

**Correlation to Massachusetts Science and Technology Curriculum Framework
CPO Science - Physics: A First Course
Student Text and Investigation Manual**

Standard #: Strand	Grade	Topic	Learning Standard	Volume One Student Text Page	Volume Two Investigation Manual Page		
PHY1.1 Introductory Physics	High School	Motion and Forces	Compare and contrast vector quantities (e.g., displacement, velocity, acceleration force, linear momentum) and scalar quantities (e.g., distance, speed, energy, mass, work).	17	speed of light	6	how can speed be measured?
				17	speed defined	9	research and define inertia and weight and mass
				18	calculating speed	13	apply the law of conservation of momentum
				19	velocity defined	18	calculate work
				40	velocity defined	18	investigate concept of work
				43	weight vs. mass	20	graph force vs. distance
				44	weight vs. mass	23	use force vectors
				45	skydiving and terminal speed	154	identify force and distance trade-off
				45	terminal speed		
				63	law of conservation of momentum		
				64	using momentum conservation to solve problems		
				66	calculating work done on objects		
				66	work defined		
				74	momentum and collisions		
				77	momentum and car safety		
				87	work results from force and distance that are in same distance		
				88	work done by or against gravity		

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				110	
				compare and contrast scalars and vectors	
				111	
				force vectors	
				115	
				finding resultant vector	
				136	
				speed vs. velocity	
				136	
				working with velocity vector	
				143	
				angular speed	

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PHY1.2 Introductory Physics	High School	Motion and Forces	Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.	17	speed of light	3	find the speed of the car
				17	speed defined	6	how can speed be measured?
				17	constant speed	7	measure the speed
				18	calculating speed	9	why did the speed change?
				18	speed units	10	find speed of car
				19	velocity defined	11	find acceleration of car
				32	acceleration defined	11	compare and contrast speed and acceleration
				32	acceleration of sports cars	11	investigating net force and acceleration
				33	acceleration and velocity	21	measure speed of car
				33	calculating acceleration	25	calculate acceleration of car
				35	changes in speed or direction always involve acceleration	25	calculate speed of car
				36	zero acceleration explained	28	calculate acceleration
				40	acceleration of falling objects	28	investigate acceleration on a ramp
				40	velocity defined	44	experiment and find average speed
				45	skydiving and terminal speed	46	measure speed of car
				45	terminal speed		
				56	calculate speed from distance/time graph		
110	compare and contrast scalars and vectors						

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Standard #: Strand	Grade	Topic	Learning Standard	Volume One Student Text Page	Volume Two Investigation Manual Page
				134 understanding displacement 136 working with velocity vector 136 speed vs. velocity 143 angular speed 149 acceleration and circular motion	
PHY1.3 Introductory Physics	High School	Motion and Forces	Create and interpret graphs of 1-dimensional motion, such as position vs. time, distance vs. time, speed vs. time, velocity vs. time, and acceleration vs. time where acceleration is constant.	46 position vs. time graphs 47 position vs. time graph for accelerating motion 48 speed vs. time graph 49 speed vs. time graph for accelerating motion 51 finding distance from a speed vs. time graph	4 position vs. time graph 11 speed vs. time graph

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Standard #: Strand	Grade	Topic	Learning Standard	Volume One Student Text Page	Volume Two Investigation Manual Page		
PHY1.4 Introductory Physics	High School	Motion and Forces	Interpret and apply Newton's three laws of motion.	29	Newton's first law	8	investigate Newton's first law of motion
				35	quantitative understanding of second law	10	investigate Newton's second law of motion
				35	Newton's second law	12	investigate Newton's 3rd law of motion
				36	applying Newton's second law properly	13	relate Newton's 3rd law of motion to car collisions
				37	using second law formula	23	Newton's second law of motion
				52	action-reaction pairs	25	apply Newton's second law of motion
				59	Newton's third law	29	apply Newton's second law of motion
				60	sorting out force pairs	29	apply Newton's second law of motion
				78	third law and rockets	29	apply Newton's second law of motion
				117	Newton's third law and springs	95	Newton's 2nd law of motion and natural frequency
				128	the third law and physics of walls		
				158	Newton's third law and helicopters		
				424	Newton's second law and oscillators		

