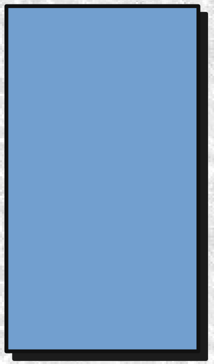
Physics 2311 – Physics I, Week 2
Dr. J. Pinkney

Outline for W2, Day 2
Finish error propagation (Ch. 1)
Motion in 1-dimension
- Position, distance, path length, displacement
- Average speed & velocity
- Instantaneous speed & velocity
- Acceleration

Homework (Do by Monday)
Ch. 2 Read sections 1-7,(8)
Ch. 2 Prob. 2,3,5-7,14,23-27,35-38,53-56

Notes: lab is “measurements in physics”
- Try practice quiz online.
- I’ll try to make exam-like practice questions (Fri).

Error propagation example



1) Find the Area of a rectangular plate with L=21.3±0.2 cm, W=9.8±0.1 cm, using the “adding the fractional errors” method to determine the errors.

Final answer: A = 209 ± 4 cm^2

2) Find the same area using the correct “add fractional errors in quadrature” approach to determine the errors.

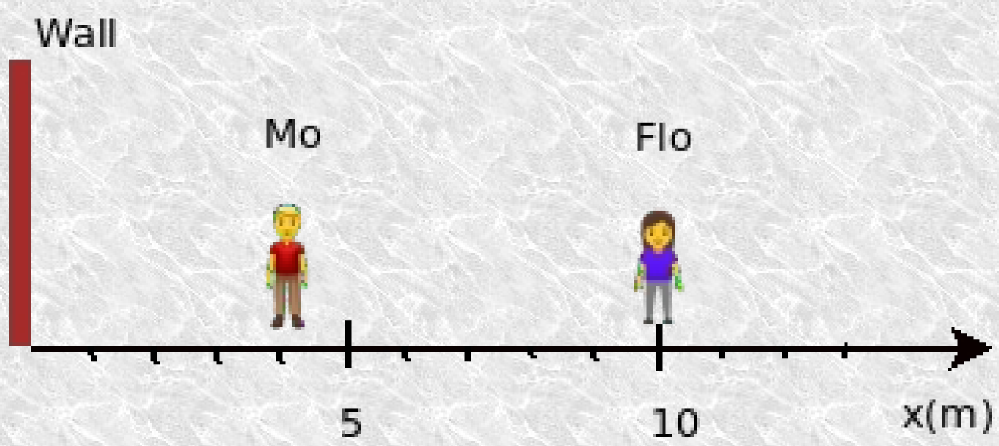
Final answer: A = 209 ± 3 cm^2

3) Find the same area supposing you were NOT given the errors, only L=21.3 cm, W=9.8 cm.

Final answer: A = 210 cm^2

Motion in 1-Dimension

Mo and Flo are standing conveniently on a number line, which has its origin, x=0, where the floor meets a wall.

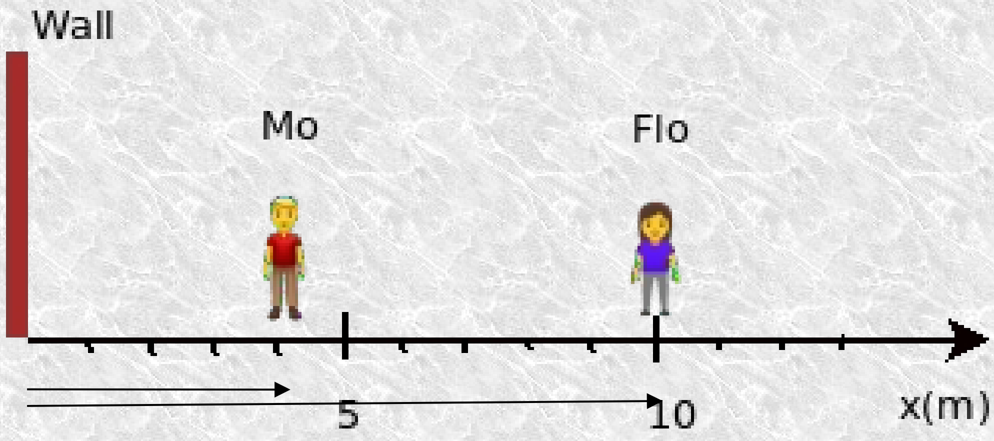


Relative to this origin, we can quantify Mo and Flo's …

Position: the distance away from a reference point.

