculate speed of car 44 experiment and find average speed 46 measure speed of car

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Standard #: Subject	Topic	Standard	Benchmark	Volume One Student Text Page	Volume Two Investigation Manual Page		
PhysHS.01.b Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).	16	constructing graphs	4	construct a graph
				16	steps to follow for graph construction	8	investigate Newton's first law of motion
				25	constructing a graph	11	create a graph
				29	Newton's first law	11	speed vs. time graph
				32	acceleration defined	15	graph speed vs. height
				36	balanced and unbalanced forces	20	graph work done vs. deflection of rubber band
				46	motion graphs	21	graph speed vs. rubber band deflection
				48	speed vs. time graph	25	graph friction vs. mass
				48	motion graphs	27	graph launch angle vs. range
				49	speed vs. time graph for accelerating motion	29	graph acceleration vs. steepness ratio
				51	finding distance from a speed vs. time graph	45	make a graph of efficiency vs. speed
				112	using a graph to find force vector components	50	graph time vs. temperature
				419	harmonic motion graphs	52	construct a graph
				420	finding the amplitude on a harmonic motion graph	61	collect and record resistance data
						75	graph current vs. time for the capacitor
						86	graph voltage vs. speed
						94	sketch harmonic motion graphs

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PhysHS.01.c Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know how to apply the law $F=ma$ to solve one-dimensional motion problems that involve constant forces (Newton's second law).	35	quantitative understanding of second law	10	investigate Newton's second law of motion
				35	Newton's second law	23	Newton's second law of motion
				36	applying Newton's second law properly	25	apply Newton's second law of motion
				37	using second law formula	29	apply Newton's second law of motion
				424	Newton's second law and oscillators	95	Newton's 2nd law of motion and natural frequency
PhysHS.01.d Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).	52	action-reaction pairs	12	investigate Newton's 3rd law of motion
				59	Newton's third law	13	relate Newton's 3rd law of motion to car collisions
				60	sorting out force pairs		
				78	third law and rockets		
				117	Newton's third law and springs		
				128	the third law and physics of walls		
158	Newton's third law and helicopters						

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PhysHS.01.e Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of the Earth.	39	calculations pertaining to free fall	26	investigate projectile motion
				39	effect of gravity on motion		
				52	acceleration shown through strobe photography		
				88	work and gravity		
				137	projectile explained		
				138	free fall component of a trajectory		
				153	Newton's law of universal gravitation explained		
402	gravitational field						

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PhysHS.01.f Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed(e.g.,Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).	39	effect of gravity on motion	23	draw a free body diagram
				39	calculations pertaining to free fall	23	use force vectors
				52	acceleration shown through strobe photography	26	investigate projectile motion
				88	work and gravity		
				111	force vectors		
				113	using a free-body diagram		
				115	finding resultant vector		
				137	projectile explained		
				138	free fall component of a trajectory		
				142	angular speed vs. linear speed		
				143	angular speed formula		
				145	calculating linear speed for a rotating object		
				147	centripetal force		
				148	centripetal force		
				149	Newton's second law and circular motion		
				153	Newton's law of universal gravitation explained		
				154	understanding orbital motion		
				402	gravitational field		

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PhysHS.01.g Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know circular motion requires the application of a constant force directed towards the center of the circle.	142 angular speed vs. linear speed 143 angular speed formula 145 calculating linear speed for a rotating object 147 centripetal force 148 centripetal force 149 Newton's second law and circular motion 154 understanding orbital motion	
PhysHS.01.h Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know Newton's laws are not exact but provide very good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.	280 meaning of Einstein's formula 284 theory of special relativity	53 explore the concept of relativity 55 a thought experiment on Einstein's theories

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PhysHS.01.I Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know how to solve two-dimensional trajectory problems.	17	speed of light	6	how can speed be measured?
				17	speed defined	8	investigate Newton's first law of motion
				18	calculating speed	24	investigate effect of friction
				29	Newton's first law	26	investigate projectile motion
				39	calculations pertaining to free fall		
				39	effect of gravity on motion		
				45	skydiving and terminal speed		
				45	terminal speed		
				45	effects of air resistance		
				52	acceleration shown through strobe photography		
				88	work and gravity		
				94	friction and machines		
				101	friction explained		
				119	cause of friction		
				119	friction explained		
				120	static and sliding friction		
				122	reducing friction		
				123	useful friction		
				136	working with velocity vector		
				137	projectile explained		

