# Students

The following students did not have their clicker response recorded (or answered on a piece of paper).

| | | |
|---|---|---|
| Aguilera, Joshua | Baty, Nicole | Becenti, Adam |
| Burlbaw, Steven | Candelaria, Steven | Cordova, Trey |
| Eaton, Brian | Economides, Megan | Elias, David |
| Espinosa, Jordan | Espinoza, Tatiana | Gagon, Nicole |
| Gillen, Cameron | Gonzalez, Raymond | Hacker, Jessica |
| Keller, Calvin | Kimball, Elizabeth | Lambert, James |
| Lee, Nayah | Martinez, Brian | McCutcheon, Whitney |
| Medina, Felipe | Mitchell, Anne | Olona, Gerome |
| Ontiveros, Francisco | Seibert, Amy | Silva, Jacob |
| Smith, Montana | Snelling, Sam | Soto, Armando |

# Students Continued

| | | |
|---|---|---|
| Stefani, Michael | Toquinto, Hilda | Vottero, Louis |
| Wisler, Tracy | Yegerlehner, Erika | |

There were 5 clickers which were recorded but not registered.

Nathan Thomas, please come see me.

# January 25, Week 2

Today: Chapter 2, Acceleration

Homework Assignment #2 due January 30
Mastering Physics: 1.6, 2.4, 2.59, and 3 special Mastering Physics problems.
Written Problem: 2.75.

Information about student boxes available on Friday.

# Review

How fast = Average speed

$$sp_{av} = \frac{distance}{elapsed\,time} = \frac{d}{\Delta t}, \quad \Delta t = t_2 - t_1$$

# Review

How fast = Average speed

$$sp_{av} = \frac{distance}{elapsed\,time} = \frac{d}{\Delta t}, \quad \Delta t = t_2 - t_1$$

Average Velocity:

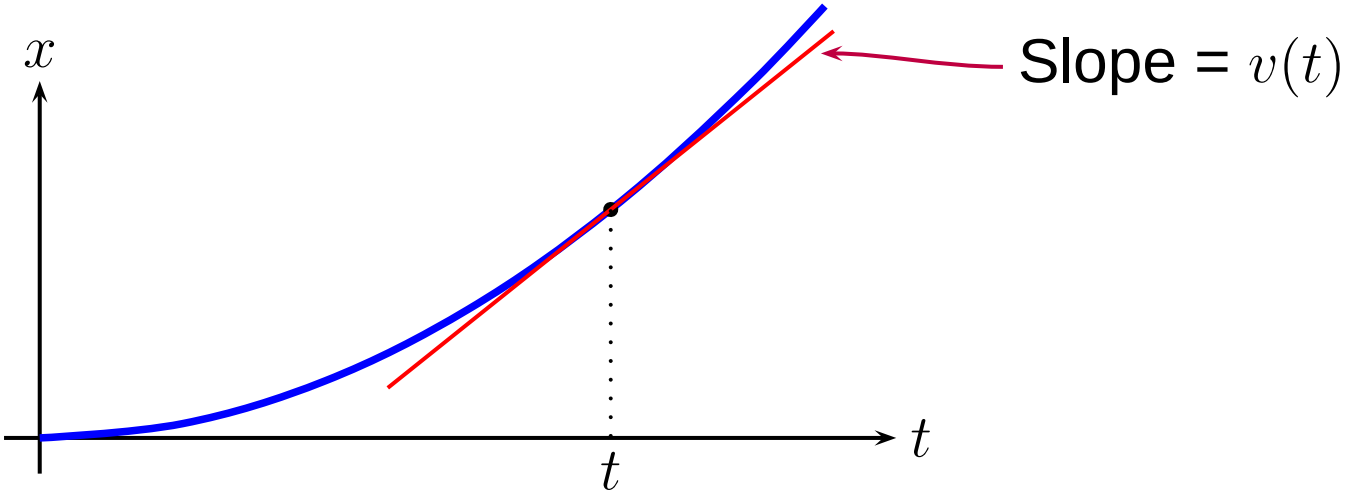
$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} \quad \text{unit: } m/s$$

