AP Physics Study Guide

Kinematics

From Simple Studies, https://simplestudies.edublogs.org & @simplestudiesinc on Instagram

All images are from the Openstax college physics textbook

Kinematics is the study of motion without considering its causes

- One-dimensional motion is motion along a straight line (a football being thrown)
- Two-dimensional motion deals with motion in multiple directions (a car rounding a curve)

Position is where an object is at any particular time

- It is more specifically where an object is relative to a convenient reference frame
    - We often use Earth as a relative reference frame

Displacement is change in position.

- $\Delta x = x_f - x_0$
    - This equation means displacement is the final position minus the initial position
- Displacement has direction and magnitude (it is a vector)
    - Motion to the right is positive, and motion to the left is negative

Distance is the magnitude or size of displacement between two positions

- **Distance traveled** is the total length of the path traveled between two positions
    - It does not have direction (it is a scalar)

A **Vector** is any quantity with both magnitude and direction

- Ex: 90 km/hr east and 500 N straight down

A **Scalar** is any quantity that has magnitude, but no direction

- Ex: 20 degrees Celsius, 1.8 meters, 90 km/kr

Time is change, or the interval over which change occurs

- $\Delta t = t_f - t_0$

- Elapsed time is the difference between ending time and beginning time

Average Velocity is displacement (change in position) divided by the time of travel

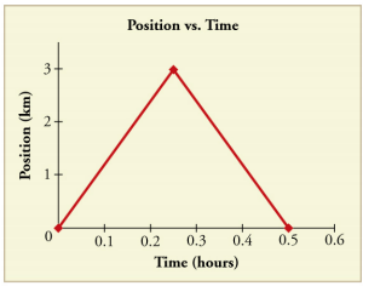
- $v = \Delta x / \Delta t$
- Velocity is a vector because displacement is a vector
- The average velocity of an object does not tell us anything about what happens to it between the starting point and ending point
    - **Instantaneous Velocity** is the average velocity at a specific instant in time

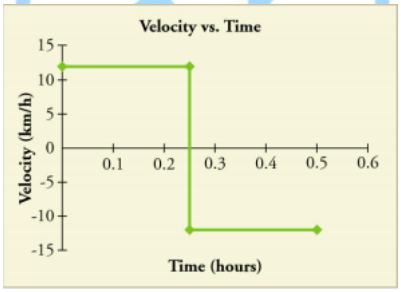
Instantaneous Speed is the magnitude of instantaneous velocity

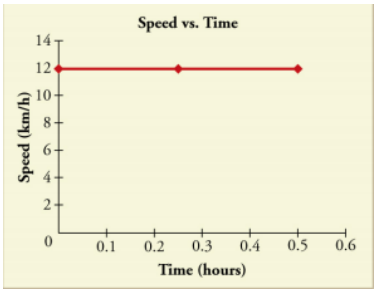
- **Average Speed** is the distance traveled by elapsed time
    - It is not simply the magnitude of average velocity

One way of visualizing the motion of an object is by using a graph

- Graphs depict a very simplified **model** of the trip







Average Acceleration is the rate at which velocity changes

- $a = \Delta v / \Delta t$
- Acceleration is a vector because velocity is a vector
    - Acceleration can change in either speed or direction, or both
- When an object's acceleration is the same direction of its motion, the object will speed up
    - When an object's acceleration is opposite to the direction of its motion, the object will slow down

These are equations that are applied to kinematic problems (they are given on your reference sheet)

- $x = x_0 + vt$
- $v = \frac{v_0+v}{2}$
- $v = v_0 + at$
- $x = x_0 + v_0 t + \frac{1}{2}at^2$
- $v^2 = v_0^2 + 2a(x - x_0)$

These are the general steps you should take when given a kinematic problem

- Examine the situation to determine which physical principles are involved
    - It often helps to draw a simple sketch of the problem
    - Determine which direction is positive and which is negative
- Make a list of what is given or can be inferred from the problem as stated
    - Identify the known variables
    - "Stopped" means the velocity is zero
    - Initial time and initial position is often zero
- Identify exactly what needs to be determined in the problem
    - Identify the unknown variables
    - Make a list

- Find an equation or set of equations that can help you solve the problem
    - Find equations that contain only one unknown variable
    - You may have to use two or more different equations to get to the final answer
- Substitute the known variables along with their units into the appropriate equation
    - Obtain numerical solutions complete with units
- Check the answer to see if it is reasonable
    - Check its magnitude, sign, and units

These are the general steps you can take to determine whether an answer is reasonable and if not, what is the cause

- Solve the problem using the steps mentioned above
- Check to see if the answer is reasonable
    - Is it too large or too small?
    - Does it have the wrong sign or improper units?
- If the answer is unreasonable, look for what specifically could cause the identified difficulty

An object falling without air resistance or friction is in **free fall**

- The acceleration of free-falling objects is called the **acceleration due to gravity**
    - It is constant, which means we can apply the kinematics equations to any falling object where air resistance and friction are negligible
    - $g = 9.80\, m/s^2$
- We can then substitute g for a in the kinematics equations
    - $v = v_0 - gt$
    - $y = y + v_0 t + \frac{1}{2} g t^2$
    - $v^2 = v_0^2 + 2g(y - y_0)$

When two physical quantities are plotted against one another in a graph, the horizontal axis is usually considered to be an **independent variable** and the vertical axis a **dependent variable**

- A straight line graph has the general form $y = mx + b$
    - m = the **slope**, the rise divided by the run
    - b = the **y-intercept**, the point at which the line crosses the vertical axis

In a displacement vs time graph, the slope of the graph is the average velocity

- The y-intercept is the displacement at time = zero

In a velocity vs time graph, the slope of the graph is the average acceleration

- The y-intercept is the velocity at time = zero