



InterActions in Physical Science Correlation to the Michigan Science Standards and Benchmarks

STANDARD P1: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS

Students will understand the nature of science and demonstrate an ability to practice scientific reasoning by applying it to the design, execution, and evaluation of scientific investigations. Students will demonstrate their understanding that scientific knowledge is gathered through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation.

Benchmark	Location/Page where Standard is found
P.1.1 Scientific Inquiry	
P1.1A Generate new questions that can be investigated in the laboratory or field.	16-24, 79-82, 87-92, 114-118, 156-158, 168-173, 248-254, 290-294, 313-317, 374-377, 442-445, 446-447, 508-511, 541-545
P1.1B Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	12-15, 25-27, 28-34, 36-40, 48-55, 102-106, 114-118, 137-143, 174-178, 295-297, 332, 446-447, 590-597, 621-622, 623, 636
P1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).	617, 624-625, 631, 632-635, 641, 647-649, 36-40, 56-64, 71-74, 76-78, 83-86, 97-101, 102-106, 114-118, 168-173, 218-224, 248-254, 336-341, 374-379, 385-389, 398-402, 411-416, 541-545
P1.1D Identify patterns in data and relate them to theoretical models.	16-24, 56-64, 137-143, 149-154, 290-294, 298-301, 308-312, 318-324

P1.1E Describe a reason for a given conclusion using evidence from an investigation.	12-15, 16-24, 28-34, 56-64, 79-82, 83-86, 87-92, 137-143, 149-154, 637
P1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.	16-24, 79-82, 87-92, 114-118, 156-158, 168-173, 248-254, 290-294, 313-317, 374-377, 446-447, 508-511, 541-545
P1.1g Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.	12-15, 16-24, 28-34, 56-64, 79-82, 83-86, 87-92, 137-143, 149-154, 636-637
P1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	12-15, 25-27, 41-47, 56-64, 93-96, 248-254, 621-622, 623
P1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.	532-533, 588-595, 596-600, 601-607, 183, 230-232, 267, 419, 517-518, 519-522
P1.2 Scientific Reflection and Social Implications	
P1.2A Critique whether or not specific questions can be answered through scientific investigations.	8-11, 12-15, 16-24, 25-27, 28-34
P1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.	353-362, 586-587, 528-534, 596-600
P1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	621-622, 623, 636-637
P1.2D Evaluate scientific explanations in a peer review process or discussion format.	16-24, 25-27, 28-34, 353-362
P1.2E Evaluate the future career and occupational prospects of science fields.	156-158, 411-416, 430-432, 530-536, 588-589, 598-602

P1.2f Critique solutions to problems, given criteria and scientific constraints.	569-571, 353-362
P1.2g Identify scientific tradeoffs in design decisions and choose among alternative solutions.	528-534, 588-595, 596-600, 601-607, 586-587
P1.2h Describe the distinctions between scientific theories, laws, hypotheses, and observations.	8-11, 12-15, 16-24, 25-27, 28-34, 331, 446-458
P1.2i Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.	16-24, 79-82, 87-92, 114-118, 156-158, 168-173, 248-254, 290-294, 313-317, 376-379, 444-447, 510-513, 540-542
P1.2j Apply science principles or scientific data to anticipate effects of technological design decisions.	16-24, 25-27, 28-34, 353-362, 569-571
P1.2k Analyze how science and society interact from a historical, political, economic, or social perspective.	528-534, 588-595, 596-600, 601-607, 586-587

STANDARD P2: MOTION OF OBJECTS

The universe is in a state of constant change. From small particles (electrons) to the large systems (galaxies) all things are in motion. Therefore, for students to understand the universe they must describe and represent various types of motion. Kinematics, the description of motion, always involves measurements of position and time. Students must describe the relationships between these quantities using mathematical statements, graphs, and motion maps. They use these representations as powerful tools to not only describe past motions but also predict future events.

Benchmark	Location/Page where Standard is found
P2.1 Position — Time	
P2.1A Calculate the average speed of an object using the change of position and elapsed time.	137-143, 144-148, 149-154

