Acceleration

A rate of a rate (how fast how fast?)

Kinematics Unit Outline

I. Vectors

II. Six Definitions:
Distance, Position, Displacement,
Speed, Velocity, **Acceleration**

III. Two Equations:
Velocity, Displacement

IV. Freefall

	The student will be able to:	HW:
1	Define and distinguish the concepts scalar and vector. Make the connection between the visual representation of a vector and its numerical representation of magnitude and direction angle.	✓
2	Define, distinguish, and apply the concepts: distance, displacement, position.	✓ 1, 2
3	Define, distinguish, and apply the concepts: average speed, instantaneous speed, constant speed, average velocity, instantaneous velocity, constant velocity.	✓ 3 – 7
4	Define, distinguish, and apply the concepts: average acceleration and instantaneous acceleration, and constant acceleration.	8 – 16
5	State the displacement and velocity relations for cases of constant acceleration and use these to solve problems given appropriate initial conditions and values.	17 – 28
6	State and use the conditions of freefall, including the value of *g*, to solve associated problems.	29 – 41

Acceleration of a Car

- A car's acceleration is often described by citing a "zero to sixty" time such as: 0 to 60 mph in 15 seconds.
- The less the time, the greater the acceleration. Zero to 60 mph in 10 seconds would be a greater acceleration than the previous example.
- The more rapid the increase in speed, the greater the acceleration.
- How could the *rate* of change in speed be quantified by a *single* value?

Acceleration in Physics

- **Acceleration** is the time rate of change in velocity. Symbol: **a** or $\vec{a}$
- Note that acceleration is a vector indicating how much change per unit time *and* the direction of change.
- Unlike our everyday use of the word, acceleration pertains to *any* change in velocity including: increase in speed,
  decrease in speed,
  or change in direction.

Equations

Average acceleration:

$$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$$

Constant acceleration:
(If the rate of change is known to be constant the word average may be dropped.)