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				138 free fall component of a trajectory 143 angular speed 402 gravitational field 418 friction and damping	
PhysHS.01.j Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.	61 momentum is calculated with velocity – not speed 61 momentum is calculated with velocity – not speed 111 force vectors 112 resolving vectors 113 using a free-body diagram 115 finding resultant vector	23 draw a free body diagram 23 use force vectors
PhysHS.01.k Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know how to solve two-dimensional problems involving balanced forces (statics).	36 balanced and unbalanced forces 45 effects of air resistance 94 friction and machines 101 friction explained 119 cause of friction 119 friction explained 120 static and sliding friction 122 reducing friction 123 useful friction 418 friction and damping	24 investigate effect of friction

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PhysHS.01.l Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know how to solve problems in circular motion by using the formula for centripetal acceleration in the following form: $a=v^2/r$.	143 angular speed formula 145 calculating linear speed for a rotating object 149 Newton's second law and circular motion	
PhysHS.01.m Physics	Motion and Force	Newton's law predicts the motion of most objects.	Students know how to solve problems involving the forces between two electric charges at a distance (Coulomb's law) or the forces between two masses at a distance (universal gravitation).	153 Newton's law of universal gravitation explained 340 understanding coulombs 342 electric forces are very strong 342 understanding Coulomb's law 404 the electric field	89 understand and investigate electric and gravitational fields

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PhysHS.02.a Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know how to calculate kinetic energy by using the formula $E=(1/2)mv^2$.	67	potential energy explained	14	investigate exchange of energy in car and track system
				67	calculating potential energy	15	apply law of energy conservation
				68	potential to kinetic energy conversions	15	calculate potential energy of car
				68	kinetic energy explained	24	calculate kinetic energy of sled
				68	calculating kinetic energy	47	calculate energy
				69	kinetic energy and stopping distance of a car		
				70	potential to kinetic energy conversions		
				70	law of conservation of energy		
				71	using energy conservation to solve problems		
				117	potential and kinetic energy in a spring		
				249	mechanical systems and energy		
				249	energy flow diagram for mechanical systems		

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PhysHS.02.b Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know how to calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) = mgh (h is the change in the elevation).	67	calculating potential energy	15	calculate potential energy of car
				68	calculating kinetic energy	24	calculate kinetic energy of sled
				69	kinetic energy and stopping distance of a car	47	calculate energy
PhysHS.02.c Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know how to solve problems involving conservation of energy in simple systems, such as falling objects.	10	conservation of energy	14	investigate exchange of energy in car and track system
				67	potential energy explained		
				68	kinetic energy explained	15	apply law of energy conservation
				70	law of conservation of energy	42	model how atoms exchange energy
				71	using energy conservation to solve problems	47	draw an energy flow diagram
249	energy flow diagram for mechanical systems						
PhysHS.02.d Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know how to calculate momentum as the product mv .	61	calculating momentum	12	investigate momentum
				61	momentum is calculated with velocity – not speed	13	calculate momentum of two cars
						13	analyze collision data

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PhysHS.02.e Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know momentum is separately conserved quantity different from energy.	63	law of conservation of momentum	13	apply the law of conservation of momentum
				64	using momentum conservation to solve problems		
				74	momentum and collisions		
				77	momentum and car safety		
PhysHS.02.f Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know an unbalanced force on an object produces a change in its momentum.	36	balanced and unbalanced forces	12	investigate momentum
				61	calculating momentum	13	calculate momentum of two cars
						13	analyze collision data

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PhysHS.02.g Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know how to solve problems involving elastic and inelastic collisions in one-dimension by using the principles of conservation of momentum and energy.	10	conservation of energy	11	investigate net force
				31	net force explained	13	apply the law of conservation of momentum
				36	balanced and unbalanced forces	22	when net force is zero
				37	net force and second law calculating	42	model how atoms exchange energy
				63	law of conservation of momentum	44	friction and energy dissipation
				64	using momentum conservation to solve problems	45	describe energy changes
				74	momentum and collisions	46	investigate energy flow in a system
				77	momentum and car safety	47	investigate friction as a part of energy flow
				116	when net force is zero	47	draw an energy flow diagram
				240	energy and systems	57	draw energy flow diagram of the circuit
				243	energy flow diagrams		
				251	energy flow in natural systems		

