GUIDED NOTES

Unit 1: Kinematics in One Dimension

OBJECTIVES:

Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

Enduring Understanding 1.A: The internal structure of a system determines many properties of the system.

Essential Knowledge 1.A.1: A system is an object or a collection of objects. Objects are treated as having no internal structure.

a. A collection of particles in which internal interactions change little or not at all, o0r in which changes in these interactions are irrelevant to the question addressed, can be treated as an object.

Essential Knowledge 1.A.5: Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important in modeling the behavior of the macroscopic system, the system itself may be referred to as an object.

Essential Knowledge 5.A.1: A system is an object or a collection of objects. The objects are treated as having no internal structure.

Big Idea 3: The interactions of an object with other objects can be described by forces.

Enduring Understanding 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames. [1]

Essential Knowledge 3.A.1: An observer in a particular reference frame can describe the motion of an object using such quantitates as position, displacement, distance, velocity, speed, and acceleration.

a. Displacement, velocity, and acceleration are all vector quantities.

b. Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.

c. A choice of reference frame determines the direction and the magnitude of each of these quantities.

Learning Objectives:

3.A.1.1: The student is able to express the motion of an object using narrative, mathematical, and graphical representations.

3.A.1.2: The student is able to design an experimental investigation of the motion of an object.

3.A.1.3: The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.

Big Idea 4: Interactions between systems can result in changes in those systems.

Enduring Understanding 4.A: The acceleration of the center of mass of a system is related to the net force exerted on the system, where $\vec{a} = \frac{\vec{F}}{m}$.

Essential Knowledge 4.A.1: The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.

Learning Objectives:

4.A.1.1: The student is able to use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semiquantitatively.

[1] We will cover the objectives in gray text when we get to our units on force.

GUIDED NOTES

Essential Knowledge 4.A.2: The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.

a. The acceleration of the center of mass of a system is directly proportional to the net force exerted on it by all objects interacting with the system and inversely proportional to the mass of the system.

b. Force and acceleration are both vectors, with acceleration in the same direction as the net force.

Learning Objectives:

4.A.2.1: The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.

NOTES:

I. Basic Information

A. _____ deals with _____.

1. _____ deals with describing _____ things move; ex., displacement, velocity, acceleration.
2. _____ deals with _____ things move; ex., forces, energy.

B. _____: The study of motion as it obeys Newton's Laws (as opposed to motion governed by Einstein's relativity)

C. _____ of the universe: The universe consists of _____ known dimensions.

1. Spatial dimensions:
   a. 1-D: line
   b. 2-D: plane
   c. 3-D: intersection
2. Time is the fourth dimension.

D. _____: The *x-y-z* spatial coordinate system.

1. The location of the point of origin is up to the physicist.
2. Positive and negative signs matter and may be defined by the physicist. Generally up and right are considered positive, but the physicist may change this to suit a situation.

E. Vectors and scalars:

1. _____ are measurements for which _____ is a relevant value.
   a. Vectors have _____, which is the _____ of the measurement.
   b. Vectors also have _____, expressed in multiple ways.
      - Up/down/left/right
      - N/S/E/W
      - + and –
      - Angles

2. _____ are measurements for which _____.

3. Create a graphic organizer to describe vectors and scalars. Generate examples for each and include these in the graphic organizer.

F. _____: In inertial reference frames…

1. …an object that does not interact with any other objects moves at constant velocity.
2. …forces are detected by their influence on the motion (specifically the velocity) of an object.
3. Examples…Inertial or non-inertial?
   a. A tow cable pulls the Top Thrill Dragster to accelerate it along the track. _____ because…
   b. The back of the seat pushes on a rider so that she moves with the Top Thrill Dragster train. _____ because…

G. Systems vs. objects

1. A _____ is an object or a _____. A system has _____ that determines its behavior in different situations.
2. _____are treated as having _____. A collection of particles in which internal interactions change little or not at all, or in which changes in these interactions are irrelevant to the question addressed, can be treated as an object.

3. Examples:

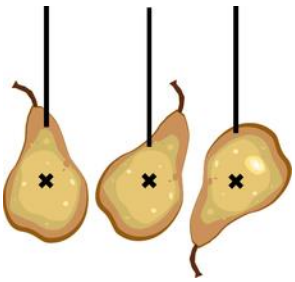
a. A ball that is moving on a frictionless surface is _____ because…

b. Three electric charges exerting forces on each other are a _____ because…

H. _____:

1. The _____of an object or system of objects is called the center of mass (_____)

2. When finding the center of mass of an object, find the point from which it can be _____.



3. When finding the center of mass of an _____, we use the following equation[2]:

- <u>Example 1</u>: A 544kg brown bear sits on the end of a log that is 5.0m long. A 408kg grizzly bear sits on the other end. The log is balanced on a rock somewhere between the two bears.
    - Predict qualitatively where the cm should be.
    - Calculate quantititatively: Where is the rock located? *Hint: Look at I.D.1 in the notes.*

[2] This is not on your formula sheet.