P2.1B Represent the velocities for linear and circular motion using motion diagrams (arrows on strobe pictures).	137-143, 144-148, 149-154, 237-239, 240-242
P2.1C Create line graphs using measured values of position and elapsed time.	137-143, 144-148
P2.1D Describe and analyze the motion that a position-time graph represents, given the graph.	137-143, 144-148
P2.1E Describe and classify various motions in a plane as one dimensional, two dimensional, circular, or periodic.	137-143, 144-148, 149-154, 237-239, 240-242, 207-209, 8-11, 12-15
P2.1F Distinguish between rotation and revolution and describe and contrast the two speeds of an object like the Earth.	237-239, 259-269, 270-274, 275-282
P2.1g Solve problems involving average speed and constant acceleration in one dimension.	149-154, 137-143, 144-148, 207-208, 8-11, 12-15
P2.1h Identify the changes in speed and direction in everyday examples of circular (rotation and revolution), periodic, and projectile motions.	149-154, 137-143, 144-148, 207-208, 8-11, 12-15
P2.2 Velocity — Time	
P2.2A Distinguish between the variables of distance, displacement, speed, velocity, and acceleration.	149-154, 137-143, 144-148, 207-208, 8-11, 12-15
P2.2B Use the change of speed and elapsed time to calculate the average acceleration for linear motion.	149-154
P2.2C Describe and analyze the motion that a velocity-time graph represents, given the graph.	137-143, 149-154
P2.2D State that uniform circular motion involves acceleration without a change in speed.	237-239
P2.2e Use the area under a velocity-time graph to calculate the distance traveled and the slope to calculate the acceleration.	
P2.2f Describe the relationship between changes in position, velocity, and acceleration during periodic motion.	8-11, 12-15, 137-143, 144-148

P2.2g Apply the independence of the vertical and horizontal initial velocities to solve projectile motion problems.	
P2.3x Frames of Reference	
P2.3a Describe and compare the motion of an object using different reference frames.	138

STANDARD P3: FORCES AND MOTION

Students identify interactions between objects either as being by direct contact (e.g., pushes or pulls, friction) or at a distance (e.g., gravity, electromagnetism), and to use forces to describe interactions between objects. They recognize that non-zero net forces always cause changes in motion (Newton’s first law). These changes can be changes in speed, direction, or both. Students use Newton’s second law to summarize relationships among and solve problems involving net forces, masses, and changes in motion (using standard metric units). They explain that whenever one object exerts a force on another, a force equal in magnitude and opposite in direction is exerted back on it (Newton’s third law).

Benchmark	Location/Page where Standard is found
P3.1 Basic Forces in Nature	
P3.1A Identify the force(s) acting between objects in “direct contact” or at a distance.	186-187, 188-190, 191-192, 36-40, 193-195, 196-200, 201-202, 203-206, 207-209, 213-217, 218-224, 243-247, 248-254
P3.1x Forces	
P3.1b Explain why scientists can ignore the gravitational force when measuring the net force between two electrons.	48-55, 233-235
P3.1c Provide examples that illustrate the importance of the electric force in everyday life.	48-55, 56-64, 65-70, 71-748-55, 233-235
P3.1d Identify the basic forces in everyday interactions.	48-55, 56-64, 65-70, 71-74, 186-187, 188-190, 191-192, 193-195, 196-200, 201-202, 203-206, 207-209, 213-217,

	218-224, 226-227, 228-229, 230-232, 233-235, 237-239, 240-242, 243-247, 248-254, 333-335
P3.2 Net Forces	
P3.2A Identify the magnitude and direction of everyday forces (e.g., wind, tension in ropes, pushes and pulls, weight).	186-187, 188-190, 191-192, 193-195, 196-200, 201-202, 203-206, 207-209, 213-217, 218-224, 243-247, 248-254, 333-335
P3.2B Compare work done in different situations.	333-335, 218-224
P3.2C Calculate the net force acting on an object.	243-247, 186-187, 188-190, 191-192, 193-195, 196-200, 201-202, 203-206, 207-209, 213-217, 237-239, 240-242, 248-254
P3.2d Calculate all the forces on an object on an inclined plane and describe the object's motion based on the forces using free-body diagrams.	218-224
P3.3 Newton's Third Law	
P3.3A Identify the action and reaction force from examples of forces in everyday situations (e.g., book on a table, walking across the floor, pushing open a door).	196-200, 201-202, 203-206, 243-247
P3.3b Predict how the change in velocity of a small mass compares to the change in velocity of a large mass when the objects interact (e.g., collide).	213-217, 188-190, 243-247
P3.3c Explain the recoil of a projectile launcher in terms of forces and masses.	201-202, 168-173
P3.3d Analyze why seat belts may be more important in autos than in buses.	201-202, 168-173
P3.4 Forces and Acceleration	
P3.4A Predict the change in motion of an object acted on by several forces.	243-247, 188-190, 191-192, 193-195, 196-200, 201-202, 203-206, 207-209, 213-217, 218-224, 248-254