- Symbols for position: x, y, z
- Positions for Mo and Flo: x_{mo} = 4 m and x_{flo} = 10 m.

Motion in 1-Dimension (cont.)



Position vector: a vector pointing from a reference point to an object of interest.

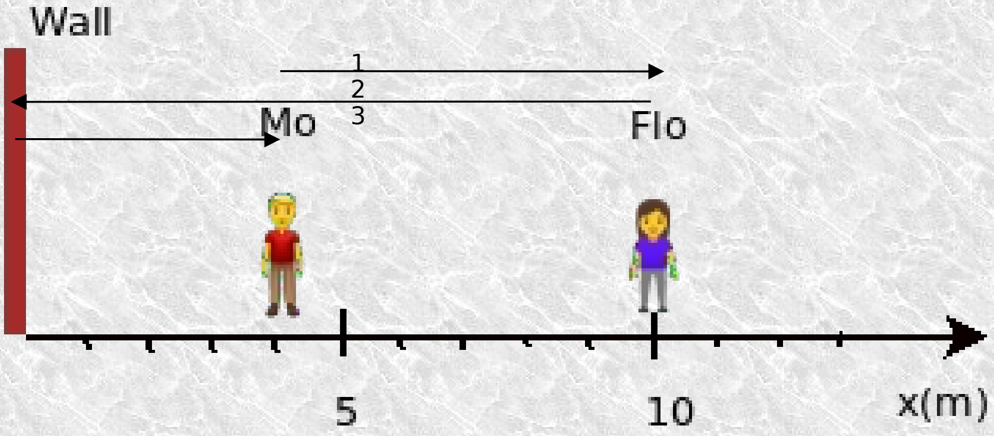
- Symbols for position vector: **x**, **r**, $\vec{x}$
- For Mo and Flo we have $\mathbf{x}_{mo}$ = 4 î m and $\mathbf{x}_{flo}$ = 10 î m.
- The position vectors for Mo and Flo are shown under the numberline.

The **distance** between two objects can be defined as the magnitude of the difference between their positions.

Ex) $d_{flo\ to\ mo} = |x_{mo} - x_{flo}| = |4 - 10| = 6$ m.

Motion in 1-Dimension

Ex) Mo walks to Flo, gets rejected, walks to the wall (x=0), and then returns to x=4.



Path length (d, l): the sum of all distances making up a path.
Ex) Mo's path length (above) is $l = d_1+d_2+d_3 = 6+10+4=20$m
Note: path length is like a cars odometer reading, only increasing.
Displacement ($\Delta\mathbf{x}$, $\Delta\vec{x}$, $\Delta\mathbf{r}$): The difference between the final position vector and the initial position vector of a journey.

$\Delta\mathbf{x} \equiv \mathbf{x}_f - \mathbf{x}_i$

Ex) Mo's displacement is $\Delta\mathbf{x} = \mathbf{x}_f - \mathbf{x}_i = 4\,\hat{\imath} - 4\,\hat{\imath} = 0\,\hat{\imath}$ m.

Week 2 (cont.)

Motion in 1-Dimension (cont.)

Average speed ($\bar{s}$, s_{avg}, $\bar{v}$, "average speed") = distance or path length per time.

- $s_{avg} \equiv d / \Delta t = l / \Delta t$
- s_{avg} is only positive. s_{avg} is a scalar, not a vector.
- Dimensions are L/T. MKS units are m/s.

Average velocity ($\bar{\mathbf{v}}$, $\mathbf{v}_{avg}$, $\vec{v}_{avg}$) = displacement per time.

