Theme Music: Run Like an Antelope
*Phish*

Cartoon: Johnny Hart
*BC*
Foothold ideas: Acceleration

- **Average acceleration** is defined by

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

- **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 **average acceleration** goes with a **time interval**.

Note: an **instantaneous acceleration** goes with a **specific time**.
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.

\[ < \ddot{a} > = \frac{\Delta \ddot{v}}{\Delta t} = \ddot{a}_0 \]

\[ \Delta \ddot{v} = \ddot{a}_0 \Delta t \]

\[ \ddot{v}(t_2) - \ddot{v}(t_1) = \ddot{a}_0 \Delta t \]

\[ \ddot{v}_{\text{final}} = \ddot{v}_{\text{initial}} + \ddot{a}_0 \Delta t \]
**Velocity to acceleration**

\[ a(t) = \frac{dv}{dt} \]

\[ a(t) = \frac{v(t + \frac{\Delta t}{2}) - v(t - \frac{\Delta t}{2})}{\Delta t} \]

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

Difference of two velocities at two (close) times
**Acceleration to velocity**

\[ dv = a(t) \, dt \]

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

change in velocity over a small time interval

sum ("\( \Sigma \)”) in the changes in velocity over many small time intervals
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)