# Review II

Instantaneous velocity, $v$:

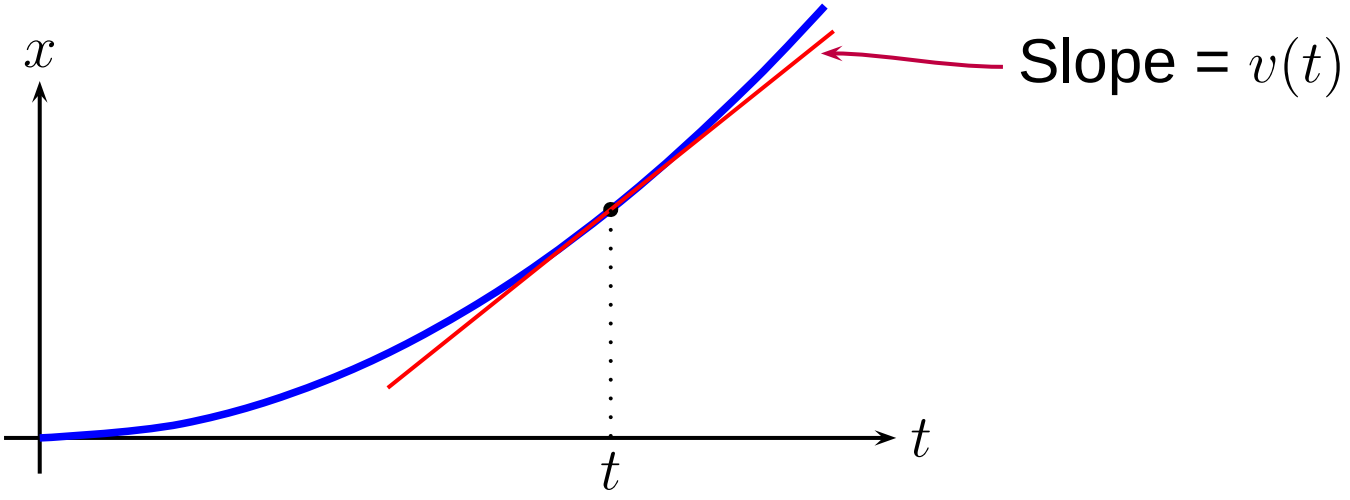
# Review II

Instantaneous velocity, $v$:



# Review II

Instantaneous velocity, $v$:




$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

Velocity is the time derivative of position, *i. e.* , the slope of the position versus time graph.

# Acceleration

- Acceleration, $a$ - rate at which *velocity* changes.

# Acceleration

- Acceleration, $a$ - rate at which *velocity* changes.
-

$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

# Acceleration

- Acceleration, $a$ - rate at which *velocity* changes.
- $$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$
- Unit: $\frac{m/s}{s} = \frac{m}{s} \times \frac{1}{s} = m/s^2$

# Acceleration

- Acceleration, $a$ - rate at which *velocity* changes.
- $$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$
- Unit: $\frac{m/s}{s} = \frac{m}{s} \times \frac{1}{s} = m/s^2$
- Example: A rabbit accelerates from rest to $2.2\,m/s$ in $0.5\,s$. A turtle accelerates from rest to $2.2\,m/s$ in $1\,min$. Find average acceleration of both.