GUIDED NOTES

II. Kinematics Concepts

A. _____: The position of an object on its coordinate system can be described by *x*.

1. _____ is the initial position.
2. _____ is the final position.
3. _____ is the change in an object's position.

B. _____: A _____ that _____ _____ and has a _____ that _____ the _____ between the two positions

1. Symbol:
2. SI Unit:
3. Formula:

4. <u>Example 2</u>: An ant on a ruler moves from the 2.5cm mark to the 10.0cm mark and then moves to the 1.2cm mark. What is its displacement? Describe this mathematically, naratively, and graphically. What is the reference frame you chose? How would this look from a different reference frame?

GUIDED NOTES

C. _____: How fast something moves

1. Symbol:
2. SI Unit:
3. Formula:

D. _____: A _____ that describes an _____

1. Symbol:
2. SI Unit:
3. Average vs. Instantaneous Velocity
   a. _____is the _____ rate of displacement.
      1.) Formula:

      2.) <u>Example 3</u>: The cm of the ant on the ruler in example 2 took 3.2 seconds to travel to the 10.0cm mark and 8.5 seconds to travel to its final position. What is its averate velocity during the first motion? The second motion? The overall average velocity? Describe this mathematically, naratively, and graphically. What is the reference frame you chose? How would this look from a different reference frame?

   b. _____is the rate of motion _____in time, such as _____ at the beginning of the period being examined. Another example is _____ the velocity at the end of the period being examined.

GUIDED NOTES

E. _____: A _____ that describes an object's _____

1. Symbol:
2. SI Unit:
3. Formula:

4. <u>Example 4</u>: A top fuel dragster accelerates from rest to 44.4m/s (about 100 miles per hour) in 0.8 seconds. Describe its acceleration mathematically, naratively, and graphically. Be sure to refer to instantaneous velocity in your answers. What is the reference frame you chose? How would this look from a different reference frame? Finally, create a data table to show how fast the car would be going every second if it continued to accelerate at this uniform rate (consistent rate) for a total of five seconds. Are these velocity values average or instantaneous? Relate your data table to the units of acceleration.

5. Relationship of +/- signs of acceleration to velocity change
   a. If the _____, the object _____ its velocity.
      - Generate an example mathematically, narratively, and graphically.

   b. If the _____, the object _____ its velocity.
      - Generate an example mathematically, narratively, and graphically.

III. Motion with a Constant Acceleration: When an object changes its velocity at a constant rate, we can examine the effects on the other kinematic variables. We examine this mathematically with formulas and conceptually with graphs.

A. Kinematic Equations:
   - $v = v_0 + at$
   - $x = x_0 + v_0 t + \frac{1}{2}at^2$
   - $v^2 = v_0^2 + 2a(x - x_0)$
   - Extra equation not on the AP list: $\Delta x = \frac{1}{2}(v_0 + v)t$

B. Classic example: Freely-Falling Bodies
   1. When air resistance is so minimal that it can be neglected, we consider an object falling due to gravity to be in _____.
   2. Free fall _____. Therefore we can use the kinematic equations.
   3. Acceleration due to gravity:

4. Example 5: A person tosses a banana straight upward with an initial velocity of 16m/s. The banana rotates around its cm, but its cm moves straight up and down, so we will consider only the motion of the cm. Brainstorm ways to represent the displacement, instantaneous velocity, acceleration, and average velocity of the cm of the banana as it moves upward and back down to the person's hands. Be sure to include mathematical, narrative, and graphical representations.

GUIDED NOTES

IV. Graphical Analysis of One-Dimensional Motion

A. Position v. Time graphs:

- The slope of a position v. time graph is the _____.
- If the slope is not constant, the object is undergoing acceleration, and the slope of the tangent line is the _____.

B. Velocity v. Time graphs:

- The slope of a velocity v. time graph is the _____.
- The area under the curve is the _____.

C. Acceleration v. Time graphs:

- The area under an acceleration v. time graph curve is the change in _____.

D. <u>Examples</u>: Analyze the graphs you created for the previous five examples. Use them to analyze as many of the above bullet-pointed values as you can.