

## Chapter 3.4: The Derivative as a Rate of Change

**Example:** For a circle what is the rate of change of the area with respect to the radius?

**Example:** For a sphere what is the rate of change of the volume with respect to the radius?

# Physics Basics

Object is moving with time  $t$ .

$s(t)$  = position (at time  $t$ )

$v(t)$  = velocity  
= how position changes  
=  $s'(t)$

$|v(t)|$  = speed

$a(t)$  = acceleration  
= how velocity changes  
=  $v'(t)$   
=  $s''(t)$

What are the units?

**Example:** A cannon ball is launched straight into the air and its vertical position is given by  $s = 200t - 20t^2$ .

1. Compute  $v$  as a function of  $t$
2. Compute  $a$  as a function of  $t$
3. What is the maximum height the ball obtains?
4. What is  $v$  of the ball when it is 320 ft above the ground and heading downward?

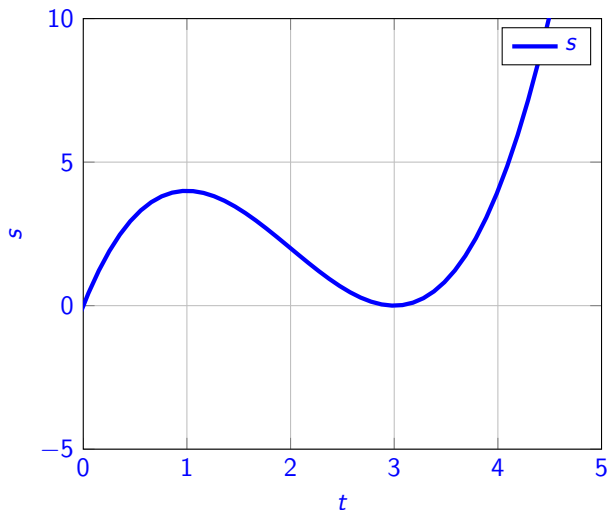
# 1-D World

**Example:** Consider a particle moving along the  $y$ -axis, whose position is given by  $s = t^3 - 6t^2 + 9t$

1. Find the particles velocity, speed, and acceleration as a function of  $t$ .
2. Find the particles displacement from  $t = 0$  to  $t = 2$ .  
*Displacement* is the change in position.
3. Find the particles average velocity from  $t = 0$  to  $t = 2$ .
4. Find the total distance the particle travels from  $t = 0$  to  $t = 2$ .

## 1-D World: Particle Path

**Example:** Consider a particle moving along the  $y$ -axis, whose position is given by  $s = t^3 - 6t^2 + 9t$ . Sketch  $v$  and  $a$ .



## 1-D World:

**Example:** Consider a particle moving along the  $y$ -axis, whose position is given by  $s = t^3 - 6t^2 + 9t$

1. Find the particles velocity, speed, and acceleration as a function of  $t$ .

$$v = s' = 3t^2 - 12t + 9 \quad \text{speed} = |v| = |3t^2 - 12t + 9| \quad a = v' = 6t - 12$$

4. Find the total distance the particle travels from  $t = 0$  to  $t = 2$ .

## Chapter 3.4 Recap

- ▶  $s(t)$  is location as a function of time  $t$
- ▶  $v(t)$  is velocity as a function of time  $t$
- ▶  $a(t)$  is acceleration as a function of time  $t$
- ▶ speed is  $|v(t)|$
- ▶  $s' = v$
- ▶  $s'' = v' = a$