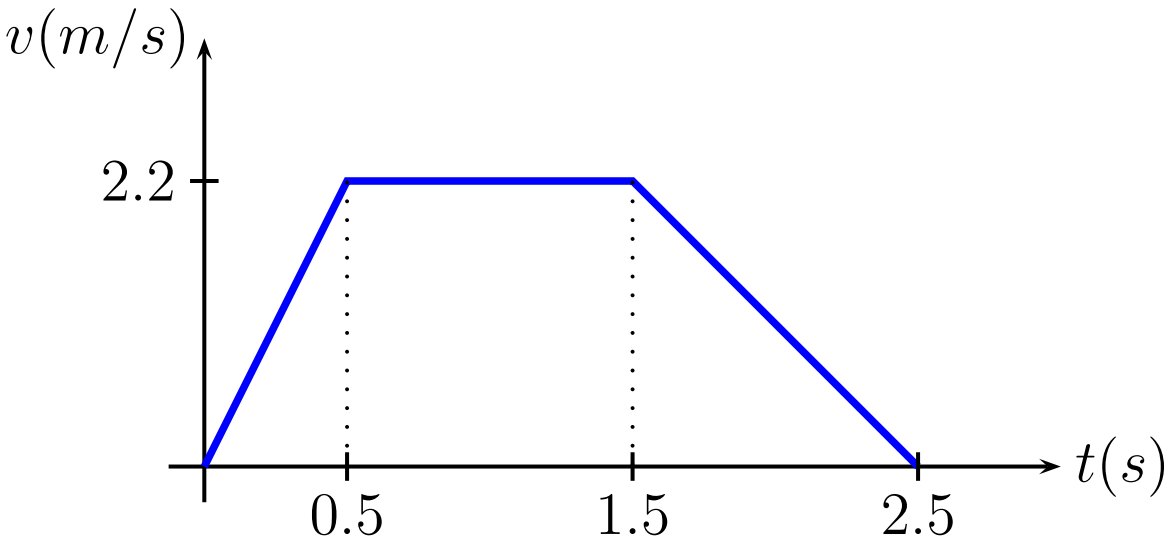
# Acceleration II

As with velocity, instantaneous acceleration, $a$, is a time derivative, *i. e.* , the slope of the velocity versus time graph.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

# Acceleration III

Example: The graph below shows the rabbit's velocity versus time graph for part of the race. Find the acceleration values.



# Acceleration versus Deceleration

- The sign of acceleration is more complicated than position's or velocity's

You *cannot* say that $a > 0$ means speeding up and $a < 0$ means slowing down.

# Acceleration versus Deceleration

- The sign of acceleration is more complicated than position's or velocity's

  You *cannot* say that $a > 0$ means speeding up and $a < 0$ means slowing down.

- Example: A rabbit going $0.7\,m/s$ to the left increases his velocity to $2.2\,m/s$ to the left. What is the rabbit's acceleration if this change takes $0.75\,s$?

# Acceleration versus Deceleration

- The sign of acceleration is more complicated than position's or velocity's

  You *cannot* say that $a > 0$ means speeding up and $a < 0$ means slowing down.

- Example: A rabbit going $0.7\,m/s$ to the left increases his velocity to $2.2\,m/s$ to the left. What is the rabbit's acceleration if this change takes $0.75\,s$?

- When $a$ and $v$ have the same sign, speed increases.

# Acceleration versus Deceleration

- The sign of acceleration is more complicated than position's or velocity's

  You *cannot* say that $a > 0$ means speeding up and $a < 0$ means slowing down.

- Example: A rabbit going $0.7\,m/s$ to the left increases his velocity to $2.2\,m/s$ to the left. What is the rabbit's acceleration if this change takes $0.75\,s$?

- When $a$ and $v$ have the same sign, speed increases.
- When $a$ and $v$ have the opposite sign, speed decreases.

# Clicker Quiz

A rabbit, located $3\,m$ to the left of the origin, is going $2.4\,m/s$ to the left with an increasing speed. Which of the following choices is a correct labeling for the rabbit's kinematics quantities?

# Clicker Quiz

A rabbit, located $3\,m$ to the left of the origin, is going $2.4\,m/s$ to the left with an increasing speed. Which of the following choices is a correct labeling for the rabbit's kinematics quantities?

(a) $x = -3\,m, \quad v = -2.4\,m/s, \quad a < 0$

# Clicker Quiz

A rabbit, located $3\,m$ to the left of the origin, is going $2.4\,m/s$ to the left with an increasing speed. Which of the following choices is a correct labeling for the rabbit's kinematics quantities?