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

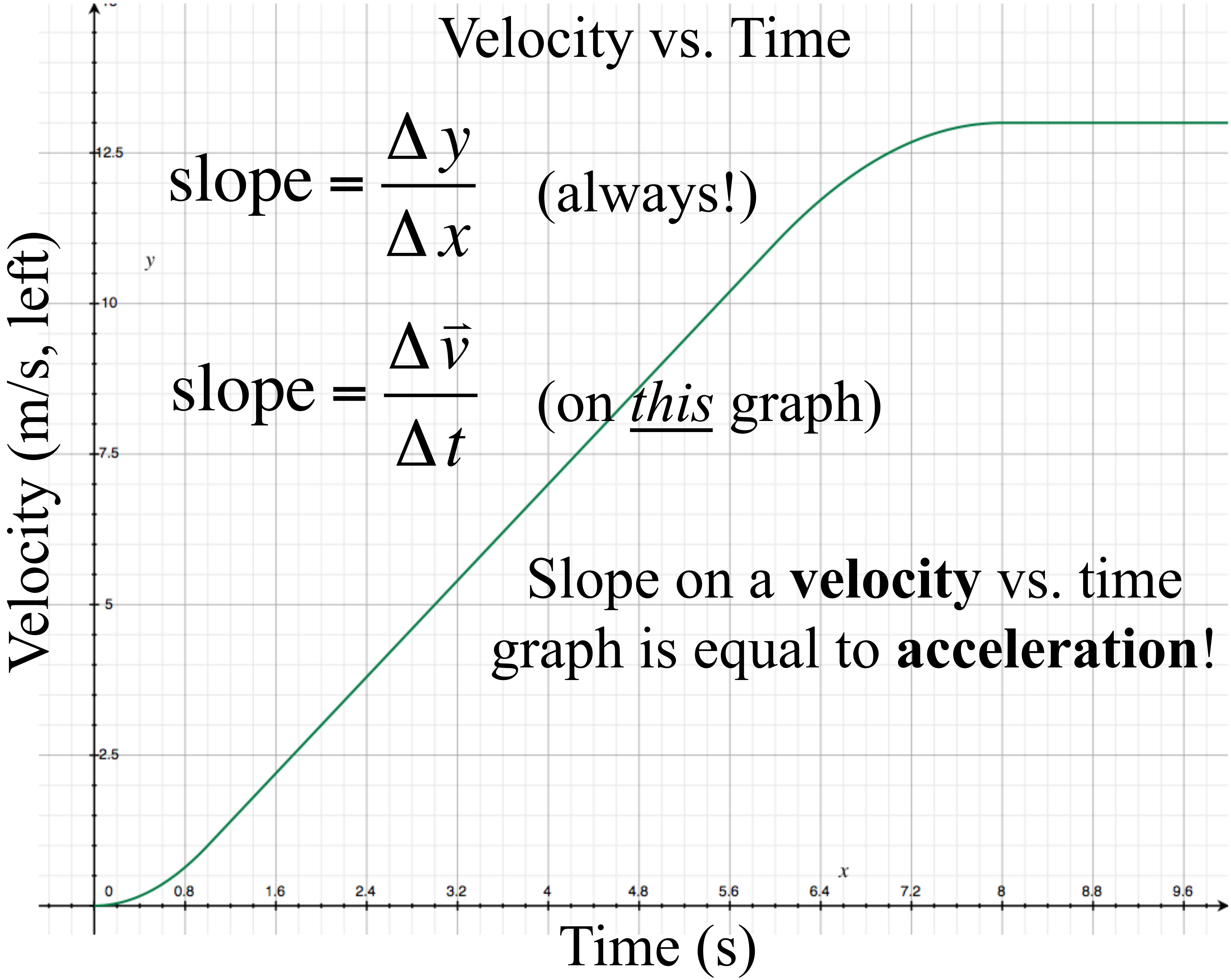
Equations

Average acceleration:

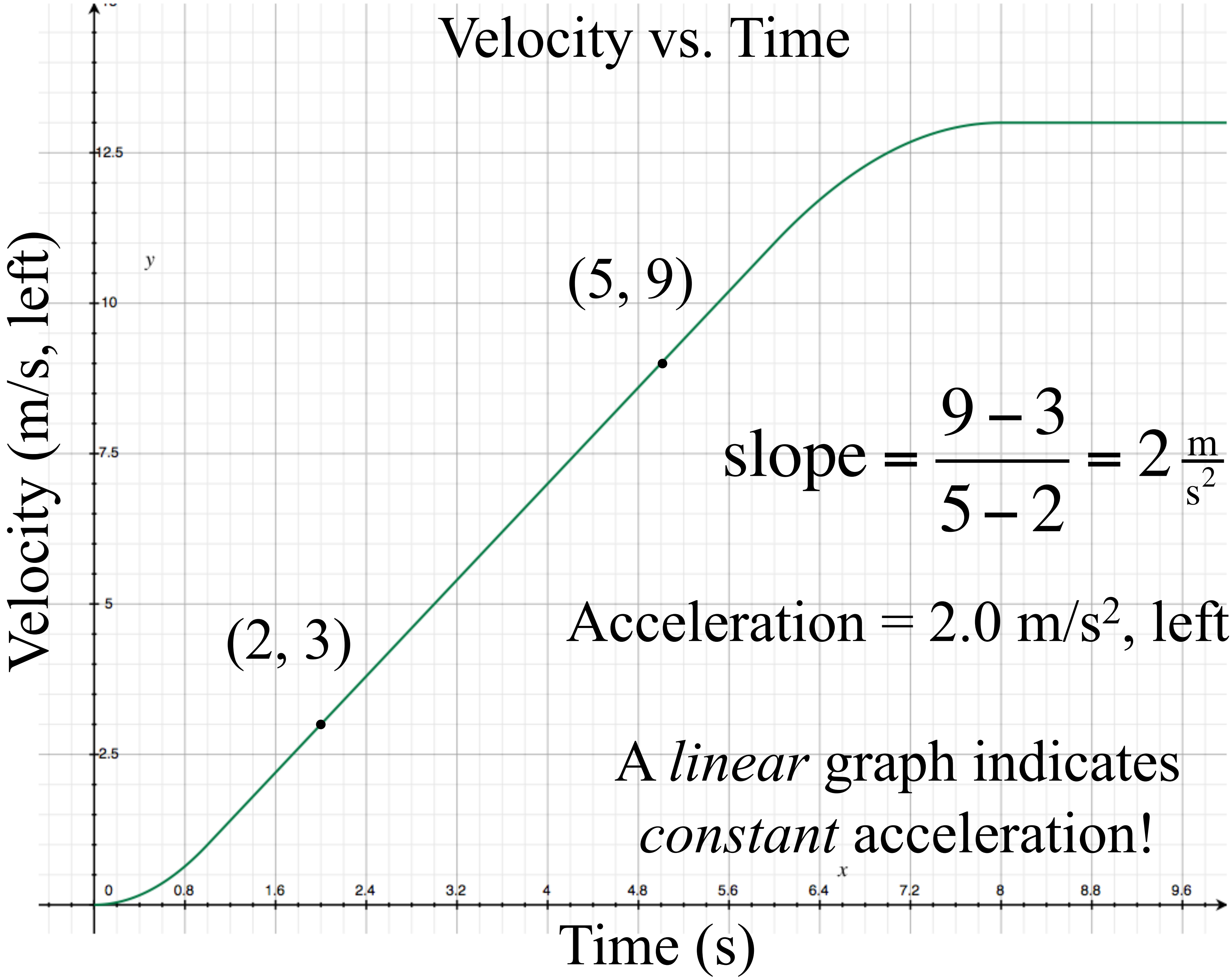
$$\vec{a}_{avg} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

