

Physics 2311 – Physics I, Week 2

Dr. J. Pinkney

Outline for W2, Day “2”

Finish measurements and errors (Ch. 1)

Motion in 1-dimension

Position, distance, path length, displacement

Average speed & velocity

Homework:

Ch. 1 Read sections 3-5,7 (skim 1 & 2)

Ch. 1 MisConcQs: 2-8,10; Probs:1-8,14,15,17,18,
23,24,54-56 (due today by 2:30 pm)

Ch. 2 Read sections 1-7,(8); Probs. 2,3,5-7,14,
23-27,35-38,53-56 (Due next Wed)

Notes: Lab is “Measurements in Physics”

Quiz 1 next Monday on Ch 1 and some Ch 2.

Try practice quiz online.

I tried to fix Canvas for Sec 2.

Tutoring confirmed Wed and Thur 7-9 pm, Het 201.

Physics 2311 – Physics I, Week 2

Dr. J. Pinkney

Outline for W2, Day “3” (Fri)

Motion in 1-dimension

Position, distance, path length, displacement

Average speed & velocity

Acceleration

Homework:

Ch. 2 Read sections 1-7,(8); Probs. 2,3,5-7,14,
23-27,35-38,53-56 (Due next Wed)

Notes:

Ch. 1 hwk key is under “NEW STUFF”

Mon and Tues Labs do Exp 1, others do Exp 2.

Quiz 1 on Monday on Ch 1 and some Ch 2.

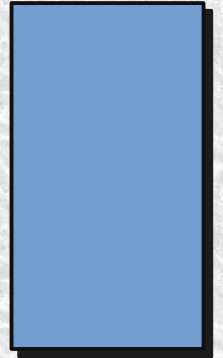
Try THREE practice quizzes online.

I tried to fix Canvas for Sec 2 (9am).

Tutoring confirmed Wed and Thur 7-9 pm, Het 201.

Error propagation example

1) Find the Area of a rectangular plate with $L=21.3\pm0.2$ cm, $W=9.8\pm0.1$ cm, using the “adding the fractional errors” method to determine the errors.



Final answer: $A = 209 \pm 4 \text{ cm}^2$

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

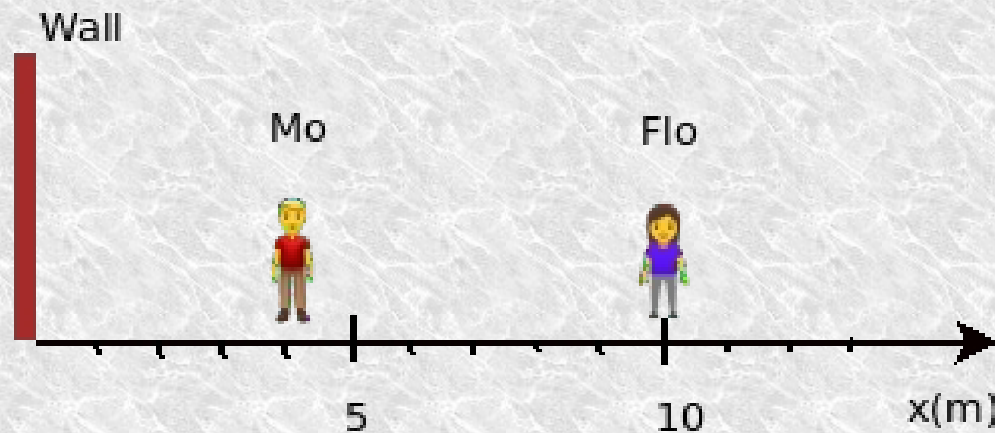
Final answer: $A = 209 \pm 3 \text{ cm}^2$

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

Final answer: $A = 210 \text{ cm}^2$

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.

