Active Physics CoreSelect 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.	**Throughout 142-146, 147-150, 239-255, 537-541, 634-645, 81-85, 208-213, 309-319, 324-325, 641-645, 720-724**
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.	**167-170, 147-150, 151-155, 239-255, 356, 561-566, 289**
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).	**33, 47, 56, 81, 87, 96, 106, 112, 123, 128, 152, 160-161, 177, 195, 210, 219, 232, 243, 267, 288, 341-342, 347, 355, 363, 378-379, 412-413, 417, 426, 434, 447, 469-471, 473, 487, 513, 568, 577-578, 596, 628, 657, 749, 772, 779**
P1.1D Identify patterns in data and relate them to theoretical models.	**634-640, 326-339, 386-390, 556-566, 759-763, 771-776**

P1.1E Describe a reason for a given conclusion using evidence from an investigation.	**94-98, 131, 171-175, 184-188, 600-601, 624-625**
P1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.	**326-339, 386-390, 556-566, 759-763, 771-776**
P1.1g Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.	**326-339, 386-390, 556-566, 759-763, 771-776**
P1.1h Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	**129-134, 86-91, 129-134, 147-150, 512-516, 517-525, 650-652, 188-193, 218-222, 354-357, 720-724**
P1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.	**584, 595-604, 567-575**
P1.2 Scientific Reflection and Social Implications	
P1.2A Critique whether or not specific questions can be answered through scientific investigations.	**94-98, 123-134, 147-150, 142-146, 533-537, 626-633**
P1.2B Identify and critique arguments about personal or societal issues based on scientific evidence.	**147-150, 105-110**
P1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	**117-121, 572-74, 759-770**
P1.2D Evaluate scientific explanations in a peer review process or discussion format.	**94-98, 135, 184-188**
P1.2E Evaluate the future career and occupational prospects of science fields.	**75, 135, 203, 391, 441, 592, 507, 689**

P1.2f Critique solutions to problems, given criteria and scientific constraints.	**567-574, 111-116, 117-121, 129-134, 208-217**
P1.2g Identify scientific tradeoffs in design decisions and choose among alternative solutions.	**111-116, 117-121, 122-128, 129-136, 309-321, 396-399, 400-404, 405-410, 411-415, 533-538, 539-541**
P1.2h Describe the distinctions between scientific theories, laws, hypotheses, and observations.	**86-91, 147-150, 456-457, 660-664, 674-675, 637-638**
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.	**86-91, 214-217,340-345, 620-621, 720-721**
P1.2j Apply science principles or scientific data to anticipate effects of technological design decisions.	**99-104, 105-11, 111-116, 117-121, 122-128, 129-134, 396-399, 400-404, 405-410, 411-415, 416-420, 421-424, 425-428, 429-432, 433-440, 486-497, 498-502, 503-506, 533-538, 539-541, 309-320**

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.	**86-93, 142-146, 156-159, 171-175**

P2.1B Represent the velocities for linear and circular motion using motion diagrams (arrows on strobe pictures).	**86-93, 176-183, 266-285**
P2.1C Create line graphs using measured values of position and elapsed time.	**80-85, 86-93, 147-150, 171-175, 218-230**
P2.1D Describe and analyze the motion that a position-time graph represents, given the graph.	**80-85, 86-93, 147-150, 171-175, 218-230**
P2.1E Describe and classify various motions in a plane as one dimensional, two dimensional, circular, or periodic.	**4-13, 15-25, 31-44, 45-49, 176-183, 142-146, 151-155, 156-160, 184-193, 161-166, 167-170, 208-217, 266-285, 656-664, 665-671, 672-677, 697-702, 709-713, 634-640**
P2.1F Distinguish between rotation and revolution and describe and contrast the two speeds of an object like the Earth.	**634-640**
P2.1g Solve problems involving average speed and constant acceleration in one dimension.	**31-44, 45-49, 50-55, 69-74, 142-146, 151-155, 160-166, 176-183, 184-193, 208-217, 309-320**
P2.1h Identify the changes in speed and direction in everyday examples of circular (rotation and revolution), periodic, and projectile motions.	**31-44, 45-49, 50-55, 69-74, 142-146, 151-155, 160-166, 176-183, 184-193, 208-217, 309-320, 253-265, 266-285**
P2.2 Velocity — Time	
P2.2A Distinguish between the variables of distance, displacement, speed, velocity, and acceleration.	**15-25, 297-308**
P2.2B Use the change of speed and elapsed time to calculate the average acceleration for linear motion.	**160-166**
P2.2C Describe and analyze the motion that a velocity-time graph represents, given the graph.	**80-85, 86-93, 147-150, 171-175, 218-230**
P2.2D State that uniform circular motion involves acceleration without a change in speed.	**266-285**
P2.2e Use the area under a velocity-time graph to calculate the distance traveled and the slope to calculate the acceleration.	**160-166**