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PHY1.5 Introductory Physics	High School	Motion and Forces	Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects.	31 net force explained 37 net force and second law calculating 113 using a free-body diagram 116 when net force is zero	11 investigate net force 22 when net force is zero 23 draw a free body diagram
PHY1.6 Introductory Physics	High School	Motion and Forces	Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.	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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PHY1.7 Introductory Physics	High School	Motion and Forces	Describe Newton's law of universal gravitation in terms of the attraction between two objects, their masses, and the distance between them.	153 154	Newton's law of universal gravitation explained understanding orbital motion
PHY1.8 Introductory Physics	High School	Motion and Forces	Describe conceptually the forces involved in circular motion.	142 143 143 143 145 147 148 149	angular speed vs. linear speed angular speed formula calculating angular speed rotations and degrees calculating linear speed for a rotating object centripetal force centripetal force Newton's second law and circular motion

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PHY2.1 Introductory Physics	High School	Conservation of Energy and Momentum	Interpret and provide examples that illustrate the law of conservation of energy.	10 conservation of energy 67 potential energy explained 68 kinetic energy explained 70 law of conservation of energy 71 using energy conservation to solve problems 243 energy conservation and closed systems 249 energy flow diagram for mechanical systems	14 investigate exchange of energy in car and track system 15 apply law of energy conservation 42 model how atoms exchange energy 47 draw an energy flow diagram

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Standard #: Strand	Grade	Topic	Learning Standard	Volume One Student Text Page	Volume Two Investigation Manual Page	
PHY2.2 Introductory Physics	High School	Conservation of Energy and Momentum	Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.	67	potential energy explained	14 investigate exchange of energy in car and track system 15 apply law of energy conservation
				68	potential to kinetic energy conversions	
				68	kinetic energy explained	
				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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PHY2.3 Introductory Physics	High School	Conservation of Energy and Momentum	Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.	66	energy is stored work	18	calculate work
				66	calculating work done on objects	18	investigate concept of work
				66	work defined	19	investigate concept of energy as stored work
				86	calculating work	20	graph force vs. distance
				87	work results from force and distance that are in same distance	154	identify force and distance trade-off
				88	calculating work		
				88	work done by or against gravity		

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PHY2.4 Introductory Physics	High School	Conservation of Energy and Momentum	Describe both qualitatively and quantitatively the concept of power as work done per unit time.	66 energy is stored work 86 calculating work 88 calculating work 89 calculating power 90 maximum power output of a person 244 power explained 245 three ways to look at power 250 power in human technology 252 power in natural systems 254 wave power 254 tidal power	19 investigate concept of energy as stored work
PHY2.5 Introductory Physics	High School	Conservation of Energy and Momentum	Provide and interpret examples showing that linear momentum is the product of mass and velocity, and is always conserved (law of conservation of momentum). Calculate the momentum of an object.	61 momentum is calculated with velocity – not speed 61 calculating momentum 63 law of conservation of momentum 64 using momentum conservation to solve problems 74 momentum and collisions 77 momentum and car safety	12 investigate momentum 13 apply the law of conservation of momentum 13 analyze collision data 13 calculate momentum of two cars

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Standard #: Strand	Grade	Topic	Learning Standard	Volume One Student Text Page	Volume Two Investigation Manual Page
PHY3.1 Introductory Physics	High School	Heat and Heat Transfer	Explain how heat energy is transferred by convection, conduction, and radiation.	181 heat conduction 183 natural and forced convection 184 thermal radiation	30 investigating heat transfer
PHY3.2 Introductory Physics	High School	Heat and Heat Transfer	Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.	176 understanding the difference between heat and temperature 176 flow of thermal energy is heat 177 heat and work 181 thermal equilibrium 185 heat transfer is everywhere	30 investigate difference between temperature and heat
PHY3.3 Introductory Physics	High School	Heat and Heat Transfer	Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a solid to a liquid to a gas, and that energy is released...	173 physical differences between phases of matter 173 phases of matter 174 boiling and melting points 174 interpreting a heating curve diagram 174 phase changes 355 plasma and lightning	34 arrangement of solid, liquid, gas particles 35 comparing equal masses of gas, solid, and liquid 36 solid, liquid, gas density differences

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Standard #: Strand	Grade	Topic	Learning Standard	Volume One Student Text Page	Volume Two Investigation Manual Page		
PHY3.4 Introductory Physics	High School	Heat and Heat Transfer	Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.	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	calories explained		
				178	specific heat explained		
				179	the heat equation		
				181	thermal equilibrium		
				182	thermal conductivity		
				185	heat transfer is everywhere		

