Physics 131 - Fundamentals of Physics for Biologists I

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Kinematics and Dynamics

• Kinematics: Describing motion (Chapter 3)
  – Acceleration

• Dynamics: What causes motion
  – Forces and Newton’s laws (Chapter 4)

Off topic (don’t ask these things via the reading assignments), but good questions:
Will we learn the equations associated with each basic concept of newton’s theory of motion?
Are definitions going to be on exams?
From this figure you can learn something about the motion of cars. The color in the figure indicates:

1. Position
2. Velocity
3. Speed
4. Speed and Velocity
5. Position and Speed
6. Position and Velocity
7. Neither, it’s an xy graph
8. What’s the difference speed/velocity?

**Speed**: Magnitude of the Velocity (always positive)
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.
When do we calculate acceleration?

<table>
<thead>
<tr>
<th>$a$ (m/s²)</th>
<th>$t$ (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$v$ (m/s)</td>
<td>$dv$</td>
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Difference of two velocities at two (close) times:

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

Change in velocity that takes place in the (small) time interval $dt$:

$$a(t) = \frac{v(t + \Delta t/2) - v(t - \Delta t/2)}{\Delta t}$$
When we do \( A \times (\Delta t) \), doesn't a velocity-like \( L/T \) dimension result?

### Acceleration to velocity

Predicting the future

(future velocity that is)

\[
\begin{align*}
\text{sum}\ (\Sigma)\ &\text{in the changes in velocity over many small time intervals} \\
\end{align*}
\]

\[
\begin{align*}
dv &= a(t) \, dt \\
\end{align*}
\]

\[
\begin{align*}
v &= \int dv = \int a(t) \, dt \\
\end{align*}
\]
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.

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

This means the average acceleration will be the same \( a_0 \) no matter what interval of time we choose.

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

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

\[ \dot{v}_{\text{final}} = \dot{v}_{\text{initial}} + \ddot{a}_0 \Delta t \]
Sketch the acceleration vs time graph corresponding to this velocity vs time graph.
The AVERAGE acceleration is

1. Zero
2. Positive
3. Negative
4. We cannot tell from velocity vs time graph