P3.4B Identify forces acting on objects moving with constant velocity (e.g., cars on a highway).	191-192, 193-195, 196-200, 201-202, 203-206, 207-209, 213-217, 243-247
P3.4C Solve problems involving force, mass, and acceleration in linear motion (Newton's second law).	213-217, 188-190, 191-192, 193-195, 196-200, 201-202, 203-206, 207-209, 243-247
P3.4D Identify the force(s) acting on objects moving with uniform circular motion (e.g., a car on a circular track, satellites in orbit).	207-209, 237-239
P3.4e Solve problems involving force, mass, and acceleration in two-dimensional projectile motion restricted to an initial horizontal velocity with no initial vertical velocity (e.g., ball rolling off a table).	
P3.4f Calculate the changes in velocity of a thrown or hit object during and after the time it is acted on by the force.	213-217, 196-200, 201-202, 248-254
P3.4g Explain how the time of impact can affect the net force (e.g., air bags in cars, catching a ball).	201-202. 168-173
P3.5x Momentum	
P3.5a Apply conservation of momentum to solve simple collision problems.	201-202. 464, 472, 168-173
P3.6 Gravitational Interactions	
P3.6A Explain earth-moon interactions (orbital motion) in terms of forces.	226-227, 228-229, 230-232, 233-235, 237-239, 258-269
P3.6B Predict how the gravitational force between objects changes when the distance between them changes.	230-232, 233-235, 258-269, 275-282
P3.6C Explain how your weight on Earth could be different from your weight on another planet.	233-235, 240-242, 258-269
P3.6d Calculate force, masses, or distance, given any three of these quantities, by applying the Law of Universal Gravitation, given the value of G .	226-227, 228-229, 230-232, 258-269, 275-282
P3.6e Draw arrows (vectors) to represent how the direction and magnitude of a force changes on an object in an elliptical orbit.	230-232, 237-239

P3.7 Electric Charges	
P3.7A Predict how the electric force between charged objects varies when the distance between them and/or the magnitude of charges change.	48-55, 56-64, 65-70, 71-74
P3.7B Explain why acquiring a large excess static charge (e.g., pulling off a wool cap, touching a Van de Graaff generator, combing) affects your hair.	48-55
P3.7x Electric Charges — Interactions	
P3.7c Draw the redistribution of electric charges on a neutral object when a charged object is brought near.	48-55
P3.7d Identify examples of induced static charges.	48-55, 56-64
P3.7e Explain why an attractive force results from bringing a charged object near a neutral object.	48-55, 56-64
P3.7f Determine the new electric force on charged objects after they touch and are then separated.	48-55, 56-64
P3.7g Propose a mechanism based on electric forces to explain current flow in an electric circuit.	56-64, 71-74, 97-101
P3.p8 Magnetic Force (prerequisite)	
P3.p8A Create a representation of magnetic field lines around a bar magnet and qualitatively describe how the relative strength and direction of the magnetic force changes at various places in the field. (<i>prerequisite</i>)	16-24, 41-47, 65-70, 71-74
P3.8x Electromagnetic Force	
P3.8b Explain how the interaction of electric and magnetic forces is the basis for electric motors, generators, and the production of electromagnetic waves.	65-70, 71-74

STANDARD P4: FORMS OF ENERGY AND ENERGY TRANSFORMATIONS

Energy is a useful conceptual system for explaining how the universe works and accounting for changes in

matter. Energy is not a “thing.” Students develop several energy-related ideas: First, they keep track of energy during transfers and transformations, and account for changes using energy conservation. Second, they identify places where energy is apparently lost during a transformation process, but is actually spread around to the environment as thermal energy and therefore not easily recoverable. Third, they identify the means of energy transfers: collisions between particles, or waves.

Benchmark	Location/Page where Standard is found
P4.1 Energy Transfer	
P4.1A Account for and represent energy into and out of systems using energy transfer diagrams.	112-113, 114-118, 156-158, 159-161, 162-167, 168-173, 175-178, 255-258, 308-312, 313-317, 318-324, 325-329, 330-331, 332, 333-335, 353-362
P4.1B Explain instances of energy transfer by waves and objects in everyday activities (e.g., why the ground gets warm during the day, how you hear a distant sound, why it hurts when you are hit by a baseball).	112-113, 114-118, 156-158, 159-161, 162-167, 168-173, 175-178, 255-258, 308-312, 313-317, 318-324, 325-329, 330-331, 332, 333-335, 353-362
P4.1x Energy Transfer — Work	
P4.1c Explain why work has a more precise scientific meaning than the meaning of work in everyday language.	333-335
P4.1d Calculate the amount of work done on an object that is moved from one position to another.	
P4.1e Using the formula for work, derive a formula for change in potential energy of an object lifted a distance h .	255-257
P4.2 Energy Transformation	
P4.2A Account for and represent energy transfer and transformation in complex processes (interactions).	112-113, 114-118, 133-136, 162-167, 168-173, 175-178, 255-258, 308-312, 313-317, 318-324, 332, 333-335, 353-362