P2.2f Describe the relationship between changes in position, velocity, and acceleration during periodic motion.	**730-735**
P2.2g Apply the independence of the vertical and horizontal initial velocities to solve projectile motion problems.	**176-183, 194-202, 703-713, 730-735**
P2.3x Frames of Reference	
P2.3a Describe and compare the motion of an object using different reference frames.	**4-14, 656-664, 176-187, 56-60, 94-104, 81-85, 176-187, 86-93, 111-116, 665-671, 672-677**

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.	**15-25, 31-44, 45-49, 69-74, 86-93, 99-104, 105-110, 111-116, 117-121, 123-134, 208-217, 239-252, 253-265, 634-640, 697-702, 714-719, 736-741**
P3.1x Forces	
P3.1b Explain why scientists can ignore the gravitational force when measuring the net force between two electrons.	**626-633, 634-640**

P3.1c Provide examples that illustrate the importance of the electric force in everyday life.	**450-454, 543-555**
P3.1d Identify the basic forces in everyday interactions.	**626-633, 634-640**
P3.2 Net Forces	
P3.2A Identify the magnitude and direction of everyday forces (e.g., wind, tension in ropes, pushes and pulls, weight).	**4-13, 15-25, 31-44, 45-49, 176-183, 142-146, 151-155, 156-160, 184-193, 161-166, 167-170, 208-217, 266-285, 656-664, 665-671, 672-677, 697-702, 709-713**
P3.2B Compare work done in different situations.	**286-296, 305, 31-41**
P3.2C Calculate the net force acting on an object.	**15-25, 31-44, 61-68, 69-74, 105-110, 117-121**
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.	**208-217, 218-230, 297-308**
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).	**45-49, 63-66, 736-741**
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).	**56-60, 61-68, 99-104, 105-110, 111-116, 117-121, 122-127, 129-134**
P3.3c Explain the recoil of a projectile launcher in terms of forces and masses.	**45-49, 63-66, 736-741**
P3.3d Analyze why seat belts may be more important in autos than in buses.	**56-60, 61-68, 99-104, 105-110, 111-116, 117-121, 122-127, 129-134**
P3.4 Forces and Acceleration	

P3.4A Predict the change in motion of an object acted on by several forces.	**142-146, 147-150, 151-155, 156-159**
P3.4B Identify forces acting on objects moving with constant velocity (e.g., cars on a highway).	**142-146, 147-150, 151-155, 156-159**
P3.4C Solve problems involving force, mass, and acceleration in linear motion (Newton's second law).	**15-25, 31-44, 45-49, 69-74, 86-93, 99-104, 105-110, 111-116, 117-121, 123-134, 208-217, 239-252, 253-265, 634-640, 697-702, 714-719, 736-741**
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).	**266-285, 634-640**
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).	**45-49, 176-183, 184-193, 709-713, 714-719**
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.	**56-60, 61-68, 99-104, 105-110, 111-116, 117-121, 122-127, 129-134**
P3.4g Explain how the time of impact can affect the net force (e.g., air bags in cars, catching a ball).	**99-104, 111-116, 117-121, 122-128, 129-134**
P3.5x Momentum	
P3.5a Apply conservation of momentum to solve simple collision problems.	**99-104, 111-116, 117-121, 122-128, 129-134**
P3.6 Gravitational Interactions	
P3.6A Explain earth-moon interactions (orbital motion) in terms of forces.	**634-640**
P3.6B Predict how the gravitational force between objects changes when the distance between them changes.	**634-640, 31-44**
P3.6C Explain how your weight on Earth could be different from your weight on another planet.	**697-702**