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PhysHS.02.h Physics	Conservation of Energy and Momentum	The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.	Students know how to solve problems involving conservation of energy in simple systems with various sources of potential energy, such as capacitors and springs.	10 67 68 70 71 249	conservation of energy potential energy explained kinetic energy explained law of conservation of energy using energy conservation to solve problems energy flow diagram for mechanical systems	14 15 42 47	investigate exchange of energy in car and track system apply law of energy conservation model how atoms exchange energy draw an energy flow diagram
PhysHS.03.a Physics	Heat and Thermodynamics	Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat.	Students know heat flow and work are two forms of energy transfer between systems.	94 101 177 181 183 184 240 243 251	work and simple machines output work is always less than input work heat and work heat conduction natural and forced convection thermal radiation energy and systems energy flow diagrams energy flow in natural systems	18 30 44 45 46 47 57	compare and contrast input and output work investigating heat transfer friction and energy dissipation describe energy changes investigate energy flow in a system investigate friction as a part of energy flow draw energy flow diagram of the circuit

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PhysHS.03.b Physics	Heat and Thermodynamics	Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat.	Students know that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature and that this is in an example of the law of conservation	68	potential to kinetic energy conversions	48 investigate energy changes in chemical reactions 157 research electricity generation methods
				70	potential to kinetic energy conversions	
				86	calculating work	
				88	calculating work	
				117	potential and kinetic energy in a spring	
				176	flow of thermal energy is heat	
				177	heat and work	
				185	heat transfer is everywhere	
				247	burning gasoline and low efficiency	
				247	sources of electrical power in the United States	
				249	mechanical systems and energy	
				254	generating electricity from the ocean's energy	
255	energy in the ocean					

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PhysHS.03.c Physics	Heat and Thermodynamics	Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat.	Students know the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy.	176	understanding the difference between heat and temperature	30	investigate difference between temperature and heat
				176	flow of thermal energy is heat	32	investiate concept of specific heat
				177	heat and work		
				178	specific heat explained		
				185	heat transfer is everywhere		

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Standard #: Subject	Topic	Standard	Benchmark	Volume One Student Text Page	Volume Two Investigation Manual Page		
PhysHS.03.d Physics	Heat and Thermodynamics	Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat.	Students know that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly.	68	potential to kinetic energy conversions	45	calculate efficiency of the experimental system
				70	potential to kinetic energy conversions	45	graph efficiency vs. speed
				102	efficiency explained	45	investigate efficiency
				117	potential and kinetic energy in a spring		
				172	kinetic theory and temperature		
				176	flow of thermal energy is heat		
				177	calories explained		
				177	heat and work		
				179	the heat equation		
				181	thermal equilibrium		
				185	heat transfer is everywhere		
				246	efficiency explained		
				247	efficiency of a heat engine		
				248	efficiency of living things		
				249	mechanical systems and energy		
				334	efficiency of gasoline engine		
				334	efficiency of electric motors		

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PhysHS.03.e Physics	Heat and Thermodynamics	Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat.	Students know that entropy is a quantity that measures the order or disorder of a system and that quantity is larger for a more disordered system.	240 system interactions 251 energy flow in natural systems 253 energy flow and food chains	7 examine energy in the system
PhysHS.03.f Physics	Heat and Thermodynamics	Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat.	Students know that statement "Entropy tends to increase" is a law of statistical probability that governs all closed systems (second law of thermodynamics).	9 energy in a system 9 stability of systems 114 systems in equilibrium 128 equilibrium and architecture 178 specific heat explained 240 system interactions 243 energy conservation and closed systems 251 energy flow in natural systems 253 energy flow and food chains 423 restoring forces and equilibrium 423 equilibrium and harmonic motion	7 examine energy in the system 22 investigate equilibrium 32 investigate concept of specific heat

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PhysHS.03.g Physics	Heat and Thermodynamics	Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat.	Students know how to solve problems involving heat flow, work, and efficiency in heat engine and know that all real engines lose some heat to their surroundings.	86	calculating work	18	compare and contrast input and output work
				88	calculating work	45	calculate efficiency of the experimental system
				89	calculating power	45	graph efficiency vs. speed
				90	maximum power output of a person	45	investigate efficiency
				94	work and simple machines		
				101	output work is always less than input work		
				102	efficiency explained		
				244	power explained		
				245	three ways to look at power		
				246	efficiency explained		
				247	efficiency of a heat engine		
				248	efficiency of living things		
				250	power in human technology		
				252	power in natural systems		
				254	wave power		
				254	tidal power		
				334	efficiency of gasoline engine		
334	efficiency of electric motors						