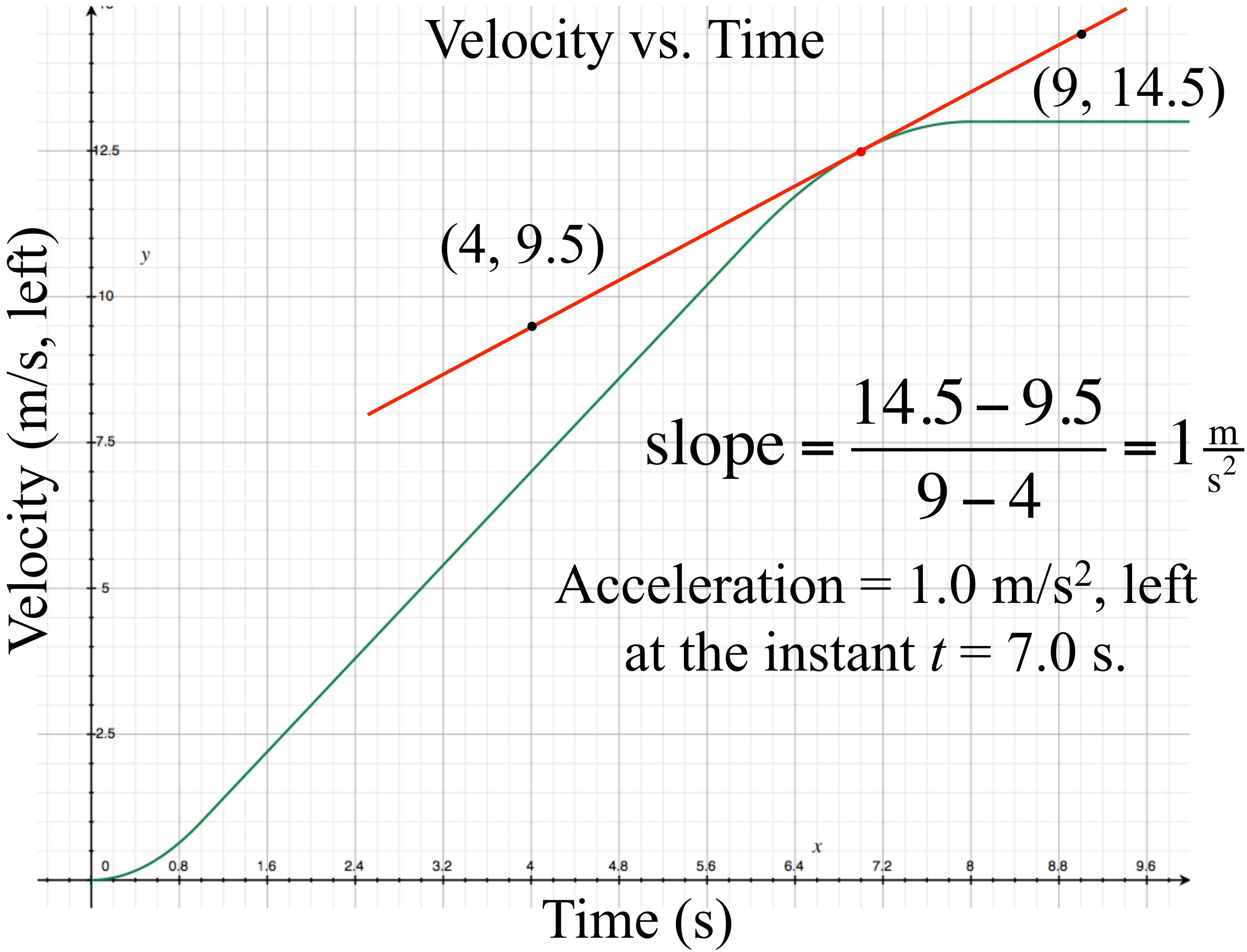
Constant acceleration:
(If the rate of change is known to be constant the word average may be dropped.)

