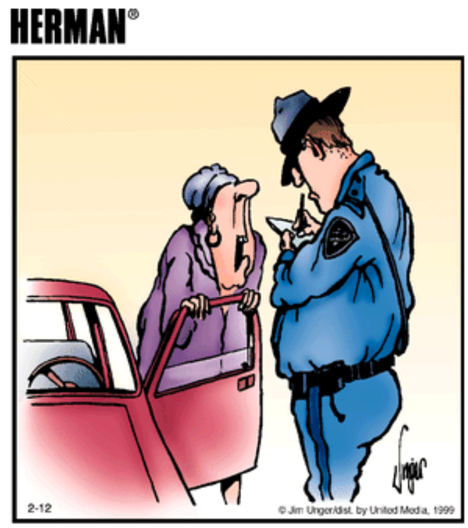
September 12, 2016 Physics 131 Prof. E. F. Redish

- **Theme Music:**
  Pfish
  Fast enough for you
- **Cartoon:**
  Jim Unger
  Herman



"How could I have been doing 70 miles an hour when I've only been driving for ten minutes?"

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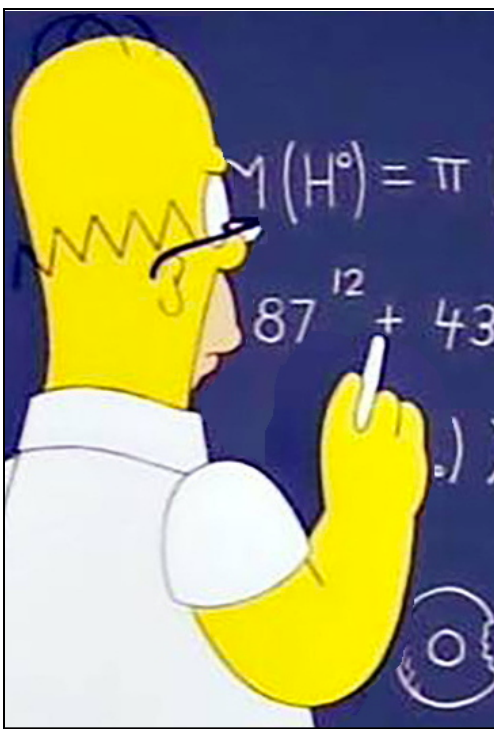

The Equation of the Day

Kinematic definitions

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

$$v = \frac{dx}{dt} \qquad a = \frac{dv}{dt}$$

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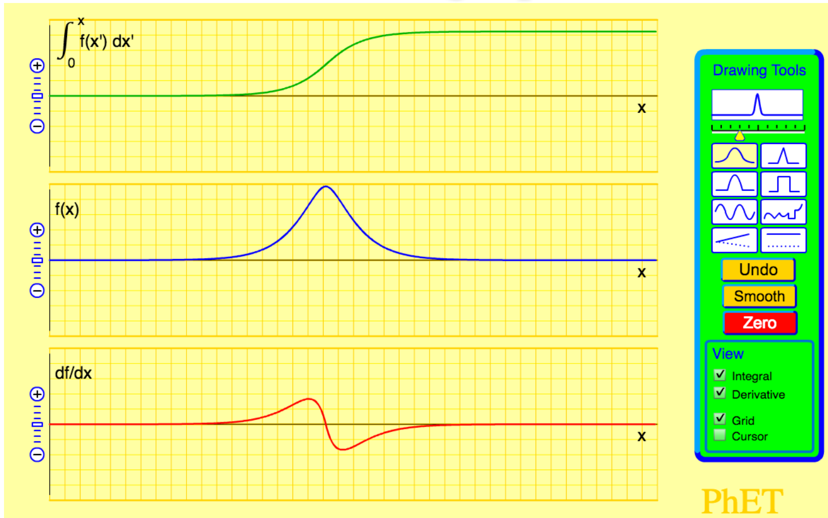
Calculus grapher



https://phet.colorado.edu/sims/calculus-grapher/calculus-grapher_en.html

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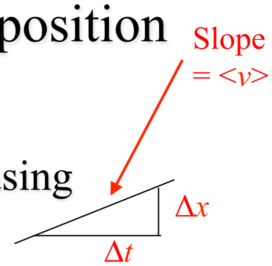
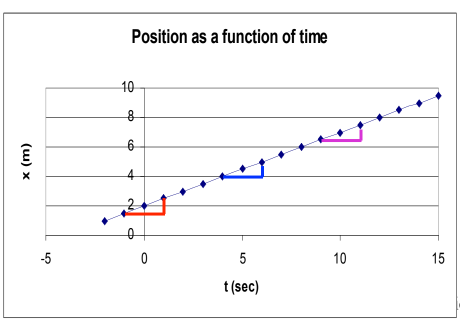
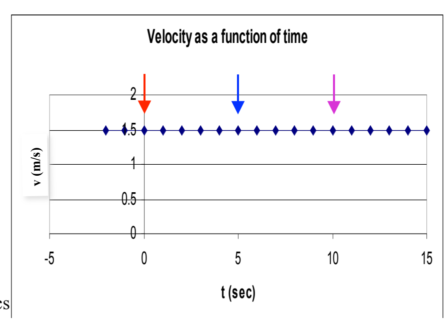
Graphing velocity: Figuring it out from the position

