Modeling Motion (Bundle 1, Sub-Unit 1)

1. Time Frame	3 Weeks (Full Year), 1.5 Week (Block)
2. Selected Performance Expectation *Standards by Topic*	While this is not specifically addressed by NGSS, it is prerequisite content necessary for success as students' progress through their Physics course.
3. Related Disciplinary Core Ideas • *Read relevant section in Framework* • Evidence Statements	N/A
4. Prior Disciplinary Core Ideas • *Note how idea progresses from K through 12 using Appendix E*	N/A
5. Related Science and Engineering Practice • *Read relevant practice in Appendix F for your grade band.* • *Read the related element (bulleted) for the practice*	**Analyzing and Interpreting Data:** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Developing and Using Models:** Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, analyze systems, or solve problems.

	Using Mathematical & Computational Thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Apply rates and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as m/s, m/s^2, etc.).
6. Related Cross-cutting Concept • *Read relevant cross-cutting concept in Appendix G for your grade band* • *Read the related element (bullet) for the practice*	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Scale, Proportion & Quantity:** They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another
7. Possible misconceptions • *Use online resources, Uncovering Students' Ideas Probes, Making Sense of Secondary Science, Misconceptions in Primary Science, Atlas for Science Literacy*	Acceleration is only speeding up. Velocity is the same thing as speed. The acceleration of an object thrown upward into the air is zero at the top of the arc. Any linear graph of distance vs. time (not with speed of 0) indicates a changing speed (acceleration).
8. Potential Phenomena • *Read about grounding the learning in a phenomenon* • *Phenomena for NGSS* • *Nat Geo Phenomena*	Driving a car. Running or walking Going on a trip Falling ball

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Critical Vocabulary	Topics/Content
Distance Displacement Position Speed Velocity Relative motion Average speed/velocity Instantaneous Average Constant (Uniform) Reference frame (Frame of Reference) Acceleration Uniform acceleration Vector Scalar Magnitude of a vector Free fall Acceleration due to gravity	• Numerical, Mathematical & Graphical Analysis of Motion ($v = \frac{d}{t}$, $a = \frac{v_f - v_0}{t}$, $d = at^2$) • Free Fall (Conceptually, Mathematically & Graphically) • Vectors (Conceptually) • Combining 1 & 2-Dimensional Vectors (Graphically & Mathematically)

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1. What we figured out Answer to the focus question; claim	**2. Focus Question** Lesson-level questions	**3. Learning Target/"I can" Statements** Lesson Level PE; includes the practice, content, and CCC students used in experience	**4. Experiences/Activities** What experience(s) will students need to answer the focus question?
A vector is a measured quantity that includes magnitude (size) & direction but a scalar is a measured quantity that only includes magnitude.	What is the difference between a vector quantity and a scalar quantity?	1.01 – I can describe the difference between a vector quantity and a scalar quantity. 1.02 – I can classify measured quantities as a vector or a scalar.	
Vectors are modeled using an arrow where the direction of the vector is the direction of the arrow and the magnitude of the vector is its length.	How do you draw a vector?	1.03 – I can model a vector quantity by drawing arrows.	
The position of an object in motion is a vector quantity whose magnitude is the distance the object is from the reference point ("0") and its direction is the direction from the reference point. The displacement of an object in motion is a vector quantity whose magnitude is the distance between its initial position and its final position, while its direction is the direction from its initial position and its final position. The distance an object travels is a scalar quantity that depends on	What is the difference between position, displacement and distance? How can I use position, displacement and distance to model the motion of an object?	1.04 – I can distinguish between the position of an object, the displacement of an object and the distance an object moves. 1.05 – I can apply the position of an object, the displacement of an object or the distance an object moves to a model of its motion.	

the path taken from its initial position and its final position.			

The speed of an object in motion is a scalar quantity that can be calculated by dividing the distance it travels by the time it takes to travel that distance. The velocity of an object in motion is a vector quantity whose magnitude can be calculated by dividing its displacement (change in position) by the time it takes for the object to be displaced. The direction of the objects velocity can be determined by the direction of the displacement. The average speed (or velocity) of an object is measured over a time interval, while the instantaneous speed (or velocity) of an object is measured at a specific moment in time. If an object does not change its speed (or velocity) it is said to have a constant velocity.	What is the speed of an object? How do you calculate the speed of an object? What is the velocity of an object? How do you calculate the velocity of an object? What is the difference between speed and velocity? What is the difference between average speed (or velocity), instantaneous speed (or velocity)? What does it mean for an object to have a constant velocity?	1.06 – I can distinguish between the speed of an object and the velocity of an object. 1.07 – I can model the speed (or velocity) of an object using a mathematical equation. 1.08 – I can use an equation to calculate the speed, distance or time for a moving object given two of the other variables. 1.09 – I can use an equation to calculate the velocity, displacement (or position), or time for a moving object given two of the other variables. 1.10 – I can distinguish between average speed (or velocity) and instantaneous speed (or velocity). 1.11 – I can describe the motion of an object that's moving with a constant speed (or velocity).	