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

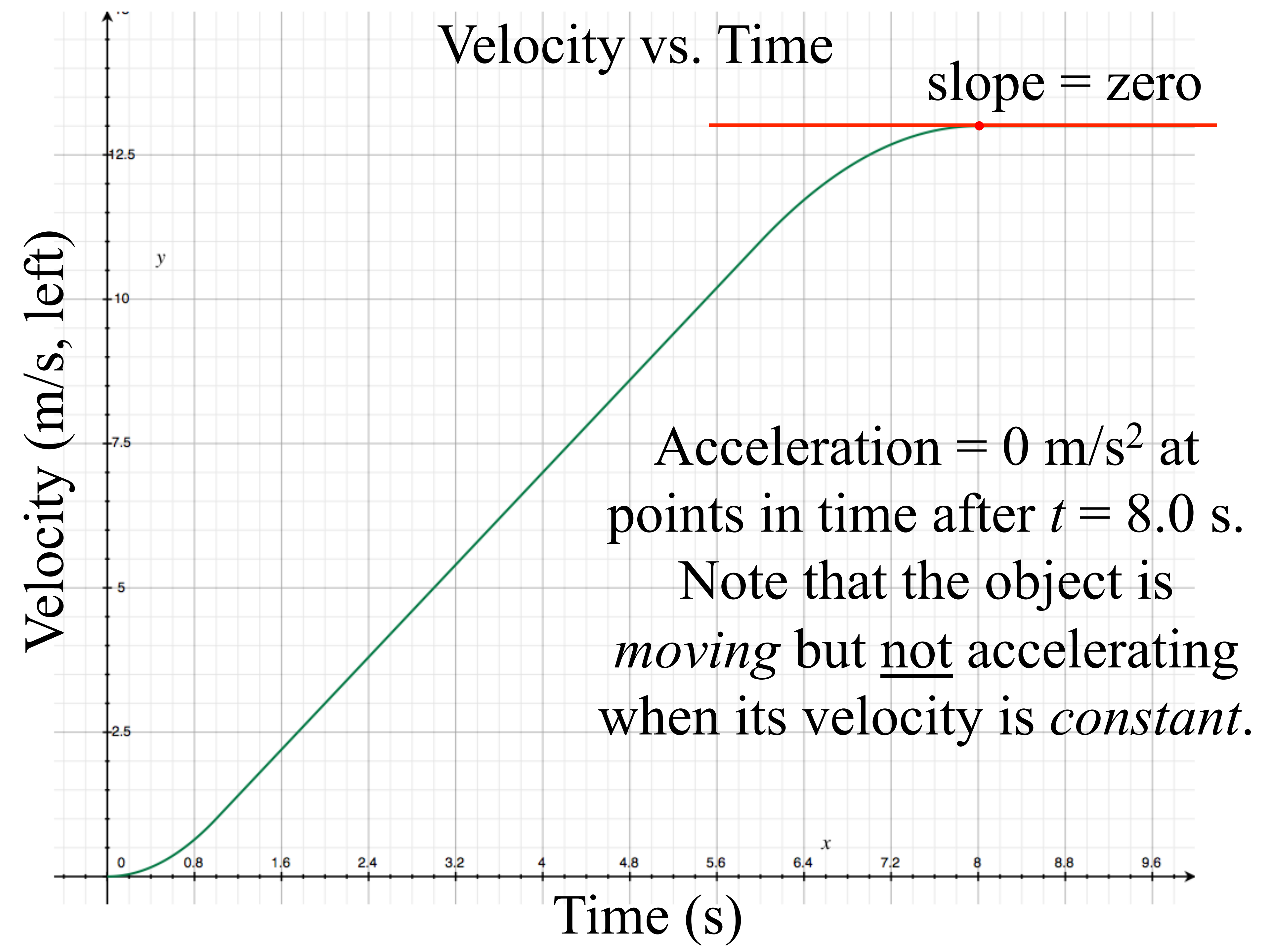


Velocity vs. Time
slope = Δy / Δx (always!)
slope = Δv⃗ / Δt (on *this* graph)
Slope on a **velocity** vs. time graph is equal to **acceleration**!
Velocity (m/s, left)
Time (s)
y
x
12.5
10
7.5
5
2.5
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
7.2
8
8.8
9.6