P4.2B Name devices that transform specific types of energy into other types (e.g., a device that transforms electricity into motion).	112-113, 114-118, 133-136, 162-167, 308-312, 333-335, 353-362
P4.2C Explain how energy is conserved in common systems (e.g., light incident on a transparent material, light incident on a leaf, mechanical energy in a collision).	325-329, 330-331, 333-335
P4.2D Explain why all the stored energy in gasoline does not transform to mechanical energy of a vehicle.	353-362, 325-329, 330-331, 333-335
P4.2e Explain the energy transformation as an object (e.g., skydiver) falls at a steady velocity.	255-258, 240-242
P4.2f Identify and label the energy inputs, transformations, and outputs using qualitative or quantitative representations in simple technological systems (e.g., toaster, motor, hair dryer) to show energy conservation.	112-113, 114-118, 133-136, 156-158, 159-161, 162-167, 168-173, 175-178, 308-312, 313-317, 318-324, 333-335
P4.3 Kinetic and Potential Energy	
P4.3A Identify the form of energy in given situations (e.g., moving objects, stretched springs, rocks on cliffs, energy in food).	112-113, 114-118, 133-136, 156-158, 159-161, 162-167, 168-173, 175-178, 255-258, 308-312, 313-317, 318-324, 353-362
P4.3B Describe the transformation between potential and kinetic energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts).	168-173, 175-178, 255-258
P4.3C Explain why all mechanical systems require an external energy source to maintain their motion.	168-173, 175-178, 333-335
P4.3x Kinetic and Potential Energy — Calculations	
P4.3d Rank the amount of kinetic energy from highest to lowest of everyday examples of moving objects.	255-258
P4.3e Calculate the changes in kinetic and potential energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts) using the formulas for kinetic energy and potential energy.	168-173, 252-258
P4.3f Calculate the impact speed (ignoring air resistance) of an object dropped from a specific height or the maximum height reached by an object (ignoring air resistance), given the initial vertical velocity.	
P4.4 Wave Characteristics	

P4.4A Describe specific mechanical waves (e.g., on a demonstration spring, on the ocean) in terms of wavelength, amplitude, frequency, and speed.	119-125, 126-132, 144-148, 149-154
P4.4B Identify everyday examples of transverse and compression (longitudinal) waves.	119-125, 126-132
P4.4C Compare and contrast transverse and compression (longitudinal) waves in terms of wavelength, amplitude, and frequency.	119-125, 126-132, 144-148, 149-154
P4.4x Wave Characteristics — Calculations	
P4.4d Demonstrate that frequency and wavelength of a wave are inversely proportional in a given medium.	119-25
P4.4e Calculate the amount of energy transferred by transverse or compression waves of different amplitudes and frequencies (e.g., seismic waves).	126-132, 119-125, 149-154
P4.5 Mechanical Wave Propagation	
P4.5A Identify everyday examples of energy transfer by waves and their sources.	119-125, 126-132, 144-148, 149-154, 313-317
P4.5B Explain why an object (e.g., fishing bobber) does not move forward as a wave passes under it.	119-125
P4.5C Provide evidence to support the claim that sound is energy transferred by a wave, not energy transferred by particles.	126-132, 144-148
P4.5D Explain how waves propagate from vibrating sources and why the intensity decreases with the square of the distance from a point source.	126-132, 144-148
P4.5E Explain why everyone in a classroom can hear one person speaking, but why an amplification system is often used in the rear of a large concert auditorium.	126-132, 144-148
P4.6 Electromagnetic Waves	
P4.6A Identify the different regions on the electromagnetic spectrum and compare them in terms of wavelength, frequency, and energy.	313-317, 348-353