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*.	**634-640, 703-708, 239-252, 253-265**
P3.6e Draw arrows (vectors) to represent how the direction and magnitude of a force changes on an object in an elliptical orbit.	**634-640, 709-713**
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.	**450-454, 548-555, 564-565, 591-594**
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.	**450-454, 548-555, 564-565**
P3.7x Electric Charges — Interactions	
P3.7c Draw the redistribution of electric charges on a neutral object when a charged object is brought near.	**548-555, 450-454**
P3.7d Identify examples of induced static charges.	**548-555, 450-454**
P3.7e Explain why an attractive force results from bringing a charged object near a neutral object.	**548-555, 450-454**
P3.7f Determine the new electric force on charged objects after they touch and are then separated.	**548-555, 450-454**
P3.7g Propose a mechanism based on electric forces to explain current flow in an electric circuit.	**626-633**
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. *(prerequisite)*	**626-633, 521-525, 512-516**
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.	**626-633, 446-449, 450-454, 512-516, 517-520**

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.	**231-238, 416-420, 433-440**
P4.1x Energy Transfer — Work	
P4.1c Explain why work has a more precise scientific meaning than the meaning of work in everyday language.	**286-296, 305, 31-44**
P4.1d Calculate the amount of work done on an object that is moved from one position to another.	**286-296, 305, 31-44**
P4.1e Using the formula for work, derive a formula for change in potential energy of an object lifted a distance h.	**31-44, 194-202, 231-238**
P4.2 Energy Transformation	
P4.2A Account for and represent energy transfer and transformation in complex processes (interactions).	**194-202, 231-238, 486-497, 503-506**
P4.2B Name devices that transform specific types of energy into other types (e.g., a device that transforms electricity into motion).	**194-202, 231-238, 486-497, 503-506**

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).	**194-202, 231-238, 486-497, 503-506**
P4.2D Explain why all the stored energy in gasoline does not transform to mechanical energy of a vehicle.	**486-497, 503-506**
P4.2e Explain the energy transformation as an object (e.g., skydiver) falls at a steady velocity.	**253-265, 697-702, 703-708**
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.	**194-202, 231-238, 486-497, 503-506**
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).	**4-14, 31-44, 194-202, 208-217, 218-230, 231-238, 697-702, 714-719**
P4.3B Describe the transformation between potential and kinetic energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts).	**4-14, 31-44, 194-202, 208-217, 218-230, 231-238, 697-702, 714-719**
P4.3C Explain why all mechanical systems require an external energy source to maintain their motion.	**4-14, 31-44, 194-202, 208-217, 218-230, 231-238, 697-702, 714-719**
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.	**31-44, 194-202**
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.	**4-14, 31-44, 194-202, 208-217, 218-230, 231-238, 697-702, 714-719**
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.	**253-265, 218-230**
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.	**326-339, 340-345, 641-649**

P4.4B Identify everyday examples of transverse and compression (longitudinal) waves.	**326-339, 340-345, 641-649**
P4.4C Compare and contrast transverse and compression (longitudinal) waves in terms of wavelength, amplitude, and frequency.	**326-339, 340-345, 641-649**
P4.4x Wave Characteristics — Calculations	
P4.4d Demonstrate that frequency and wavelength of a wave are inversely proportional in a given medium.	**326-339, 340-345, 641-649**
P4.4e Calculate the amount of energy transferred by transverse or compression waves of different amplitudes and frequencies (e.g., seismic waves).	**326-339, 340-345, 641-649**
P4.5 Mechanical Wave Propagation	
P4.5A Identify everyday examples of energy transfer by waves and their sources.	**641-649, 326-339, 340-345**
P4.5B Explain why an object (e.g., fishing bobber) does not move forward as a wave passes under it.	**641-649, 326-339, 340-345**
P4.5C Provide evidence to support the claim that sound is energy transferred by a wave, not energy transferred by particles.	**641-649, 326-339, 340-345, 346-353**
P4.5D Explain how waves propagate from vibrating sources and why the intensity decreases with the square of the distance from a point source.	**326-339, 340-345, 346-353**
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.	**340-345, 346-353**
P4.6 Electromagnetic Waves	
P4.6A Identify the different regions on the electromagnetic spectrum and compare them in terms of wavelength, frequency, and energy.	**764-770**
P4.6B Explain why radio waves can travel through space, but sound waves cannot.	**764-770, 683-688**