(a) $x = -3\,m, \quad v = -2.4\,m/s, \quad a < 0$

(b) $x = -3\,m, \quad v = -2.4\,m/s, \quad a > 0$

# Clicker Quiz

A rabbit, located $3\,m$ to the left of the origin, is going $2.4\,m/s$ to the left with an increasing speed. Which of the following choices is a correct labeling for the rabbit's kinematics quantities?

(a) $x = -3\,m, \quad v = -2.4\,m/s, \quad a < 0$

(b) $x = -3\,m, \quad v = -2.4\,m/s, \quad a > 0$

(c) $x = -3\,m, \quad v = 2.4\,m/s, \quad a < 0$

# Clicker Quiz

A rabbit, located $3\,m$ to the left of the origin, is going $2.4\,m/s$ to the left with an increasing speed. Which of the following choices is a correct labeling for the rabbit's kinematics quantities?

(a) $x = -3\,m, \quad v = -2.4\,m/s, \quad a < 0$

(b) $x = -3\,m, \quad v = -2.4\,m/s, \quad a > 0$

(c) $x = -3\,m, \quad v = 2.4\,m/s, \quad a < 0$

(d) $x = -3\,m, \quad v = 2.4\,m/s, \quad a > 0$

# Clicker Quiz

A rabbit, located $3\,m$ to the left of the origin, is going $2.4\,m/s$ to the left with an increasing speed. Which of the following choices is a correct labeling for the rabbit's kinematics quantities?

(a) $x = -3\,m, \quad v = -2.4\,m/s, \quad a < 0$

(b) $x = -3\,m, \quad v = -2.4\,m/s, \quad a > 0$

(c) $x = -3\,m, \quad v = 2.4\,m/s, \quad a < 0$

(d) $x = -3\,m, \quad v = 2.4\,m/s, \quad a > 0$

# Constant Acceleration

An easily solved kinematics problem has the acceleration unchanging with time.

# Constant Acceleration

An easily solved kinematics problem has the acceleration unchanging with time.

Objects in free fall near the surface of the earth have a constant acceleration of $g = 9.8\, m/s^2$.

# Constant Acceleration

An easily solved kinematics problem has the acceleration unchanging with time.

Objects in free fall near the surface of the earth have a constant acceleration of $g = 9.8\, m/s^2$.

In the absence of air resistance.

# Equations of Motion

To find the equations of motion ($x(t)$, $v(t)$), we solve differential equations.

# Equations of Motion

To find the equations of motion ($x(t)$, $v(t)$), we solve differential equations.

$$a = \frac{dv}{dt}$$

# Equations of Motion

To find the equations of motion ($x(t)$, $v(t)$), we solve differential equations.

$$a = \frac{dv}{dt} \Rightarrow dv = a\,dt$$

# Equations of Motion

To find the equations of motion ($x(t)$, $v(t)$), we solve differential equations.

$$a = \frac{dv}{dt} \Rightarrow dv = a\,dt \Rightarrow \int dv = \int a\,dt = a\int dt$$

# Equations of Motion

To find the equations of motion ($x(t)$, $v(t)$), we solve differential equations.

$$a = \frac{dv}{dt} \Rightarrow dv = a\,dt \Rightarrow \int dv = \int a\,dt = a\int dt$$

There is never a indefinite integral in physics. Variables always change from their initial to final values.

It is customary to change our notation slightly here. From now on, initial time is assumed to be zero. Initial values are given a zero subscript - $v_o$, $x_o$.

# The Velocity Equation

$$\int_{v_o}^{v} dv = a \int_{o}^{t} dt$$

# The Velocity Equation

$$\int_{v_o}^{v} dv = a \int_{o}^{t} dt \Rightarrow v - v_o = at$$

# The Velocity Equation

$$\int_{v_o}^{v} dv = a \int_{o}^{t} dt \Rightarrow v - v_o = at \Rightarrow \boxed{v = v_o + at}$$

# The Velocity Equation

$$\int_{v_o}^{v} dv = a \int_{o}^{t} dt \Rightarrow v - v_o = at \Rightarrow \boxed{v = v_o + at}$$