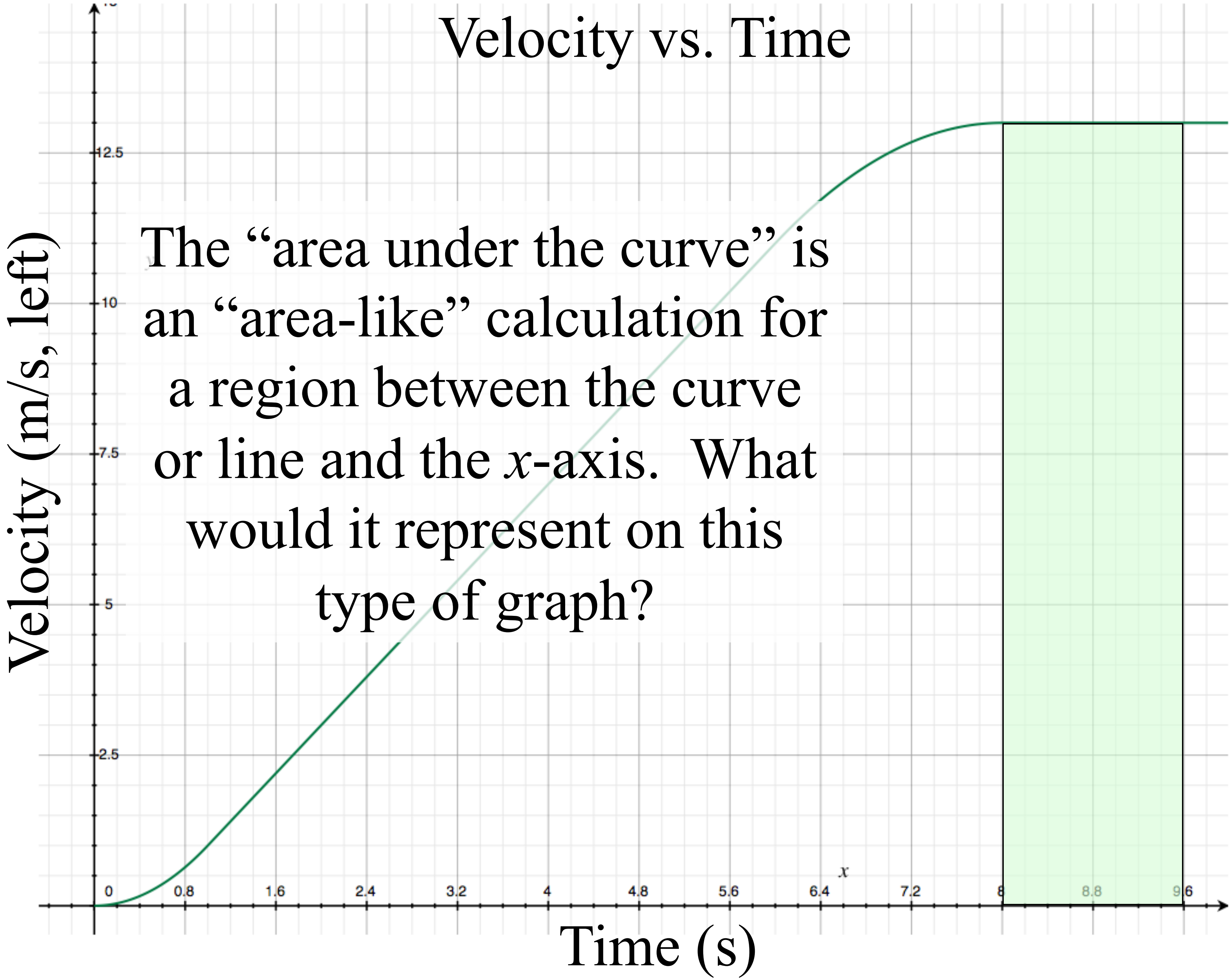

Velocity vs. Time
Velocity (m/s, left)
Time (s)
(5, 9)
(2, 3)
slope = $\frac{9-3}{5-2} = 2\,\frac{m}{s^2}$
Acceleration = 2.0 m/s², left
A linear graph indicates constant acceleration!
12.5
10
7.5
5
2.5
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
7.2
8
8.8
9.6
y
x



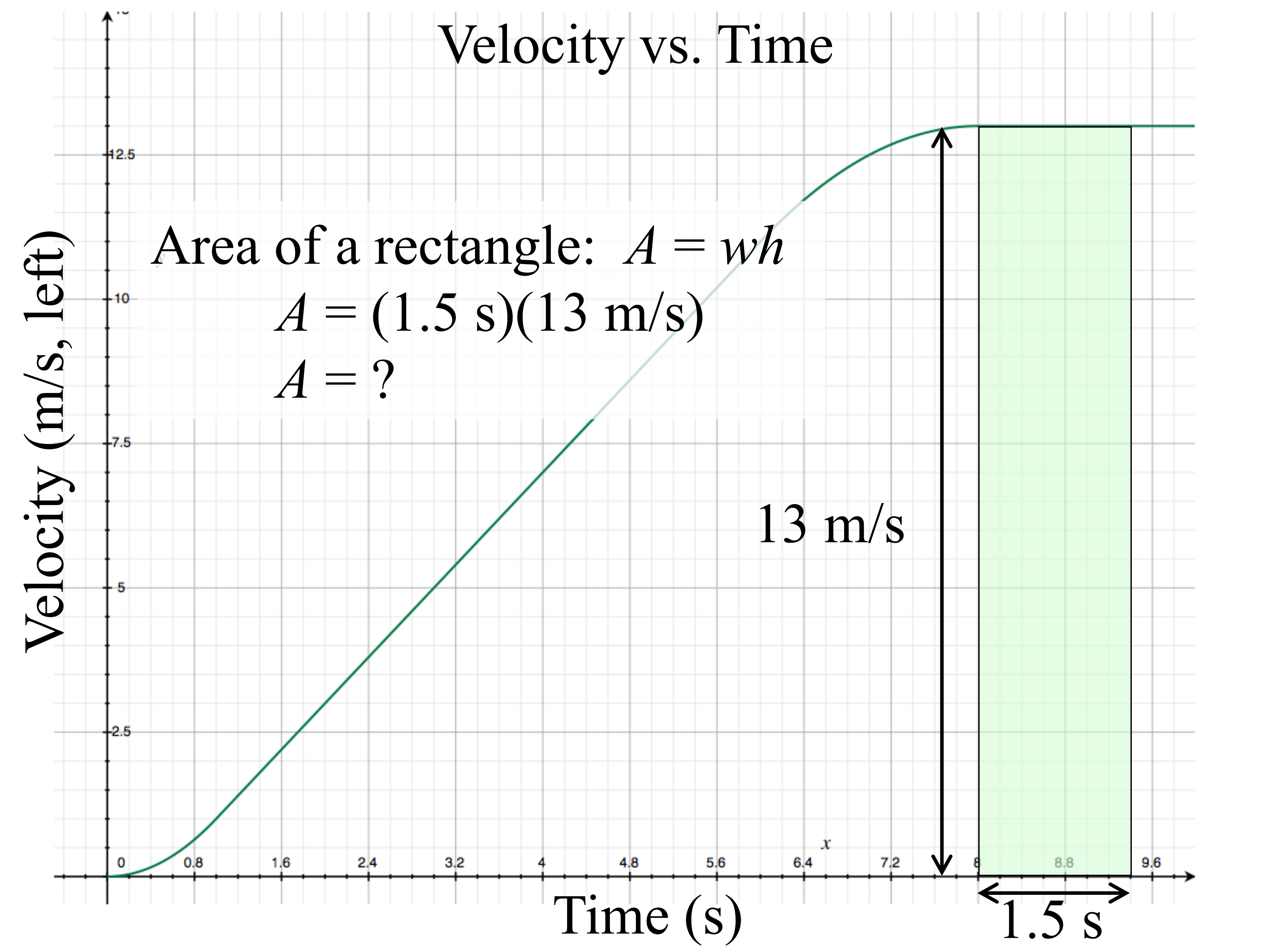
Velocity vs. Time
(9, 14.5)
(4, 9.5)
12.5
10
7.5
5
2.5
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
7.2
8
8.8
9.6
y
x
Velocity (m/s, left)
Time (s)
slope = (14.5 – 9.5)/(9 – 4) = 1 m/s²
Acceleration = 1.0 m/s², left
at the instant t = 7.0 s.