P4.6B Explain why radio waves can travel through space, but sound waves cannot.	313-317
P4.6C Explain why there is a delay between the time we send a radio message to astronauts on the moon and when they receive it.	270-274, 313-317
P4.6D Explain why we see a distant event before we hear it (e.g., lightning before thunder, exploding fireworks before the boom).	313-317
P4.6x Electromagnetic Propagation	
P4.6e Explain why antennas are needed for radio, television, and cell phone transmission and reception.	313-317
P4.6f Explain how radio waves are modified to send information in radio and television programs, radio-control cars, cell phone conversations, and GPS systems.	313-317
P4.6g Explain how different electromagnetic signals (e.g., radio station broadcasts or cell phone conversations) can take place without interfering with each other.	348-352
P4.6h Explain the relationship between the frequency of an electromagnetic wave and its technological uses.	119-125
P4.r7x Quantum Theory of Waves (<i>recommended</i>)	
P4.r7a Calculate and compare the energy in various electromagnetic quanta (e.g., visible light, x-rays). (<i>recommended</i>)	336-341, 348-352
P4.8 Wave Behavior — Reflection and Refraction	
P4.8A Draw ray diagrams to indicate how light reflects off objects or refracts into transparent media.	336-341, 342-347, 348-352
P4.8B Predict the path of reflected light from flat, curved, or rough surfaces (e.g., flat and curved mirrors, painted walls, paper).	336-341, 342-347, 348-352
P4.8x Wave Behavior — Diffraction, Interference, and Refraction	

P4.8c Describe how two wave pulses propagated from opposite ends of a demonstration spring interact as they meet.	126-132
P4.8d List and analyze everyday examples that demonstrate the interference characteristics of waves (e.g., dead spots in an auditorium, whispering galleries, colors in a CD, beetle wings).	126-132
P4.8e Given an angle of incidence and indices of refraction of two materials, calculate the path of a light ray incident on the boundary (Snell's Law).	342-347
P4.8f Explain how Snell's Law is used to design lenses (e.g., eye glasses, microscopes, telescopes, binoculars).	342-347
P4.9 Nature of Light	
P4.9A Identify the principle involved when you see a transparent object (e.g., straw, piece of glass) in a clear liquid.	342-347
P4.9B Explain how various materials reflect, absorb, or transmit light in different ways.	336-341, 342-347
P4.9C Explain why the image of the Sun appears reddish at sunrise and sunset.	348-352, 342-347
P4.r9x Nature of Light — Wave-Particle Nature (<i>recommended</i>)	
P4.r9d Describe evidence that supports the dual wave- particle nature of light. (<i>recommended</i>)	348-352
P4.10 Current Electricity — Circuits	
P4.10A Describe the energy transformations when electrical energy is produced and transferred to homes and businesses.	56-64, 65-70, 71-74, 97-101, 333-335
P4.10B Identify common household devices that transform electrical energy to other forms of energy, and describe the type of energy transformation.	
P4.10B Identify common household devices that transform electrical energy to other forms of energy, and describe the type of energy transformation.	56-64, 65-70, 71-74, 97-101, 333-335

P4.10C Given diagrams of many different possible connections of electric circuit elements, identify complete circuits, open circuits, and short circuits and explain the reasons for the classification.	56-64, 65-70, 71-74, 97-101, 333-335
P4.10D Discriminate between voltage, resistance, and current as they apply to an electric circuit.	56-64, 71-74
P4.10x Current Electricity — Ohm’s Law, Work, and Power	
P4.10e Explain energy transfer in a circuit, using an electrical charge model.	56-64, 65-70, 71-74, 97-101
P4.10f Calculate the amount of work done when a charge moves through a potential difference, V .	
P4.10g Compare the currents, voltages, and power in parallel and series circuits.	56-64, 65-70, 71-74, 97-101
P4.10h Explain how circuit breakers and fuses protect household appliances.	56-64, 65-70, 71-74, 97-101
P4.10i Compare the energy used in one day by common household appliances (e.g., refrigerator, lamps, hair dryer, toaster, televisions, music players).	56-64, 65-70, 71-74
P4.10j Explain the difference between electric power and electric energy as used in bills from an electric company.	333-335, 56-64, 65-70, 71-74
P4.11x Heat, Temperature, and Efficiency	
P4.11a Calculate the energy lost to surroundings when water in a home water heater is heated from room temperature to the temperature necessary to use in a dishwasher, given the efficiency of the home hot water heater.	308-312, 313-317
P4.11b Calculate the final temperature of two liquids (same or different materials) at the same or different temperatures and masses that are combined.	308-312
P4.12 Nuclear Reactions	
P4.12A Describe peaceful technological applications of nuclear fission and radioactive decay.	528-534, 360

P4.12B Describe possible problems caused by exposure to prolonged radioactive decay.	528-534, 360
P4.12C Explain how stars, including our Sun, produce huge amounts of energy (e.g., visible, infrared, ultraviolet light).	528-534, 360, 259-269
P4.12x Mass and Energy	
P4.12d Identify the source of energy in fission and fusion nuclear reactions.	528-534, 330-331, 360