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PHY4.1 Introductory Physics	High School	Waves	Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion.	414	a pendulum's cycle	92 explore harmonic motion using a pendulum 92 explore the meaning of cycle 92 explore the meaning of amplitude 93 measure the period of a pendulum 94 investigate harmonic motion with a pendulum 101 investigate standing waves and frequency
				414	understanding a cycle	
				416	frequency explained	
				416	period is the time for one cycle	
				417	frequency is the inverse of period	
				418	amplitude explained	
				430	identify period and frequency and cycle and amplitude	
				437	frequency and amplitude and wavelength of waves	
				438	the speed of waves	
				456	speed of sound	
				461	wavelength of sound	
				468	pitch and the musical scale	
				PHY4.2 Introductory Physics	High School	
440	standing waves on a vibrating string					

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PHY4.3 Introductory Physics	High School	Waves	Distinguish between the two types of mechanical waves, transverse and longitudinal.	436	longitudinal waves	98	study waves on a string
				436	transverse waves	99	explore transverse waves
				440	standing waves on a vibrating string	100	study water waves
						124	relating transverse waves on a spring to light waves
PHY4.4 Introductory Physics	High School	Waves	Describe qualitatively the basic principles of reflection and refraction of waves.	442	refracted waves	111	colors of light
				442	reflected waves	120	investigate reflection of light
				478	seeing and reflected light	121	investigate refraction of light
				482	refraction of light		
				482	reflection of light		
				485	how the human eye sees color		
				501	reflection explained		
				503	understanding refraction		
504	angles of incidence and refraction						
PHY4.5 Introductory Physics	High School	Waves	Recognize that mechanical waves generally move faster through a solid than through a liquid and faster through a liquid than through a gas.	435	how to recognize waves	98	study waves on a string
				440	standing waves on a vibrating string		
				459	sound waves and different media		

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PHY4.6 Introductory Physics	High School	Waves	Describe the apparent change in frequency of waves due to the motion of a source or a receiver (the Doppler effect).	442	how boundaries affect waves	106	investigate interference and beats
				442	refracted waves	125	explore polarization of light
				442	reflected waves	126	explore the concept of polarization of light
				443	absorption explained		
				443	diffraction explained		
				445	destructive interference		
				445	constructive interference		
				457	understanding the Doppler effect		
				469	frequency of sound and beats		
				529	interference of light waves		
531	polarization						
PHY5.1 Introductory Physics	High School	Electromagnetism	Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.	340	understanding electric charge	72	investigate the nature of electric charge
				341	what causes shocks	73	build an electroscope and conduct experiments
				341	charged objects and static electricity		
				344	how an electroscope works		
				354	understanding lightning		

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PHY5.2 Introductory Physics	High School	Electromagnetism	Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's law).	298	electric current	58	measure voltage
				300	resistors	59	measure current
				302	current in simple circuits	60	measure voltage
				303	understanding voltage	61	investigate resistance
				305	measuring current with a multimeter	62	investigate Ohm's law
				306	understanding electrical resistance	63	investigate resistance and potentiometers
				307	measuring resistance	63	use Ohm's law
				308	Ohm's law	64	investigating voltage drops
				309	resistance of common objects	65	measure the voltage
				311	resistors	66	current in a series circuit
				319	resistance in a series circuit	67	Ohm's law and short circuits
				319	current in a series circuit	74	investigate the flow of electric charge
				320	voltage in a series circuit	75	work with Ohm's law
				321	Ohm's law and voltage drops		
				323	current in a parallel circuit		
				324	voltage in a parallel circuit		
				346	charge and current		
				349	voltage and charge		
				351	voltage and capacitors		

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PHY5.3 Introductory Physics	High School	Electromagnetism	Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram.	299	examples of electric circuits in nature	57	open and closed circuits
				299	electric circuits	57	build circuits
				300	circuit diagrams	59	draw and interpret circuit diagrams
				301	open and closed circuits	60	a circuit with a dimmer switch
				301	battery circuits	65	investigate series circuits
				318	series circuits	65	build a circuit with three bulbs and a switch
				323	parallel circuits	66	investigate series circuits
				325	comparing series and parallel circuits	67	understand why short circuits are dangerous
				326	understanding short circuits	67	investigate short circuits and learn how to avoid
				326	parallel circuits in homes	68	compare series and parallel circuits
68	investigate parallel circuits	69	construct a simple circuit				
PHY5.4 Introductory Physics	High School	Electromagnetism	Describe conceptually the attractive or repulsive forces between objects relative to their charges and the distance between them (Coulomb's law).	342	understanding Coulomb's law		