Velocity vs. Time
slope = zero
Acceleration = 0 m/s² at points in time after *t* = 8.0 s. Note that the object is *moving* but not accelerating when its velocity is *constant*.
Velocity (m/s, left)
Time (s)
y
x
12.5
10
7.5
5
2.5
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
7.2
8
8.8
9.6

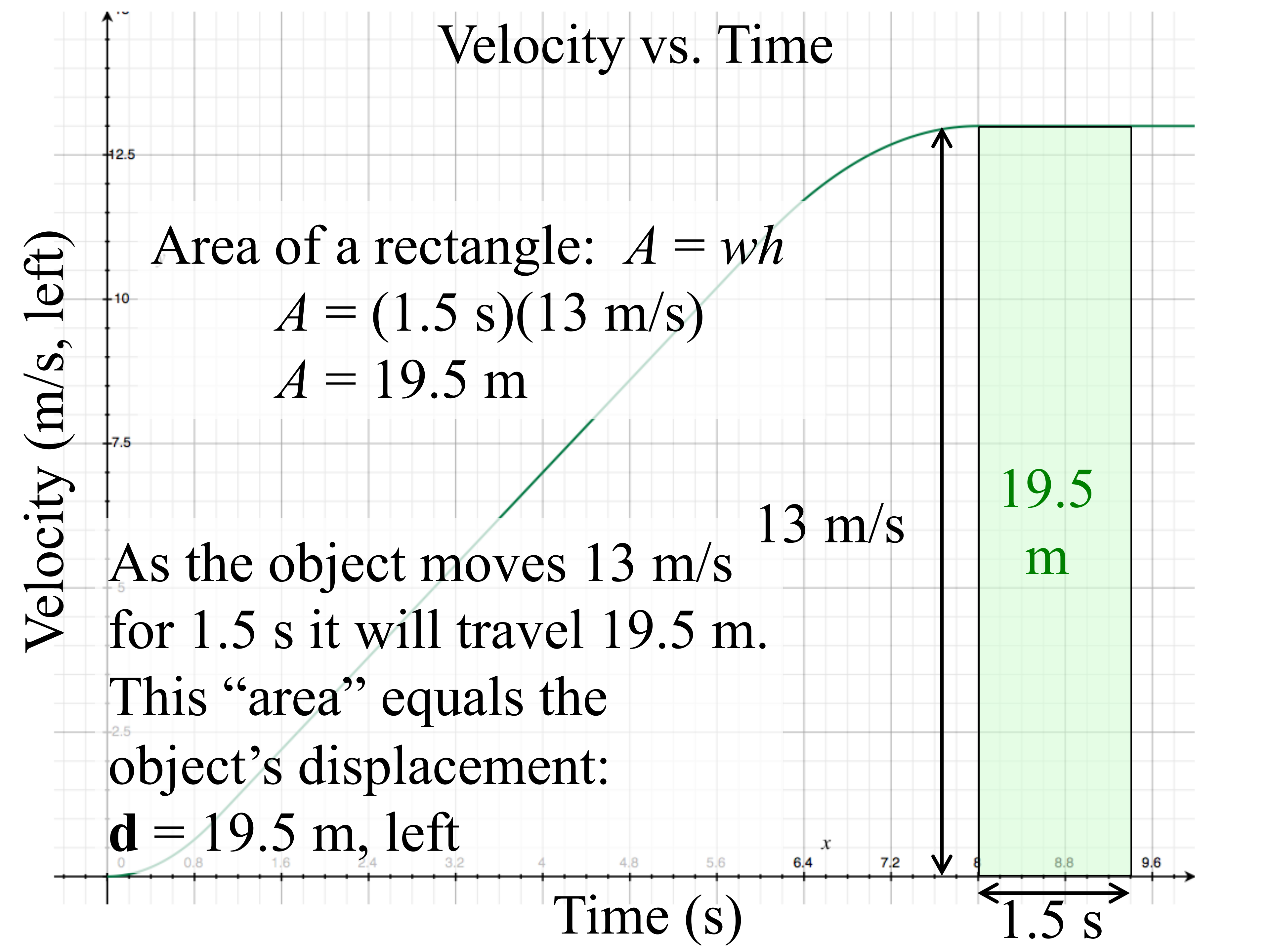
Velocity vs. Time