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

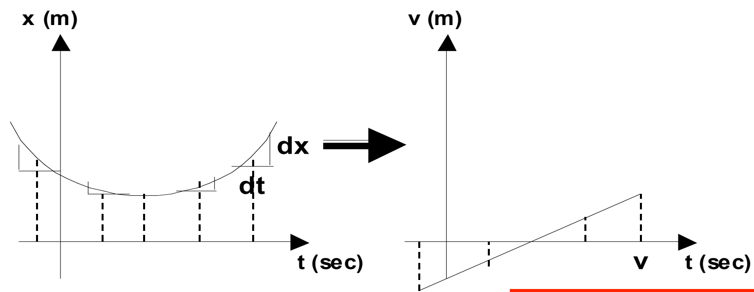
$$\langle v \rangle = \frac{\Delta x}{\Delta t} \qquad \Delta x = \langle v \rangle \Delta t$$







Position to velocity



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

← Ratio of change in position that takes place to the (small) time interval

Difference of two positions at two (close) times →

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

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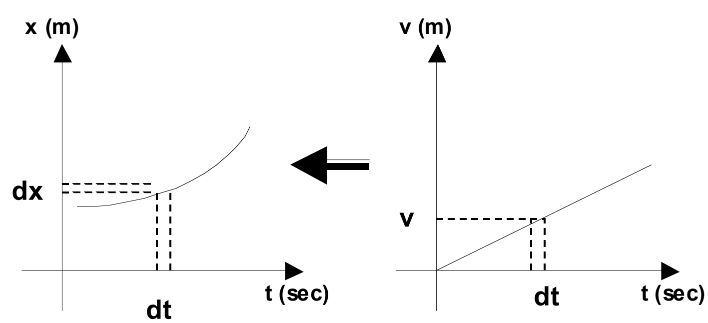
Velocity to position



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

← change in position that takes place in a small time interval

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

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

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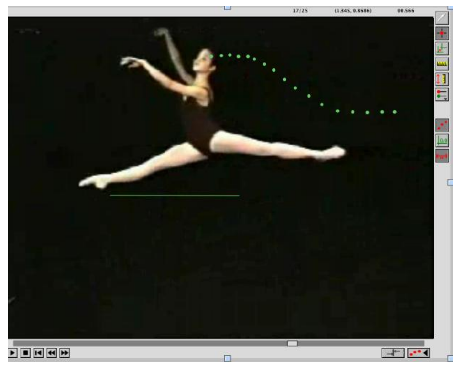
Graphing Position

- Graphs for the eye vs. graphs for the mind.
- Describe where something is in terms of its coordinate at a given time.
  - Choose origin
  - Choose axes
  - Choose scale
  - Set scales on graph
  - Take data from video
  - Construct different graphs
  - Fit the graphs with math functions



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.

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 $\langle v \rangle = \dfrac{\Delta x}{\Delta t}$ $\qquad v = \dfrac{dx}{dt}$

- Velocity graph → position graph

  areas $\Delta x = v\,\Delta t$ $\qquad \Delta x = \int v\,dt$

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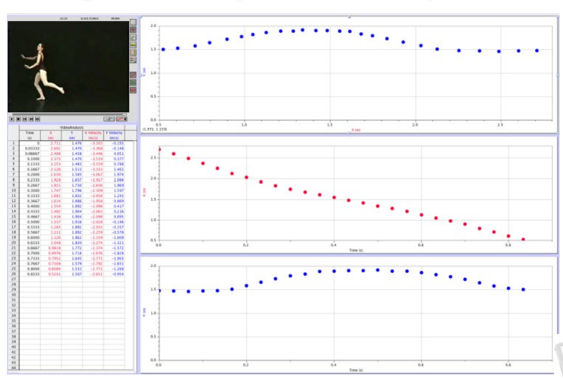
Figuring out velocity

- We have looked at the *x-y*, *x-t*, and *y-t* plots.
- Velocity is the derivative of the position wrt time. Which plots can we get velocity from? Why?
- What will they look like?

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



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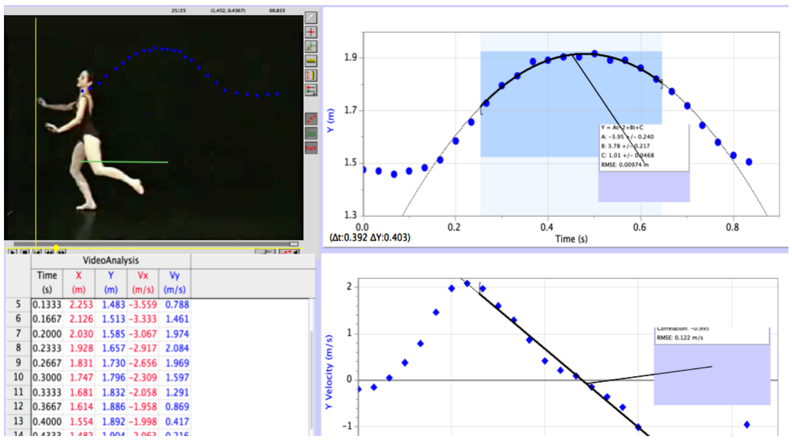
Does the derivative stuff work?

What do a and b mean physically?

If the velocity is a linear function of time what do you expect the position to look like?

$$v(t) = at + b$$

$$\frac{dx}{dt} = at + b \qquad x(t) = ?$$



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