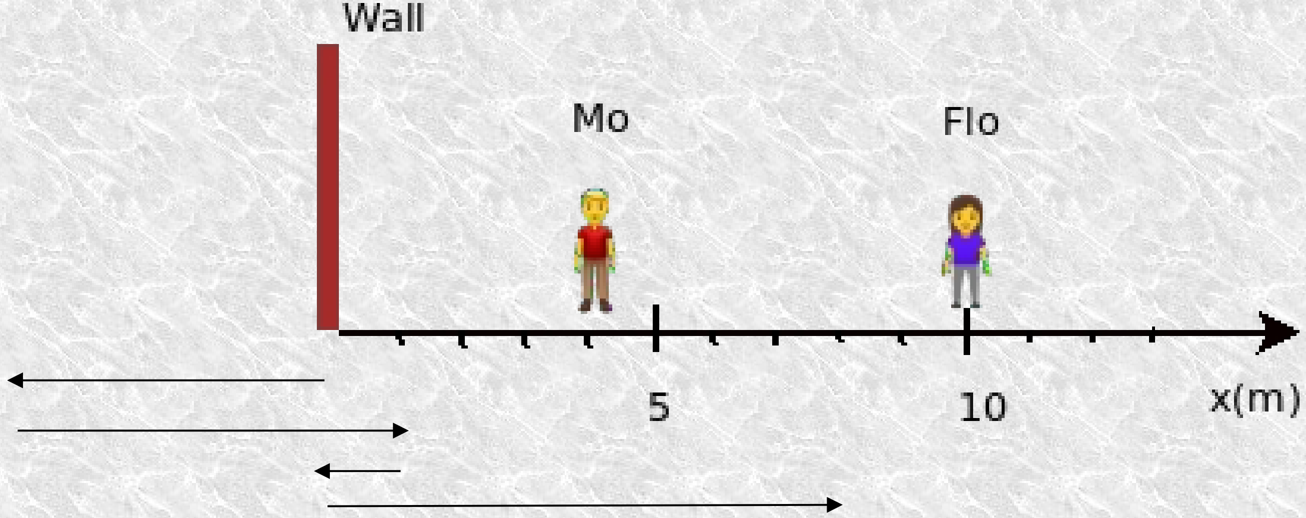
$\bar{\mathbf{v}} \equiv \Delta\mathbf{x}/\Delta t$

$\bar{\mathbf{v}}$ is a vector – it has magnitude and direction.

$\bar{\mathbf{v}}$ can be positive (in the +x direction) or negative (in the -x direction).

Week 2 (cont.)

Motion in 1-Dimension (cont.)



Example) Doing chores, Mo starts at x=0, walks 5' left, 6' right, 1' left, and 8' right in 40 seconds. What was Mo's average speed?

Ans: d = 5 + 6 + 1 + 8 = 20', so $\bar{s}$ = 20'/40sec = 0.5 ft/sec.

Example) What was Mo's average velocity for this journey?

Ans: $\bar{\mathbf{v}} \equiv \Delta\mathbf{x}/\Delta t = (8\hat{\imath} - 0\hat{\imath})/\,(40 \text{ sec}) = 8\hat{\imath}/40 = 0.2\ \hat{\imath}$ ft/s

Note: we don't have enough info to say how fast Mo was moving at any point in time during this journey!

Week 2 (cont.)

Motion in 1-Dimension (cont.)

Instantaneous speed, (s,s_{inst}): the speed at an instant in time.

- Definition: $s \equiv \lim_{\Delta t \to 0} \frac{d}{\Delta t}$
- s is a scalar and so is always positive
- Dimensions: L/T

Instantaneous velocity, (**v**, **v**$_{inst}$, $\vec{v}$): the velocity at an instant in time.

- Definition: $\vec{v} \equiv \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$
- **v** is a vector, and so can be positive or negative
- Dimensions: L/T

Ex) A racecar moves obeying **x**(t) = 3 - 6t^2 m î. What is it's instantaneous velocity at t=3 seconds?
Ans: **v**(t) = dx/dt = -12t î, so **v**(t=3) = -36 m/s î .

Week 2 (cont.)

Motion in 1-Dimension (cont.)

Inequalities involving speed and velocity

Possible inequalities: $=$, $\leq$, $\geq$, $\neq$, $<$, $>$

1) The instantaneous speed is the magnitude of the instantaneous velocity.

$$s = |\vec{v}|$$

Q: Is *average* speed equal to the magnitude of average velocity?