The “area under the curve” is an “area-like” calculation for a region between the curve or line and the *x*-axis. What would it represent on this type of graph?

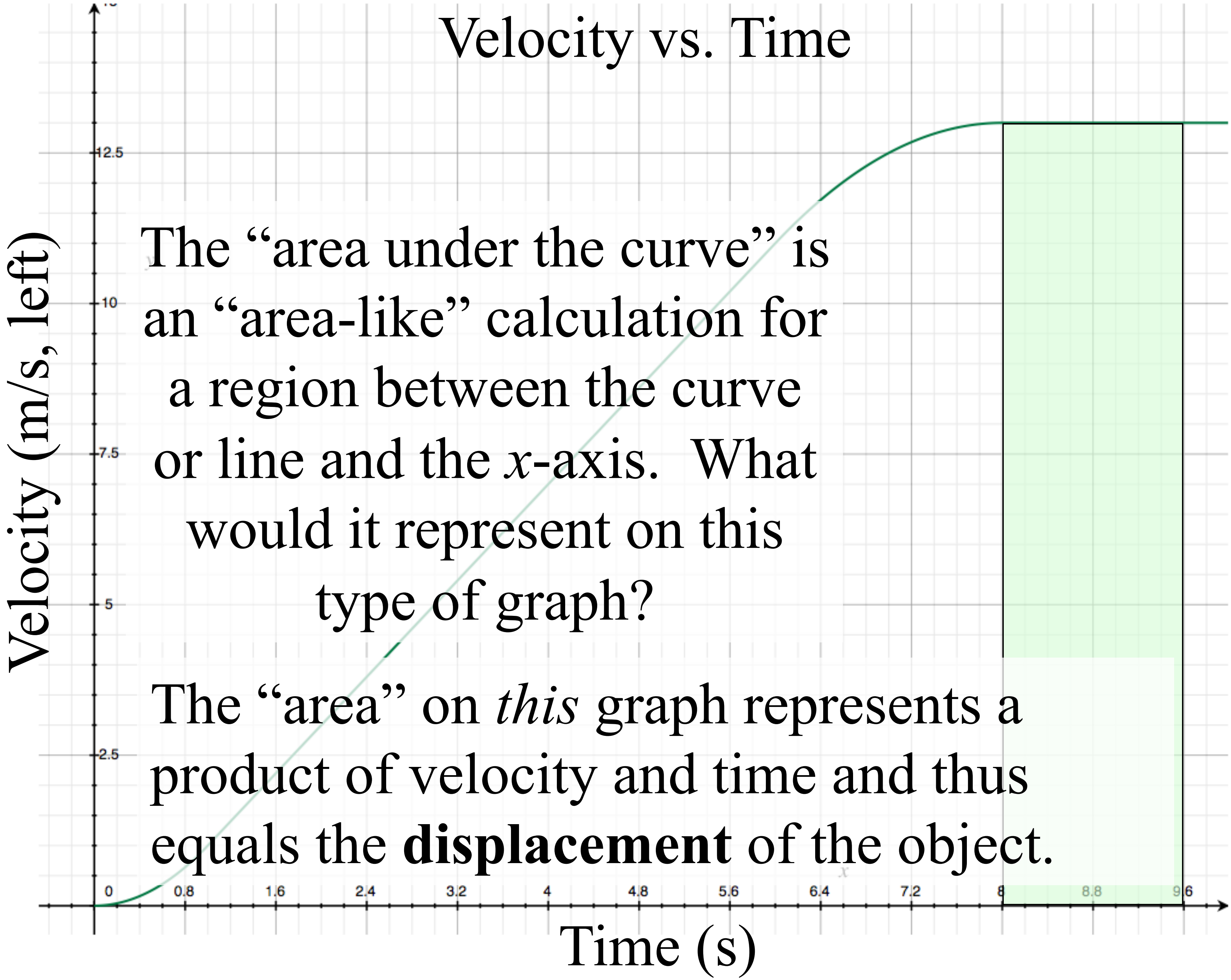


Velocity vs. Time
Area of a rectangle: $A = wh$
$A = (1.5\text{ s})(13\text{ m/s})$
$A = ?$
13 m/s
1.5 s
Velocity (m/s, left)
Time (s)
12.5
10
7.5
5
2.5
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
7.2
8
8.8
9.6
x



