Physics 201
Lec 2
Hobin

CH 1 - Measurement

Only three basic dimensions in 201:

- **time** \( t \), second (s) = \( 9,192,631,770 \) Cs vibrations
- **length** \( l \), meter (m) = distance traveled by light in vacuum in \( 1/299,792,458 \) s

\[
\Rightarrow \text{ defines speed of light } c = 299,792,458 \text{ m/s!}
\]

- **mass** \( m \), kilogram (kg) = standard solid cylinder of Pt-Ir

DIMENSIONS MATTER!

Carry dimensions through calculations, check answer has correct dimensions.

Ex: My motorcycle travels 250 mi on 5.0 gal of gas - what is the mileage?

U.S. mileage = \( \frac{250 \text{ mi}}{5.0 \text{ gal}} = 50 \text{ mi/gal} \) \( \frac{\text{distance}}{\text{volume}} \)

But in Europe they use liters per 100 km:

fuel consumption = \( \frac{5.0 \text{ gal} \times 3.785 \ell}{250 \text{ mi}} \times \frac{62.1 \text{ mi}}{1 \text{ gal}} \times \frac{1 \text{ gal}}{100 \text{ km}} = 47 \ell \)

Also - keep track of significant figures in answer (too sig. figs. in above example)
Dimensional analysis can be helpful to get a good start on a solution.

Ex. in free-fall, an object falls a distance \( h = \frac{1}{2} gt^n \) from rest in time \( t \), where \( n \) is some integer.

Look at dimensions: \( \text{length} = \frac{1}{2} \frac{\text{length}}{(\text{time})^n} \)

\( \Rightarrow n \) has to be 2, \( h = \frac{1}{2} gt^2 \)

Pretty much all of the formulas in 201 can be found via dimensional analysis up to factors like \( 1/2 \).

Estimates are critical to checking your solution; knowing typical magnitudes.

You will get credit for realizing a solution is way off.

1 m/s? too slow

10 m/s? about right (100 m/10 s = fast, do-able)

100 m/s? too fast

So roughly how long does it take a healthy human to run 5 km?

\( t \approx \frac{1000 \text{ m}}{10 \text{ m/s}} \approx 100 \text{ s} \approx 2 \text{ min} \)
CH 2 - Motion in One Dimension

CH 2-4 = Kinematics = math description of motion
CH 5+ = Dynamics = causes of motion

Motion = relation between position and time
- table of positions and times
- picture of object at various times
  "step-motion diagram"
- position-time graph
- formula giving position for input time

D1 Eye-blink step motion
D2 Stroke at two different speeds

How to describe position?
"where El Rancho used to be." NOT USEFUL
"Corner of University and Claver" STILL VAGUE

GPS lat/long 43.074° N 89.405° W
- accurate -

Cartesian Grid (Descartes 1596-1650)

(x, y) coordinates

Motion

Diagram
Specify position & time with "space-time coordinate" \((x, y, t)\).

Describe trajectory with time as parameter: \(x(t), y(t)\).

Position-time graph:

<table>
<thead>
<tr>
<th>(t (s))</th>
<th>(x (m))</th>
<th>(y (m))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Motion - start with one spatial dimension \(x(t)\).

**Solving Problems**

1. Draw picture
2. Identify and label unknowns
3. Relate unknowns to knowns
4. Solve \(\Box\)

Speed = rate of change of position

Average speed = \[
\frac{\Delta x \text{ (over some time } \Delta t)}{\Delta t} = V_{\text{avg}}
\]

Ex. Madison to Milwaukee: 90 mi in 90 minutes

\[
V_{\text{avg}} = \frac{90 \text{ mi}}{90 \text{ min}} = 1 \text{ mi/min} = 60 \text{ mi/hr}
\]
BUT sometimes you're going 72 mi/hr, sometimes 45 mi/hr (traffic, etc.).

\[
\text{instantaneous speed} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} = x'(t) = \dot{x}
\]

= slope of \( x(t) \) plot

- Madison to Milwaukee \( x(\text{mi}) \) (odometer)
- Madison traffic, low \( \dot{v} \)
- open highway
- heavy traffic
- low \( \dot{v} \)
- speeding

Usain Bolt world record 100 m

\[
\dot{v}_{\text{avg}} = \frac{100 \text{ m}}{9.62 \text{ s}} = 10.4 \text{ m/s}
\]

\( \dot{v} = 0 \text{ at start} \)