Ans: not necessarily!

2) The average speed is greater than or equal to the magnitude of $\mathbf{v}_{avg}$.

$$s_{avg} \geq |\vec{v}_{avg}|$$

Q: When is the magnitude of average velocity less than average speed?

(Hint: see previous problem with Mo's 4-leg journey.)

Ans: when there are reversals, or "switchbacks" in the journey.

Q: What is the inequality between path length and magnitude of displacement?

$$d \geq |\Delta \vec{x}_{avg}|$$

Physics 2311 – Physics I, Week 23
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Outline for Day W2, D3

Motion in 1-D (cont.)

- Instantaneous velocity as a slope of x vs t graph
- Acceleration (average and instantaneous)
- Graphs of x, v, and a vs t.
  - Equations of motion
  - Equations of uniform acceleration

Homework (Do by Monday)

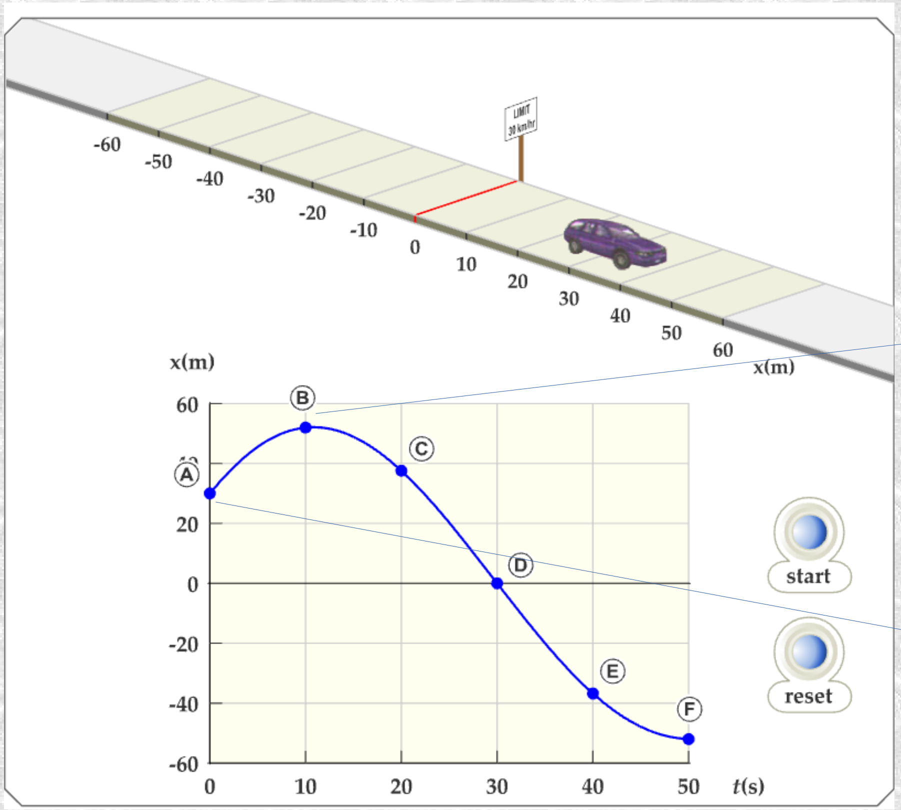
Ch. 2 Prob. 2,3,5-7,14,23-27,35-38,53-56