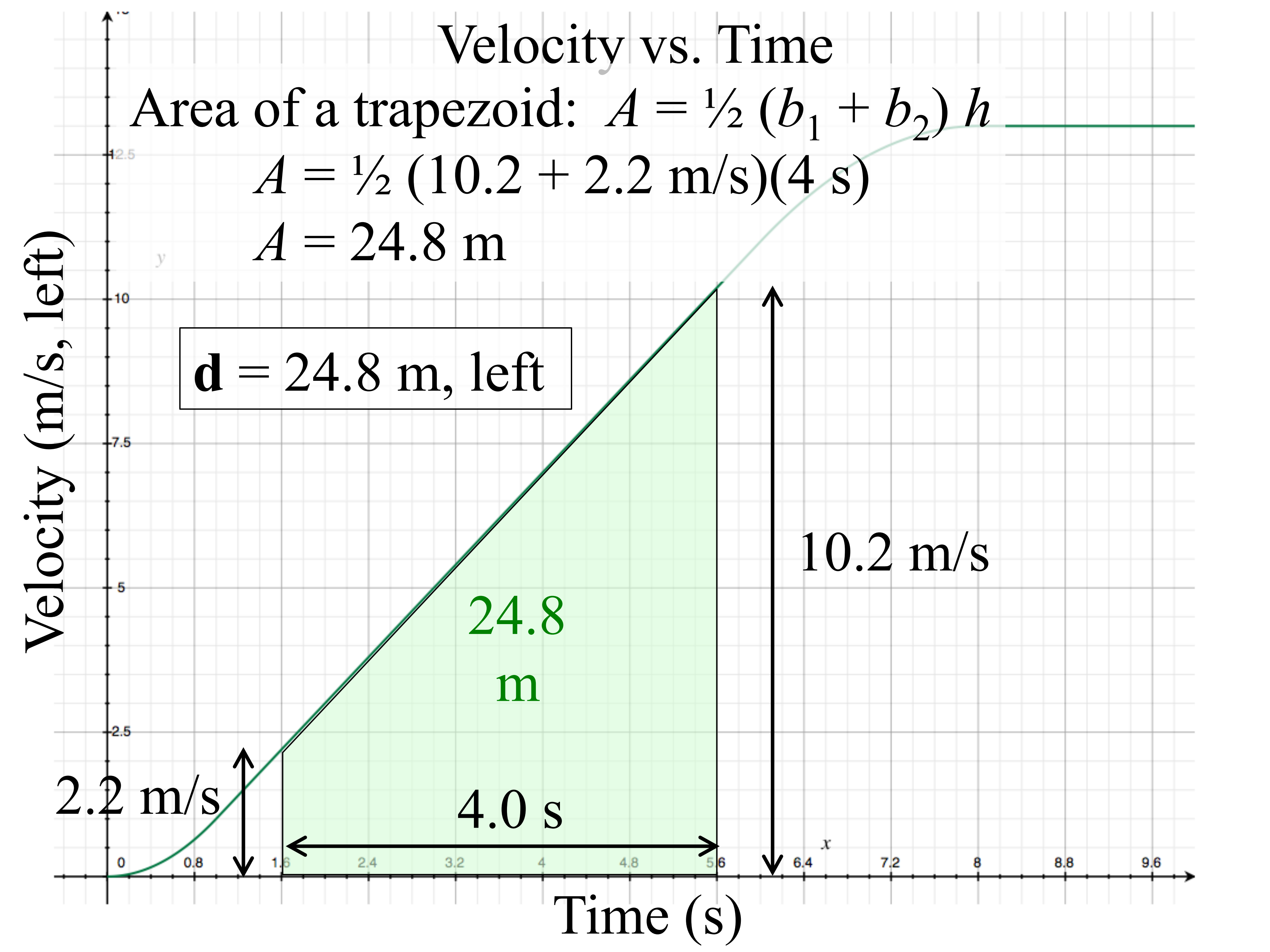
Velocity vs. Time
Area of a rectangle: A = wh
A = (1.5 s)(13 m/s)
A = 19.5 m
13 m/s
19.5 m
As the object moves 13 m/s for 1.5 s it will travel 19.5 m.
This "area" equals the object's displacement:
d = 19.5 m, left
1.5 s
Velocity (m/s, left)
Time (s)
12.5
10
7.5
5
2.5
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
7.2
8
8.8
9.6
x

Velocity vs. Time



The "area under the curve" is an "area-like" calculation for a region between the curve or line and the *x*-axis. What would it represent on this type of graph?

The "area" on *this* graph represents a product of velocity and time and thus equals the **displacement** of the object.



Velocity vs. Time
Area of a trapezoid: $A = \frac{1}{2}(b_1 + b_2)h$
$A = \frac{1}{2}(10.2 + 2.2\ \text{m/s})(4\ \text{s})$
$A = 24.8\ \text{m}$
d = 24.8 m, left
24.8 m
10.2 m/s
2.2 m/s
4.0 s
Velocity (m/s, left)
Time (s)
12.5
10
7.5
5
2.5
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
7.2
8
8.8
9.6