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PhysHS.04.a Physics	Waves	Waves have characteristic properties that do not depend on the type of wave.	Students know waves carry energy from one place to another.	434 waves transmit energy 435 waves and technology 447 waves and energy 455 acoustics 461 how a French horn works 462 acoustics of concert halls 467 how the ear works	
PhysHS.04.b Physics	Waves	Waves have characteristic properties that do not depend on the type of wave.	Students know how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).	436 longitudinal waves 436 transverse waves 440 standing waves on a vibrating string	98 study waves on a string 99 explore transverse waves 100 study water waves 124 relating transverse waves on a spring to light waves
PhysHS.04.c Physics	Waves	Waves have characteristic properties that do not depend on the type of wave.	Students know how to solve problems involving wavelength, frequency, and wave speed.	437 frequency and amplitude and wavelength of waves 438 the speed of waves 461 wavelength of sound	101 investigate standing waves and frequency

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PhysHS.04.d Physics	Waves	Waves have characteristic properties that do not depend on the type of wave.	Students know sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.	415 sound is a wave 435 how to recognize waves 454 sound is a wave 456 speed of sound 458 how sound is recorded 459 sound is a wave 459 sound waves and different media 468 pitch and the musical scale	104 properties of sound waves 105 investigate sound wave interference
PhysHS.04.e Physics	Waves	Waves have characteristic properties that do not depend on the type of wave.	Students know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second).	481 speed of light 523 electromagnetic spectrum 524 wavelength and frequency of visible light 526 low-energy electromagnetic waves 527 high-energy electromagnetic waves 536 the electromagnetic spectrum 537 infrared telescopes	111 mixing primary colors of light 123 investigate visible light wavelengths

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PhysHS.04.f Physics	Waves	Waves have characteristic properties that do not depend on the type of wave.	Students know how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.	442	refracted waves	106	investigate interference and beats
				442	reflected waves	125	explore polarization of light
				443	absorption explained	126	explore the concept of polarization of light
				443	diffraction explained		
				445	destructive interference		
				445	constructive interference		
				457	understanding the Doppler effect		
				469	frequency of sound and beats		
				531	polarization		

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PhysHS.05.a Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know how to predict the voltage or current in simple direct current(DC) electric circuits constructed from batteries, wires, resistors, and capacitors.	299	examples of electric circuits in nature	57	build circuits
				299	electric circuits	57	open and closed circuits
				300	circuit diagrams	58	measure voltage
				301	battery circuits	59	draw and interpret circuit diagrams
				301	open and closed circuits	60	a circuit with a dimmer switch
				303	understanding voltage	60	measure voltage
				304	how batteries work	64	investigating voltage drops
				318	series circuits	65	measure the voltage
				320	voltage in a series circuit	65	investigate series circuits
				323	parallel circuits	65	build a circuit with three bulbs and a switch
				324	voltage in a parallel circuit	66	investigate series circuits
				325	comparing series and parallel circuits	67	investigate short circuits and learn how to avoid
				326	parallel circuits in homes	67	understand why short circuits are dangerous
				326	understanding short circuits	68	investigate parallel circuits
				349	voltage and charge	68	compare series and parallel circuits
				350	how capacitors work	69	construct a simple circuit
				351	voltage and capacitors	70	investigate capacitors
				351	charging a capacitor	75	calculate charge stored in capacitor
				351	capacitors and current		
				352	measuring capacitance		

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PhysHS.05.b Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know how to solve problems involving Ohm's law.	308 Ohm's law 321 Ohm's law and voltage drops	62 investigate Ohm's law 63 use Ohm's law 67 Ohm's law and short circuits 75 work with Ohm's law
PhysHS.05.c Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula $Power = IR$.	300 resistors 306 understanding electrical resistance 307 measuring resistance 309 resistance of common objects 311 resistors 319 resistance in a series circuit 328 calculating power in a circuit 330 direct current	61 investigate resistance 63 investigate resistance and potentiometers 69 finding power used by a circuit 70 explain what you observed in terms of energy and power 71 calculate energy and power
PhysHS.05.e Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.	340 understanding electric charge 341 what causes shocks 341 charged objects and static electricity 354 understanding lightning 404 the electric field	72 investigate the nature of electric charge 89 understand and investigate electric and gravitational fields