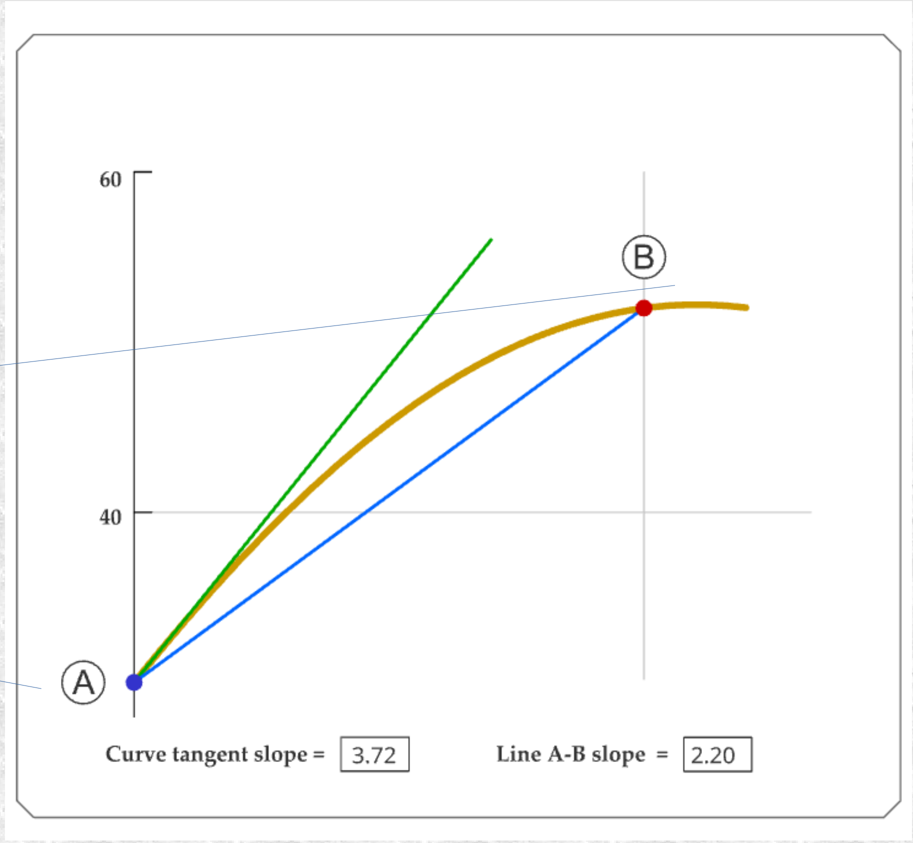
Notes: See online homework keys, example probs.
Use tutoring (2^{nd} floor Heterick).
Last day to Drop is Feb 7.

Week 2 (cont.)

Motion in 1-Dimension (cont.)

Position vs Time graphs





The instantaneous velocity (at A) is the slope of the green line tangent to the *x* vs. *t* curve.

$$\vec{v} \equiv \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$$

Week 2 (cont.)

Motion in 1-Dimension (cont.)

Average acceleration ($\bar{a}$, $\mathbf{a}_{avg}$): a change of velocity per time.

$\mathbf{a}_{avg} \equiv \Delta\mathbf{v}/\Delta t = (v_f - v_i)/(t_f - t_i)$

$\mathbf{a}_{avg}$ (and $\bar{a}$) are vectors

Negative $\mathbf{a}_{avg}$ means "to the left" (NOT decelerating!)

Slope of a line connecting 2 points on a v vs t graph

Instantaneous acceleration ($\mathbf{a}$,$\mathbf{a}_{inst}$): rate of change of velocity with time at an instant.

$\mathbf{a} \equiv \lim(\Delta t \to 0)\ \Delta\mathbf{v}/\Delta t = d\mathbf{v}/dt$

a is a vector. We will NOT have a scalar version of acceleration which is always positive.

Negative **a** means "to the left" (NOT decelerating)

Slope of a tangent to a v vs t graph.

Week 2 (cont.)

Example problems involving acceleration definitions

Average acceleration ($\bar{a}$, $\mathbf{a}_{avg}$): $\mathbf{a}_{avg} \equiv \Delta\mathbf{v}/\Delta t = (v_f - v_i)/(t_f - t_i)$

Instantaneous acceleration ($\mathbf{a}$, $\mathbf{a}_{inst}$): $\mathbf{a} \equiv \lim(\Delta t \rightarrow 0)\ \Delta\mathbf{v}/\Delta t = d\mathbf{v}/dt$

Ex (P. 2.24): A car accelerates at $a=1.8\ m/s^2$. How long does it take to acclerate from 65 km/hr to 120 km/hr?

