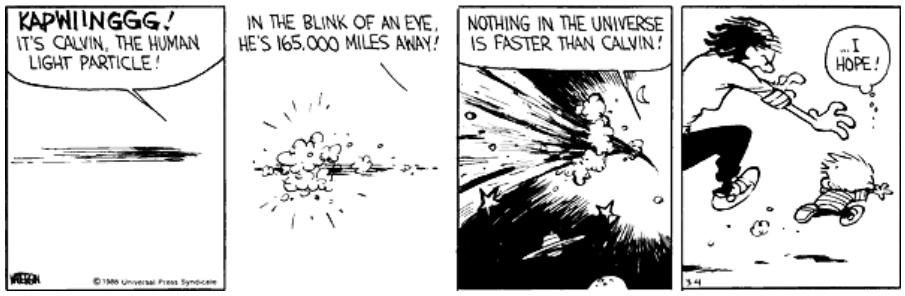
September 12, 2011 Physics 121 Prof. E. F. Redish

- **Theme Music:** Elton John
  Rocket Man
- **Cartoon:** Bill Waterson
  Calvin & Hobbes



9/12/11 Physics 131 1

Reading question

- I found the section of the webpage that explains how t is transformed into a variable to be confusing. I do not understand how it can just be changed like that, or how you would know when to change it. Can this be done to other equations as well, or just when dealing with constant acceleration?

9/12/11 Physics 131 3

Multiple Representations

- We choose different ways of representing things depending on what we want to do.

- Adding multiple sensory modes adds to our sense of an object's reality.

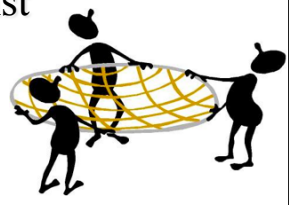
Knowing-how-to-know icon: Multiple Representations

- We have many different ways that we represent information:
  - Words
  - Equations
  - Diagrams
  - Pictures

- Each gives its own way of building up something "real" in our minds.

Knowing-how-to-know icon: Coherence – Your safety net

- Throughout the class we will be looking to see physical situations in a variety of different ways.
- The consistency among the different views protects us against errors of reconstructed memory.

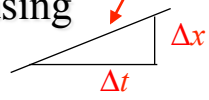


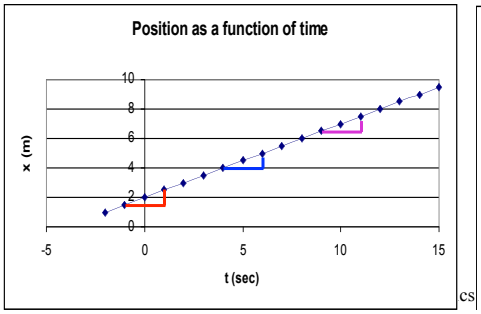
9/1/10 6

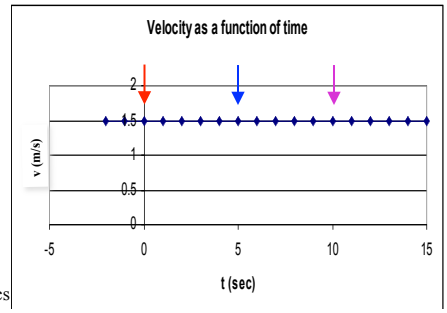
Graphing velocity: Figuring it out from the position

- You can figure out the velocity graph from the position graph using

$$\langle v \rangle = \frac{\Delta x}{\Delta t} \qquad \Delta x = \langle v \rangle \Delta t$$

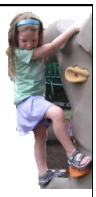






cs

Foothold ideas: Velocity



- Average velocity is defined by

$$\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t} = \frac{\text{vector displacement}}{\text{time it took to do it}}$$

Note: an average velocity goes with a time interval.

- Instantaneous velocity is what we get when we consider a very small time interval (compared to times we care about)

$$\vec{v} = \frac{d\vec{r}}{dt}$$

Note: an instantaneous velocity goes with a specific time.

