# Physics NGSS - 2016 IAS Correlation Guide

| NGSS | Indiana's Academic Standards 2016 Physics I |
|---|---|
| | **PI.1.1** Develop graphical, mathematical, and pictorial representations (e.g. a motion map) that describe the relationship between the clock reading (time) and position of an object moving at a uniform rate and apply those representations to qualitatively and quantitatively describe the motion of an object. |
| | **PI.1.2** Describe the slope of the graphical representation of position vs. clock reading (time) in terms of the velocity of the object. |
| | **PI.1.3** Rank the velocities of objects in a system based on the slope of a position vs. clock reading (time) graphical representation. Recognize that the magnitude of the slope representing a negative velocity can be greater than the magnitude of the slope representing a positive velocity. |
| | **PI.1.4** Describe the differences between the terms “distance,” “displacement,” “speed,” “velocity,” “average speed,” and “average velocity” and be able to calculate any of those values given an object moving at a single constant velocity or with different constant velocities over a given time interval. |
| | **PI.2.1** Develop graphical, mathematical and pictorial representations (e.g. a motion map) that describe the relationship between the clock reading (time) and velocity of an object moving at a uniformly changing rate and apply those representations to qualitatively and quantitatively describe the motion of an object. |
| | **PI.2.2** Describe the slope of the graphical representation of velocity vs. clock reading (time) in terms of the acceleration of the object. |

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| | **PI.2.3** Rank the accelerations of objects in a system based on the slope of a velocity vs. clock reading (time) graphical representation. Recognize that the magnitude of the slope representing a negative acceleration can be greater than the magnitude of the slope representing a positive acceleration. |
| | **PI.2.4** Given a graphical representation of the position, velocity, or acceleration vs. clock reading (time), be able to identify or sketch the shape of the other two graphs. |
| | **PI.2.5** Qualitatively and quantitatively apply the models of constant velocity and constant acceleration to determine the position or velocity of an object moving in free fall near the surface of the Earth. |
| **HS-PS2-1**. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. | **PI.3.1** Understand Newton's first law of motion and describe the motion of an object in the absence of a net external force according to Newton's first law. |
| | **PI.3.2** Develop graphical and mathematical representations that describe the relationship among the inertial mass of an object, the total force applied and the acceleration of an object in one dimension where one or more forces is applied to the object and apply those representations to qualitatively and quantitatively describe how a net external force changes the motion of an object. |
| | **PI.3.3** Construct force diagrams using appropriately labeled vectors with magnitude, direction, and units to qualitatively and quantitatively analyze a scenario and make claims (i.e. develop arguments, justify assertions) about forces exerted on an object by other objects for different types of forces or components of forces. |

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| | **PI.3.4** Understand Newton's third law of motion and describe the interaction of two objects using Newton's third law and the representation of action-reaction pairs of forces. |
| **HS-PS2-4**. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. | **PI.3.5** Develop graphical and mathematical representations that describe the relationship between the gravitational mass of an object and the force due to gravity and apply those representations to qualitatively and quantitatively describe how changing the gravitational mass will affect the force due to gravity acting on the object. |
| | **PI.3.6** Describe the slope of the force due to gravity vs. gravitational mass graphical representation in terms of gravitational field. |
| | **PI.3.7** Explain that the equivalence of the inertial and gravitational masses leads to the observation that acceleration in free fall is independent of an object's mass. |
| **HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy | **PI.4.1** Evaluate the translational kinetic, gravitational potential, and elastic potential energies in simple situations using the mathematical definitions of these quantities and mathematically relate the initial and final values of the translational kinetic, gravitational potential, and elastic potential energies in the absence of a net external force. |
| | **PI.4.2** Identify the forms of energy present in a scenario and recognize that the potential energy associated with a system of objects and is not stored in the object itself. |

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| | **PI.4.3** Conceptually define “work” as the process of transferring of energy into or out of a system when an object is moved under the application of an external force and operationally define “work” as the area under a force vs. change in position curve. |
| | **PI.4.4** For a force exerted in one or two dimensions, mathematically determine the amount of work done on a system by an unbalanced force over a change in position in one dimension. |
| **HS-PS2-2.** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. | **PI.4.5** Understand and apply the principle of conservation of energy to determine the total mechanical energy stored in a closed system and mathematically show that the total mechanical energy of the system remains constant as long as no dissipative (i.e. non-conservative) forces are present. |
| | **PI.4.6** Develop and apply pictorial, mathematical or graphical representations to qualitatively and quantitatively predict changes in the mechanical energy (e.g. translational kinetic, gravitational or elastic potential) of a system due to changes in position or speed of objects or non-conservative interactions within the system. |
| **HS-PS3-1**. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known | **PI.5.1** For an object moving at constant rate, define linear momentum as the product of an object’s mass and its velocity and be able to quantitatively determine the linear momentum of a single object. |