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PhysHS.05.f Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.	360 what is a magnet 362 magnetic fields 363 magnetic field lines 374 magnets and MRI scanners 381 magnetic field of a wire 388 Faraday's law of induction 404 the electric field	77 investigate the strength of magnetic force 79 investigate interactions of different materials with magnets 80 compare magnetic force and electric current in an electromagnet 80 explore properties of electromagnets 81 find relationship between current and magnetic field 81 compare electromagnet and permanent magnet 88 investigate magnetic fields 89 understand and investigate electric and gravitational fields 90 use magnetic fields to solve a puzzle

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PhysHS.05.g Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know how to determine the direction of a magnetic field produced by current flowing in a straight wire or in a coil.	298	electric current	59	measure current
				302	current in simple circuits	59	work with volts and amps
				302	measuring electric current	66	current in a series circuit
				303	measuring voltage	74	investigate the flow of electric charge
				305	measuring current with a multimeter	77	investigate the strength of magnetic force
				319	current in a series circuit	79	investigate interactions of different materials with magnets
				323	current in a parallel circuit		
				346	charge and current		
				360	what is a magnet	81	compare electromagnet and permanent magnet
				361	using magnetic forces	88	investigate magnetic fields
				362	magnetic fields	90	use magnetic fields to solve a puzzle
				363	magnetic field lines		
				364	right-hand rule		
				374	magnets and MRI scanners		
				381	magnetic field of a wire		
PhysHS.05.h Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.	364	electromagnets	85	investigate electromagnetic induction
				365	building an electromagnet		
				387	electromagnetic induction explained		

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PhysHS.05.l Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know plasmas, the fourth state of matter, contains ions or free electrons or both and conduct electricity.	173 phases of matter 174 heat energy and molecular motion 175 plasma	34 arrangement of solid, liquid, gas particles 35 comparing equal masses of gas, solid, and liquid 36 solid, liquid, gas density differences
PhysHS.05.j Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know electric and magnetic fields contain energy and act as vector force fields.	360 what is a magnet 362 magnetic fields 363 magnetic field lines 374 magnets and MRI scanners 381 magnetic field of a wire 404 the electric field	77 investigate the strength of magnetic force 79 investigate interactions of different materials with magnets 81 compare electromagnet and permanent magnet 88 investigate magnetic fields 89 understand and investigate electric and gravitational fields 90 use magnetic fields to solve a puzzle
PhysHS.05.k Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know the force on a charged particle in an electric field is qE , where E is the electric field at the position of the particle and q is the charge of the particle.	340 understanding electric charge 341 what causes shocks 341 charged objects and static electricity 354 understanding lightning	72 investigate the nature of electric charge

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PhysHS.05.l Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know how to calculate the electric field resulting from a point charge.	340	understanding electric charge	72	investigate the nature of electric charge
				341	what causes shocks	89	understand and investigate electric and gravitational fields
				341	charged objects and static electricity		
				354	understanding lightning		
				404	the electric field		
PhysHS.05.m Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know static electric fields have as their source some arrangement of electric charges.	340	understanding electric charge	72	investigate the nature of electric charge
				341	what causes shocks	89	understand and investigate electric and gravitational fields
				341	charged objects and static electricity		
				354	understanding lightning		
				404	the electric field		
PhysHS.05.n Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know the magnitude of the force on a moving particle in a magnetic field is $qvB \sin(a)$, where a is the angle between v and B , and the students use the right-hand rule to find the direction of this force.	360	what is a magnet	77	investigate the strength of magnetic force
				362	magnetic fields	79	investigate interactions of different materials with magnets
				363	magnetic field lines		
				364	right-hand rule	81	compare electromagnet and permanent magnet
				374	magnets and MRI scanners	88	investigate magnetic fields
				381	magnetic field of a wire	90	use magnetic fields to solve a puzzle

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PhysHS.05.o Physics	Electric and Magnetic Phenomena	Electric and magnetic phenomena are related and have many practical applications.	Students know how to apply the concepts of electrical and gravitational potential energy to solve problems involving conservation of energy.	10 conservation of energy 67 potential energy explained 68 kinetic energy explained 68 potential to kinetic energy conversions 70 law of conservation of energy 70 potential to kinetic energy conversions 71 using energy conservation to solve problems 117 potential and kinetic energy in a spring 240 energy and systems 243 energy flow diagrams 249 energy flow diagram for mechanical systems 249 mechanical systems and energy 251 energy flow in natural systems	14 investigate exchange of energy in car and track system 15 apply law of energy conservation 42 model how atoms exchange energy 45 describe energy changes 46 investigate energy flow in a system 47 draw an energy flow diagram 57 draw energy flow diagram of the circuit