Soln: $\mathbf{a}_{avg} = \Delta\mathbf{v}/\Delta t = 1.8\ m/s^2$ so solve for $\Delta t = \Delta\mathbf{v} / \mathbf{a}_{avg}$

Need to convert units of $\Delta\mathbf{v} = (120 – 65\ km/hr)$

$= 55\ km/hr * (1hr/3600s)*(1000m/km)= 15.28\ m/s$

So $\Delta t = 15.28/1.8 = 8.49\ sec \rightarrow \boxed{8.5\ sec.}$

Ex (P. 2.26): If $x(t)=4.8t + 7.3\ t^2$, what is the acceleration as a function of time?

Soln: $a = dv/dt = d^2x/dt^2$ so find $dx/dt = 4.8 + 14.6\ t$

And then $d^2x/dt^2 = \boxed{14.6\ m/s^2}$

Week 2 (cont.)

Motion in 1-Dimension (cont.)

More on graphing

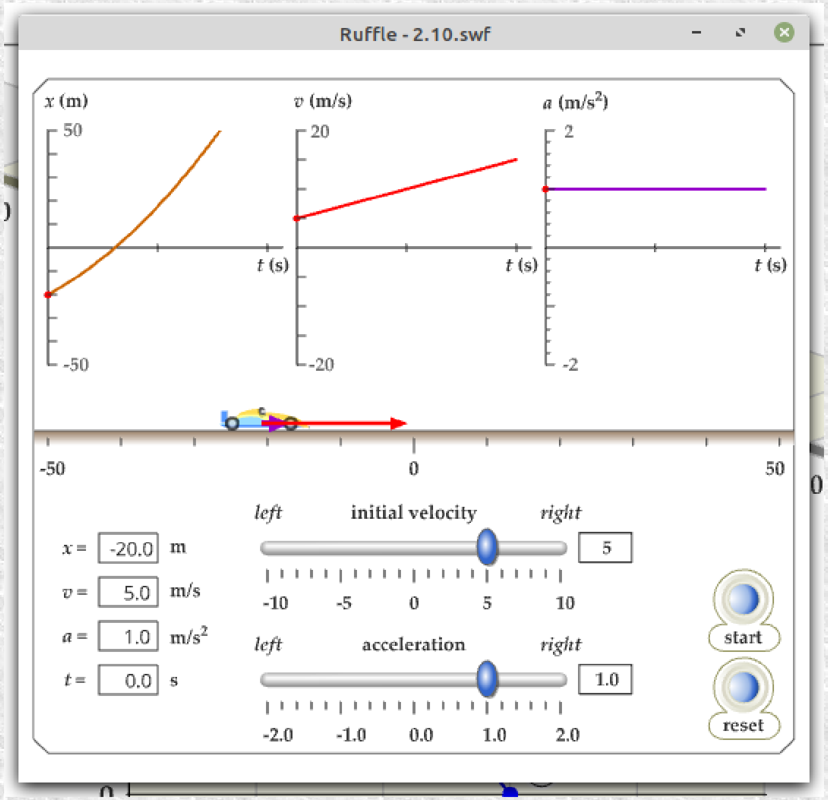
x vs t: **v**$_{inst}$ is slope of x vs t (but area under x vs t is nothing!)

v vs t: **a**$_{inst}$ is slope of v vs t

v vs t: Δ**x** is area under v vs t

a vs t: Δ**v** is area under a vs t

See 2.10.swf:



Week 2 (cont.)

<u>Motion in 1-Dimension (cont.)</u>

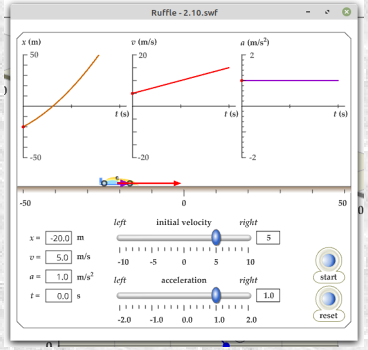
<u>Equations of motion</u>: equations which show x as a function of time.

$x=x_0$ Object is stationary!

$x=x_0+v_0t$ Object moves with a constant speed/velocity.
x_0 is position at t=0, v_0 is velocity at t=0.

$x=x_0+v_0t+\frac{1}{2}at^2$ Object has uniform acceleration.

Show graphs on board and with swf:



Week 2 (cont.)

Motion in 1-Dimension (cont.)

Next: Equations of uniform acceleration.