01 Kinematics

Content Area: **Science**
Course(s): **AP Physics 1**
Time Period: **Semester 1**
Length: **13 Periods**
Status: **Published**

Standards

	Patterns
PS2.B	Types of Interactions
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.
PS2.A	Forces and Motion
	Cause and Effect
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.
	Scale, Proportion, and Quantity
	Using Mathematics and Computational Thinking
HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
ESS1.B	Earth and the Solar System
	Analyzing and Interpreting Data

Enduring Understandings

All forces share certain common characteristics when considered by observers in inertial reference frames.

The acceleration of the center of mass of a system is related to the net force exerted on the system, where a = F/m

Essential Questions

1. How can the idea of frames of reference allow two people to tell the truth yet have conflicting reports?
2. How can we estimate the height of a very tall building with only a small rock and a stopwatch?
3. Why might it seem like you are moving backwards when a car passes you on the highway?
4. Why is the general rule for stopping your car "when you double your speed, you must give yourself four times as much distance to stop"?

Knowledge and Skills

Topic 1.1 Scalars and Vectors in One Dimension

Knowledge

- Scalars are quantities described by magnitude only; vectors are quantities described by both magnitude and direction.
- Vectors can be visually modeled as arrows with appropriate direction and lengths proportional to their magnitude.
- Distance and speed are examples of scalar quantities, while position, displacement, velocity, and acceleration are examples of vector quantities
- Vectors are notated with an arrow above the symbol for that quantity.
- Vector notation is not required for vector components along an axis. In one dimension, the sign of the component completely describes the direction of that component.
- When determining a vector sum in a given one-dimensional coordinate system, opposite directions are denoted by opposite signs.

Skills

- Create diagrams, tables, charts, or schematics to represent physical situations.
- Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.
- Apply an appropriate law, definition, theoretical relationship or model to make a claim
- Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

Topic 1.2 Displacement, Velocity, and Acceleration

Knowledge

- When using the object model, the size, shape, and internal configuration are ignored. The object may be treated as a single point with extensive properties such as mass and charge
- Displacement is the change in an object's position.
- Averages of velocity and acceleration are calculated considering the initial and final states of an object over an interval of time.
- Average velocity is the displacement of an object divided by the interval of time in which that displacement occurs.
- Average acceleration is the change in velocity divided by the interval of time in which that change in velocity occurs
- An object is accelerating if the magnitude and/or direction of the object's velocity are changing.
- Calculating average velocity or average acceleration over a very small time interval yields a value that is very close to the instantaneous velocity or instantaneous acceleration.

Skills

- Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.
- Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.

- Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.
- Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

Topic 1.3 Representing Motion

Knowledge

- Motion can be represented by motion diagrams, figures, graphs, equations, and narrative descriptions.
- For constant acceleration, three kinematic equations can be used to describe instantaneous linear motion in one dimension.

- Near the surface of Earth, the vertical acceleration caused by the force of gravity is downward, constant, and has a measured value approximately equal to $g \approx 10$ m/s/s.

- Graphs of position, velocity, and acceleration as functions of time can be used to find the relationships between those quantities.
    - An object's instantaneous velocity is the rate of change of the object's position, which is equal to the slope of a line tangent to a point on a graph of the object's position as a function of time.
    - An object's instantaneous acceleration is the rate of change of the object's velocity, which is equal to the slope of a line tangent to a point on a graph of the object's velocity as a function of time.

    - The displacement of an object during a time interval is equal to the area under the curve of a graph of the object's velocity as a function of time (i.e., the area bounded by the function and the horizontal axis for the appropriate interval).

    - The change in velocity of an object during a time interval is equal to the area under the curve of a graph of the acceleration of the object as a function of time.

Skills

- Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system
- Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway
- Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.
- Apply an appropriate law, definition, theoretical relationship, or model to make a claim

1.4 Reference Frames and Relative Motion

Knowledge

- The choice of reference frame will determine the direction and magnitude of quantities measured by an observer in that reference frame.
- Measurements from a given reference frame may be converted to measurements from another reference frame.
- The observed velocity of an object results from the combination of the object's velocity and the velocity of the observer's reference frame.
    - Combining the motion of an object and the motion of an observer in a given reference frame

involves the addition or subtraction of vectors
    - The acceleration of any object is the same as measured from all inertial reference frames.

Skills

- Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.
- Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.
- Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.
- Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

1.5 Vectors and Motion in Two Dimensions

Knowledge

- Vectors can be mathematically modeled as the resultant of two perpendicular components.
- Vectors can be resolved into components using a chosen coordinate system.
- Vectors can be resolved into perpendicular components using trigonometric functions and relationships.
- Motion in two dimensions can be analyzed using one-dimensional kinematic relationships if the motion is separated into components.
- Projectile motion is a special case of two dimensional motion that has zero acceleration in one dimension and constant, nonzero acceleration in the second dimension.

Skills

- Create quantitative graphs with appropriate scales and units, including plotting data.
- Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway
- Predict new values or factors of change of physical quantities using functional dependence between variables.
- Create experimental procedures that are appropriate for a given scientific question
- Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

Transfer Goals

Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Cause and Effect: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at

different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

Energy and Matter: Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.

Structure and Function: The way an object is shaped or structured determines many of its properties and functions.

Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing

Science Modifications