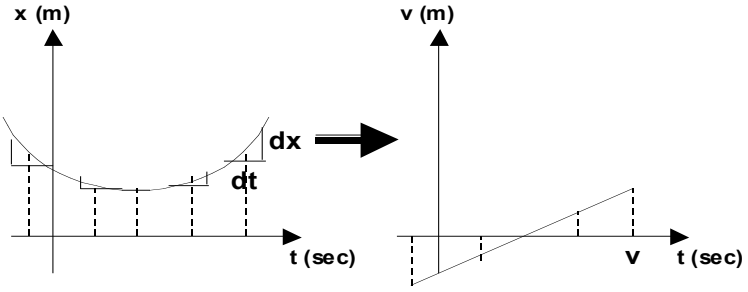
9/12/11 Physics 131 8

Graphing Velocity: Figuring it out from the motion

- An object in uniform motion has constant velocity.
- This means the instantaneous velocity does not change with time. Its graph is a horizontal line.
- You can make sense of this by putting your mind in "velocity mode" and running a mental movie.

9/12/11 Physics 131 9

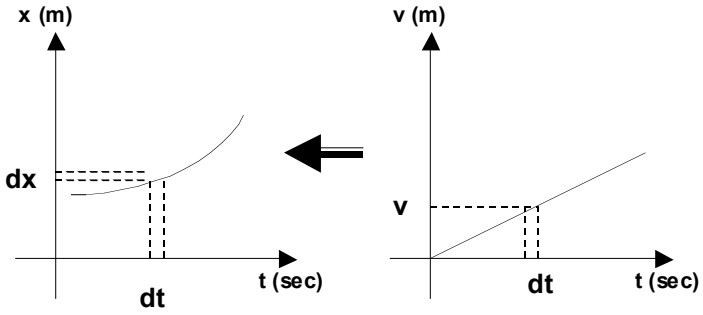
Position to velocity



$$v(t) = \frac{dx}{dt}$$

$$v(t) = \frac{x(t + \Delta t/2) - x(t - \Delta t/2)}{\Delta t}$$

Velocity to position



$$dx = v(t)\,dt$$

change in position over a small time interval

sum ("Σ") in the changes in position over many small time intervals

$$x = \sum dx = \int v(t)\,dt$$

What have we learned? Representations and consistency

- Visualizing where an object is at different times → a position graph
- Visualizing how fast an object is moving at different times → a velocity graph
- Position graph → velocity graph slopes $v = \frac{\Delta x}{\Delta t}$
- Velocity graph → position graph areas $\Delta x = v\,\Delta t$

9/12/11 Physics 131 12

Average Acceleration

- We need to keep track not only of the fact that something is moving but how that motion is changing.
- Define the <u>average acceleration</u> by

$$< \vec{a} > = \frac{\text{change in velocity}}{\text{time it took to make the change}}$$

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

9/12/11 Physics 131 14

Technical term alert!

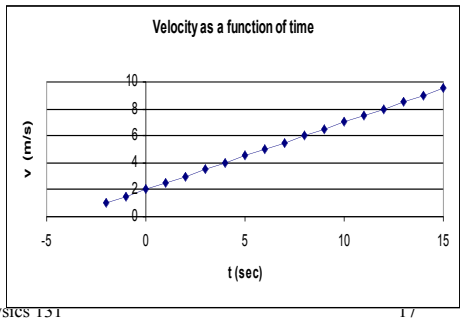
- Note that in physics we use the term "**acceleration**" in a technically defined way:
  - "acceleration" = changing velocity
- The object may be speeding up or slowing down or keeping the same speed and changing direction. We still say "it is accelerating."
- In common speech "*acceleration*" = speeding up, "*deceleration*" = slowing down, and "*turning*"=changing direction.
- How many (physics) accelerators are there on your car?

Uniformly changing motion

- If an object moves so that it changes its velocity by the same amount in each unit of time, we say it is in uniformly accelerated motion.
- This means the average acceleration will be the same no matter what interval of time we choose.

$$< \vec{a} > = \frac{\Delta \vec{v}}{\Delta t} = \vec{a}_0$$

$$\Delta \vec{v} = \vec{a}_0 \ \Delta t$$

$$\vec{v}(t_2) - \vec{v}(t_1) = \vec{a}_0 \ \Delta t$$

$$\vec{v}_{final} = \vec{v}_{initial} + \vec{a}_0 \ \Delta t$$