Unit 2: Applications involving Position and Velocity

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To gain a better understanding of the derivative let's examine objects that are moving. This movement is referred to as a change in position. This will allow us to see the difference between calculating the rate of change (slope) as an *average* vs. calculating the rate of change (slope) at an *instant* in time.

Velocity: the change in position of an object over a change in time.

Note: **The velocity of an object is directional.**
-It will be positive if the change in position is linear and the object is moving up and to the right.
-It will be negative if the change in position is linear and the object is moving down and to the left.

Examples:

1a. Find the average velocity of a projectile that went from 2 meters to 20 meters in the time interval from t = 1 to t = 4 seconds.

1b. Find the average velocity of an object moving from 50 feet to 30 feet in the time interval from t = 3 to t = 7 seconds.

If an object's movement is defined by a ***position function*** [often called s(t)], the average velocity in an interval of time [t, t + h] would be given by using the slope formula:

2. If a particle moves according to the formula s(t) = $2t^2 + 3$, find the ***average velocity*** of the particle in the time interval t = [1, 4] seconds.

Instantaneous Velocity:

As the time interval "h" continues to get smaller for an interval of time ($h \to 0$), the average velocity approaches the instantaneous velocity at a specific time, thus requiring the use of the limit definition.

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3. If s(t) = $2t^2 + 3$, find the ***instantaneous velocity*** at t = 3 seconds.

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4. A person bungee jumps from a height of 1024 ft. and falls toward the ground .
   (note: free falling objects (ignoring air resistance) dropped from rest will fall s(t) = $16t^2$ feet in the first t seconds.

   What is the function to determine their position? $s(t) =$ _____

5a. A rock falls from the top of a cliff. What is the average speed during the first 2 seconds of the fall? (note: free falling objects (ignoring air resistance) dropped from rest will fall s(t)=$16t^2$ feet in the first t seconds.

5b. Find the instantaneous velocity of the rock at t = 2 seconds.

5c. Find the speed of the rock at instant t = 2.

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6. Given the position function $s(t) = 6t^2 + 7t + 2$ in meters and t in seconds.
   Find the distance traveled after the first 15 seconds.

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For each of the following position functions find

a) the average velocity in the given interval.
b) the instantaneous velocity formula.
c) the instantaneous velocity for the 3 times given.

1. $s(t) = 200 - 16t^2$ $[0,3]$ t = 1, 2, 3

2. $s(t) = 2t^2 + 2$ $[1,4]$ t = 0, 2, 4

3. $s(t) = 40t - 16t^2$ $[0,2]$ t = 1, 1.5, 2

4. $s(t) = t^3 + 2t$ $[0,2]$ t = 2, 5, 10

5. A rock is dropped from a height of 576 ft. and falls toward earth in a straight line. In t seconds the rock drops a distance of $16t^2$ feet.

   a) How many seconds after release does the rock hit the ground?
   b) What is the average velocity during the time that it is falling?
   c) What is the average velocity for the first 3 seconds?
   d) What is the instantaneous velocity at t = 4 seconds?
   e) At what velocity does the rock hit the ground?

6. During the first 40 seconds of a rocket flight, the rocket is propelled straight up so that in t seconds it reaches a height of $5t^3$ feet.

   a) How high does the rocket travel in 40 seconds?
   b) What is the average velocity of the rocket during the first 40 seconds?
   c) What is the average velocity of the rocket during the first 135 feet of its flight?
   d) What is the instantaneous velocity of the rocket at t = 10 seconds?
   e) What is the instantaneous velocity of the rocket at t = 40 seconds?