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.	**683-688, 665-671, 783-787**
P4.6D Explain why we see a distant event before we hear it (e.g., lightning before thunder, exploding fireworks before the boom).	**683-688, 665-671**
P4.6x Electromagnetic Propagation	
P4.6e Explain why antennas are needed for radio, television, and cell phone transmission and reception.	**764-770**
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.	**764-770**
P4.6g Explain how different electromagnetic signals (e.g., radio station broadcasts or cell phone conversations) can take place without interfering with each other.	**764-770**
P4.6h Explain the relationship between the frequency of an electromagnetic wave and its technological uses.	**764-770**
P4.r7x Quantum Theory of Waves *(recommended)*	
P4.r7a Calculate and compare the energy in various electromagnetic quanta (e.g., visible light, x-rays). *(recommended)*	**764-770**
P4.8 Wave Behavior — Reflection and Refraction	
P4.8A Draw ray diagrams to indicate how light reflects off objects or refracts into transparent media.	**354-361, 748-753**
P4.8B Predict the path of reflected light from flat, curved, or rough surfaces (e.g., flat and curved mirrors, painted walls, paper).	**354-361, 362-370, 371-376, 377-385**
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.	**650-655**

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).	**650-655, 771-776**
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).	**748-753**
P4.8f Explain how Snell's Law is used to design lenses (e.g., eye glasses, microscopes, telescopes, binoculars).	**748-753**
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.	**377-385, 748-753**
P4.9B Explain how various materials reflect, absorb, or transmit light in different ways.	**377-385**
P4.9C Explain why the image of the Sun appears reddish at sunrise and sunset.	**371-376, 771-776**
P4.r9x Nature of Light — Wave-Particle Nature *(recommended)*	
P4.10A Describe the energy transformations when electrical energy is produced and transferred to homes and businesses.	**486-497, 498-502, 503-506**
P4.10B Identify common household devices that transform electrical energy to other forms of energy, and describe the type of energy transformation.	**486-497, 498-502, 503-506**
P4.10B Identify common household devices that transform electrical energy to other forms of energy, and describe the type of energy transformation.	**486-497, 498-502, 503-506**
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.	**455-462, 463-471, 472-485**
P4.10D Discriminate between voltage, resistance, and current as they apply to an electric circuit.	**455-462, 463-471, 472-485**
P4.10x Current Electricity — Ohm's Law, Work, and Power	

P4.10e Explain energy transfer in a circuit, using an electrical charge model.	**455-462, 463-471, 472-485**
P4.10f Calculate the amount of work done when a charge moves through a potential difference, *V*.	**455-462, 463-471, 472-485**
P4.10g Compare the currents, voltages, and power in parallel and series circuits.	**472-485**
P4.10h Explain how circuit breakers and fuses protect household appliances.	**463-471, 472-485**
P4.10i Compare the energy used in one day by common household appliances (e.g., refrigerator, lamps, hair dryer, toaster, televisions, music players).	**498-502, 503-506**
P4.10j Explain the difference between electric power and electric energy as used in bills from an electric company.	**498-502, 503-506**
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.	**486-497**
P4.11b Calculate the final temperature of two liquids (same or different materials) at the same or different temperatures and masses that are combined.	**433-441, 486-497**
P4.12 Nuclear Reactions	
P4.12A Describe peaceful technological applications of nuclear fission and radioactive decay.	**612-619, 595-604, 605-611**
P4.12B Describe possible problems caused by exposure to prolonged radioactive decay.	**612-619**
P4.12C Explain how stars, including our Sun, produce huge amounts of energy (e.g., visible, infrared, ultraviolet light).	**612-619**
P4.12x Mass and Energy	

P4.12d Identify the source of energy in fission and fusion nuclear reactions.	**612-619**