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PHY5.5 Introductory Physics	High School	Electromagnetism	Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage.	328	calculating power in a circuit	69	finding power used by a circuit
				330	alternating current	70	explain what you observed in terms of energy and power
				330	direct current	71	calculate energy and power
PHY5.6 Introductory Physics	High School	Electromagnetism	Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces...	364	electromagnets	80	compare magnetic force and electric current in an electromagnet
				365	building an electromagnet		
				385	how an electric motor works	80	explore properties of electromagnets
				386	how a battery-powered electric motor works	81	find relationship between current and magnetic field
				387	electromagnetic induction explained	83	build a simple electric motor
				389	how a generator works	84	build an electric motor and perform experiments
		85	investigate electromagnetic induction				
		87	investigate how generators work				

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PHY6.1 Introductory Physics	High School	Electromagnetic Radiation	Recognize that electromagnetic waves are transverse waves and travel at the speed of light through a vacuum.	481	speed of light	111	mixing primary colors of light
				483	color and light	123	investigate visible light wavelengths
				523	electromagnetic spectrum	123	how colors of light relate to frequency and wavelength
				524	wavelength and frequency of visible light	123	measure wavelengths of visible light using a spectrometer
				524	energy and color of light		
				526	low-energy electromagnetic waves		
				527	high-energy electromagnetic waves		
				536	the electromagnetic spectrum		
			537	infrared telescopes			

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PHY6.2 Introductory Physics	High School	Electromagnetic Radiation	Describe the electromagnetic spectrum in terms of frequency and wavelength, and identify the locations of radio waves, microwaves, infrared radiation, visible light...	435	waves and technology	111	mixing primary colors of light
				483	white light is a mixture of colors	111	investigate the RGB model of color
				483	color and light	112	investigate the CMYK model of color
				488	the CMYK color process	122	observe white light through diffraction glasses
				489	the RGB color process	123	investigate visible light wavelengths
				523	electromagnetic spectrum	123	how colors of light relate to frequency and wavelength
				524	wavelength and frequency of visible light	123	measure wavelengths of visible light using a spectrometer
				524	energy and color of light		
				526	low-energy electromagnetic waves		
				527	high-energy electromagnetic waves		
				536	the electromagnetic spectrum		
537	infrared telescopes						
SIS1 Introductory Physics	High School	Scientific Inquiry Skills	Make observations, raise questions, and formulate hypotheses.	8	formulating a hypothesis	6	form a hypothesis
				8	hypothesis defined	30	state a hypothesis about the water's energy
				8	asking a scientific question	94	state a hypothesis about period of pendulum
						96	state a hypothesis about the natural frequency of the oscillator

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SIS2 Introductory Physics	High School	Scientific Inquiry Skills	Design and conduct scientific investigations.	4	what is an experiment	6 design a better experiment
				8	designing experiments	13 design other experiments 15 design another experiment 47 conduct the experiment you designed 47 design an experiment 94 design pendulum experiments

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SIS3 Introductory Physics	High School	Scientific Inquiry Skills	Analyze and interpret results of scientific investigations.		<p>3 car launching technique is a possible source of error</p> <p>4 car launching technique is a possible source of error</p> <p>6 do results agree with hypothesis?</p> <p>6 reflecting on the experiment</p> <p>7 construct explanations supported by evidence</p> <p>9 how do your observations support your answer?</p> <p>11 what experimental data support answer?</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 marble launching technique is a possible source of error</p> <p>47 construct a reasonable explanation</p> <p>60 propose a relationship between power and voltage</p>

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SIS4 Introductory Physics	High School	Scientific Inquiry Skills	Communicate and apply the results of scientific investigations.	11 importance of units 11 communicating via measurement 26 applying your knowledge: three opportunities to research topics and write reports 132 explain your answer using diagrams 132 applying your knowledge: two opportunities to research topics and write reports 163 applying your knowledge: two opportunities to research topics and write reports 295 applying your knowledge: three opportunities to research topics and write reports	each investigation contains a "thinking about what you observed" section, and students must be able to communicate and defend their findings from the investigation 67 explain what happened 154 create a report