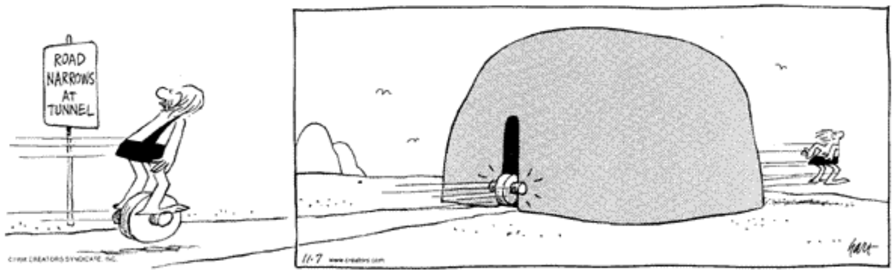
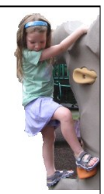
September 16, 2016 Physics 131 Prof. E. F. Redish

- **<u>Theme Music:</u> Acceleration Waltz**
  Johann Strauss II
- **<u>Cartoon:</u> Johnny Hart**
  BC



9/16/16 Physics 131 1

Foothold ideas: Acceleration



- Average acceleration is defined by

$$\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t} = \frac{\text{change in velocity}}{\text{time it took to do it}}$$

Note: an average acceleration goes with a <u>time interval</u>.

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

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

Note: an instantaneous acceleration goes with a <u>specific time</u>.

This is a bit of a "math fake" since creating a derivative requires considering two points – to see a change!

9/16/16 Physics 131

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

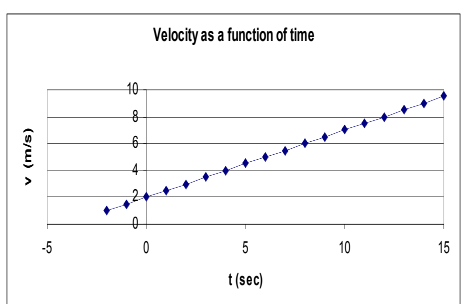
- If an object moves so that it changes its velocity by the same amount in each unit of time, we say it is in uniformly accelerated motion.
- This means the average acceleration will be the same no matter what interval of time we choose.

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

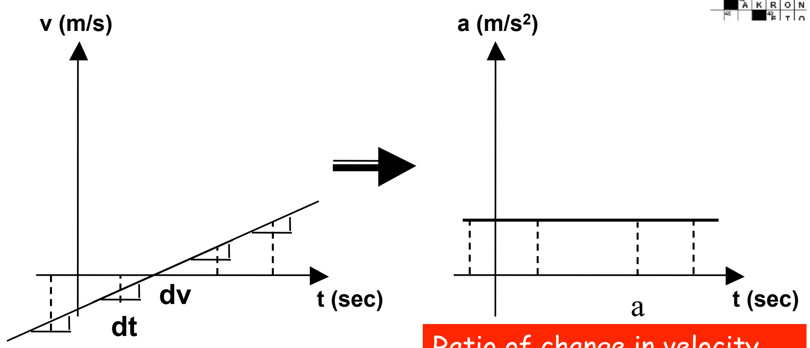
$$\Delta\vec{v} = \vec{a}_0 \, \Delta t$$

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

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



Velocity to acceleration



$$a(t) = \frac{dv}{dt}$$

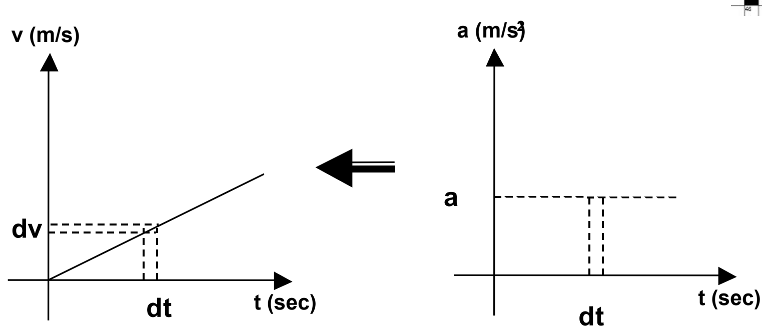
Ratio of change in velocity that takes place to the (small) time interval

Difference of two velocities at two (close) times

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

9/16/16 Physics 131 9

Acceleration to velocity



$$dv = a(t)\, dt$$

change in velocity over a small time interval

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

$$v = \sum dv = \int a(t)\, dt$$

Physics 131 10

What have we learned?
Representations & consistency

- Position $\hat{r} = x\hat{i} + y\hat{j}$
  (where *x* and *y* are signed lengths)
- Velocity $\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t}$ $\vec{v} = \frac{d\vec{r}}{dt}$
- Acceleration $\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t}$ $\vec{a} = \frac{d\vec{v}}{dt}$
- Seeing from the motion
- Seeing consistency (graphs & equations)

9/16/16 Physics 131 16

Example: Calculating with acceleration

- In The Fellowship of the Ring, the hobbit Peregrine Took (Pippin for short) drops a rock into a well while the travelers are in the caves of Moria. This wakes a Balrog (a bad thing) and causes all kinds of trouble. Pippin heard the rock hit the water 7.5 s after he dropped it. Assuming that the rock fell with a constant acceleration of 10 m/s^2, how deep is the well?

9/16/16 Physics 131 17

Some questions

- What's "the story" of the problem?
- What principles/equations do you know that might be relevant?
- What assumptions might we make to create a solvable first model?
- Give names to the relevant parameters and variables.
- Of the variables and parameters that appear in your equation, which do you know?
- How many unknowns do you have?
- How many equations do you have?

9/16/1