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| | **PI.5.2** Operationally define "impulse" as the area under a force vs. change in clock reading (time) curve and be able to determine the change in linear momentum of a system acted on by an external force. Predict the change in linear momentum of an object from the average force exerted on the object and time interval during which the force is exerted. |
| | **PI.5.3** Demonstrate that when two objects interact through a collision or separation that both the force experienced by each object and change in linear momentum of each object are equal and opposite, and as the mass of an object increases, the change in velocity of that object decreases. |
| | **PI.5.4** Determine the individual and total linear momentum for a two-body system before and after an interaction (e.g. collision or separation) between the two objects and show that the total linear momentum of the system remains constant when no external force is applied consistent with Newton's third law. |
| | **PI.5.5** Classify an interaction (e.g. collision or separation) between two objects as elastic or inelastic based on the change in linear kinetic energy of the system. |
| | **PI.5.6** Mathematically determine the center of mass of a system consisting of two or more masses. Given a system with no external forces applied, show that the linear momentum of the center of mass remains constant during any interaction between the masses. |

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| | **PI.6.1** Develop graphical and mathematical representations that describe the relationship between the amount of stretch of a spring and the restoring force and apply those representations to qualitatively and quantitatively describe how changing the stretch or compression will affect the restoring force and vice versa, specifically for an ideal spring. |
| | **PI.6.2** Describe the slope of the graphical representation of restoring force vs. change in length of an elastic material in terms of the elastic constant of the material, specifically for an ideal spring. |
| | **PI.6.3** Develop graphical and mathematical representations which describe the relationship between the mass, elastic constant, and period of a simple horizontal mass-spring system and apply those representations to qualitatively and quantitatively describe how changing the mass or elastic constant will affect the period of the system for an ideal spring. |
| | **PI.6.4** Develop graphical and mathematical representations which describe the relationship between the strength of gravity, length of string, and period of a simple mass-string (i.e. pendulum) system apply the those representations to qualitatively and quantitatively describe how changing the length of string or strength of gravity will affect the period of the system in the limit of small amplitudes. |
| | **PI.6.5** Explain the limit in which the amplitude does not affect the period of a simple mass-spring (i.e. permanent deformation) or mass-string (i.e. pendulum, small angles) harmonic oscillating system. |

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| | **PI.7.1** Differentiate between transverse and longitudinal modes of oscillation for a mechanical wave traveling in one dimension. |
| | **PI.7.2** Understand that a mechanical wave requires a medium to transfer energy, unlike an electromagnetic wave, and that only the energy is transferred by the mechanical wave, not the mass of the medium. |
| **HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. | **PI.7.3** Develop graphical and mathematical representations that describe the relationship between the frequency of a mechanical wave and the wavelength of the wave and apply those representations to qualitatively and quantitatively describe how changing the frequency of a mechanical wave affects the wavelength and vice versa. |
| | **PI.7.4** Describe the slope of the graphical representation of wavelength vs. the inverse of the frequency in terms of the speed of the mechanical wave. |
| | **PI.7.5** Apply the mechanical wave model to sound waves and qualitatively and quantitatively determine how the relative motion of a source and observer affects the frequency of a wave as described by the Doppler Effect. |
| | **PI.7.6** Qualitatively and quantitatively apply the principle of superposition to describe the interaction of two mechanical waves or pulses. |
| | **PI.7.7** Qualitatively describe the phenomena of both resonance frequencies and beat frequencies that arise from the interference of sound waves of slightly different frequency and define the beat frequency as the difference between the frequencies of two individual sound wave sources. |

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| | **PI.8.1** Develop graphical, mathematical, and pictorial representations that describe the relationship between length, cross-sectional area, and resistivity of an ohmic device and apply those representations to qualitatively and quantitatively describe how changing the composition, size, or shape of the device affect the resistance. |
| | **PI.8.2** Describe the slope of the graphical representation of resistance vs. the ratio of length to cross-sectional area in terms of the resistivity of the material. |
| | **PI.8.3** Develop graphical and mathematical representations that describe the relationship between the amount of current passing through an ohmic device and the amount of voltage (i.e. EMF) applied across the device according to Ohm's Law and apply those representations to qualitatively and quantitatively describe how changing the current affects the voltage and vice versa. |
| | **PI.8.4** Describe the slope of the graphical representation of current vs. voltage or voltage vs. current in terms of the resistance of the device. |
| | **PI.8.5** Qualitatively and quantitatively describe how changing the voltage or resistance of a simple series (i.e. loop) circuit affects the voltage, current and power measurements of individual resistive devices and for the entire circuit. |
| | **PI.8.6** Qualitatively and quantitatively describe how changing the voltage or resistance of a simple parallel (i.e. ladder) circuit affects the voltage, current and power measurements of individual resistive devices and for the entire circuit. |

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| | **PI.8.7** Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule (∑ V = 0) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. |
| | **PI.8.8** Apply conservation of electric charge (i.e. Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed. |
| | **PI.8.9** Use a description or schematic diagram of an electrical circuit to calculate unknown values of current, voltage or resistance in various components or branches of the circuit according to Ohm's Law, Kirchhoff's junction rule, and Kirchhoff's loop rule. |