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A motion diagram for an object moving with a constant velocity shows dots that are evenly spaced (. . . . .). A motion diagram for an object moving with a uniform acceleration will show the dots getting farther apart (positive acceleration) (. . . .) or closer together (negative acceleration) (. . . .).	What does a motion diagram of an object moving with a constant velocity look like? What does the motion diagram of an object moving with a uniform acceleration look like?	1.12 – I can model constant velocity motion using a motion diagram. 1.13 – I can identify the motion diagram for an object moving with a constant velocity. 1.14 – I can model motion with a uniform acceleration using a motion diagram. 1.15 – I can identify the motion diagram for an object moving with a uniform acceleration (positive or negative). 1.16 – I can distinguish between the motion diagrams of an object traveling with a constant velocity and an object traveling with a uniform acceleration.	

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A position vs. time for an object in motion provides information about the motion including position, displacement, distance, speed, velocity, acceleration and time. The position vs. time graph for an object traveling with a constant velocity is linear and the slope of the line is the velocity of the object. The position vs. time graph for an object traveling with a uniform acceleration is a parabola. The slope of the parabola helps to determine the velocity of the object.	How do you model the motion of an object using a position vs. time graph? What information about the motion of an object can be determined by analyzing a position vs. time graph?	1.17 – I can model the motion of an object using a position vs. time graph. 1.18 – I can analyze a position vs. time graph to describe the motion of an object. 1.19 – I can use a position vs. time graph for an object traveling with a constant velocity to find its velocity. 1.20 – I can distinguish between the position vs. time graph for an object traveling with a constant velocity and an object traveling with a uniform acceleration.	

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The acceleration of an object in motion is a vector quantity whose magnitude can be found by dividing its change in velocity by the time it takes the velocity to change. The direction of the acceleration is in the same direction as its change in velocity. For an accelerating object traveling in a straight line, it will speed up if its acceleration and its velocity act in the same direction. The object will initially slow down if its acceleration and its velocity act in opposite directions. Objects that are accelerating either change speeds, change directions or both. An object with a constant speed can be acceleration if it is changing directions. The distance an object travels with a uniform acceleration (assuming it starts from rest) is related to its acceleration and time by the equation ($d = at^2$).	What is the acceleration of an object? What is the difference between acceleration and velocity? How do you calculate the acceleration of an object? How do the direction of the acceleration and the direction of the velocity of an object affect its change in speed? How do you calculate the distance an object travels with uniform acceleration?	1.21 – I can describe the motion of an object that is accelerating. 1.22 – I can distinguish between the acceleration of an object and the velocity of an object. 1.23 – I can model the motion of an accelerating object using an equation that depends on its change in velocity and time. 1.24 – I can calculate the acceleration of an object, its final velocity or its time given the other information. 1.25 – I can describe how speed and/or the direction of an object are affected by the direction of its acceleration compared to the direction of its velocity. 1.26 – I can model the distance a uniformly accelerating object travels related to its acceleration and time with an equation assuming it starts from rest. 1.27 – I can calculate the distance a uniformly accelerated object travels, its acceleration or its time given that it starts from rest and two of the other variables.	

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An object in free fall (up or down) is just a uniformly accelerated object whose downward acceleration is the acceleration due to gravity (9.8-m/s^2 on Earth). The equations, motion diagrams and graphs of motion that model uniform acceleration are the same that model free-fall.	What is free fall? How can I model free-fall using equations, motion diagrams and graphs of motion? How can I calculate the speed of a falling object? How can I calculate the distance a falling object falls?	1.28 – I can model free-fall as uniform acceleration using the same equations, motion diagrams and graphs of motion. 1.29 – I can calculate the acceleration of free-falling object, its final velocity or its time given the other information. 1.30 – I can calculate the distance a free-falling object travels, its acceleration or its time given that it starts from rest and two of the other variables.	