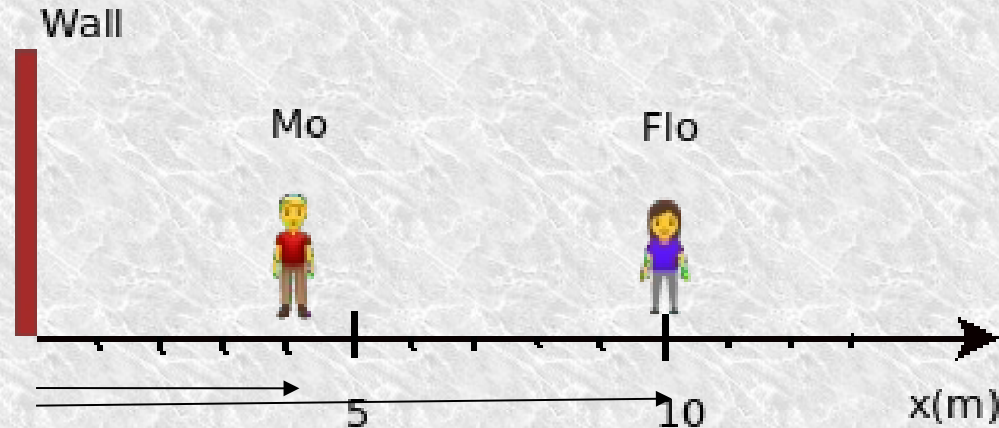


Relative to this origin, we can quantify Mo and Flo's ...

Position: the distance away from a reference point.

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

Motion in 1-Dimension (cont.)



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

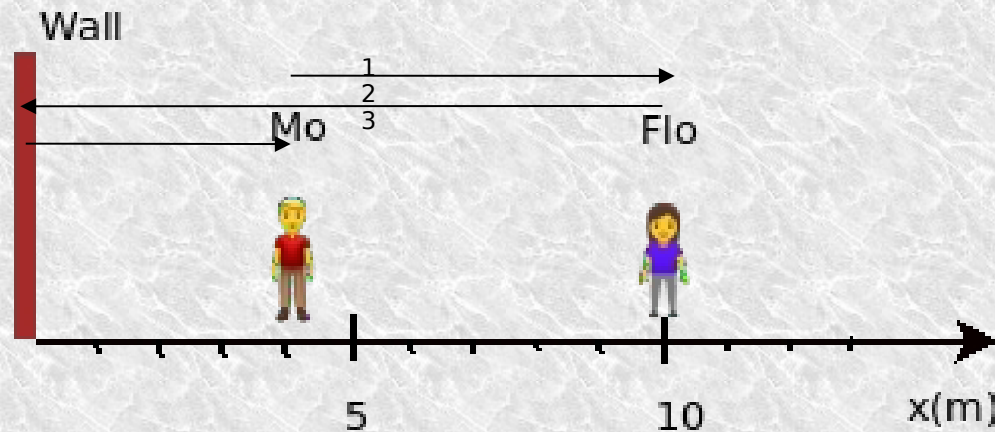
- Symbols for position vector: \mathbf{x} , \mathbf{r} , \vec{x}
- For Mo and Flo we have $\mathbf{x}_{\text{mo}} = 4 \hat{\text{m}}$ and $\mathbf{x}_{\text{flo}} = 10 \hat{\text{m}}$.
- The position vectors for Mo and Flo are shown under the numberline.

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

$$\text{Ex) } d_{\text{flo to mo}} = |\mathbf{x}_{\text{mo}} - \mathbf{x}_{\text{flo}}| = |4 - 10| = 6 \text{ m.}$$

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 $\ell = d_1 + d_2 + d_3 = 6 + 10 + 4 = 20\text{m}$

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 $\Delta\mathbf{x} = \mathbf{x}_f - \mathbf{x}_i = 4\hat{i} - 4\hat{i} = 0\hat{i}\text{ m}$.

Week 2 (cont.)

Motion in 1-Dimension (cont.)

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

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

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

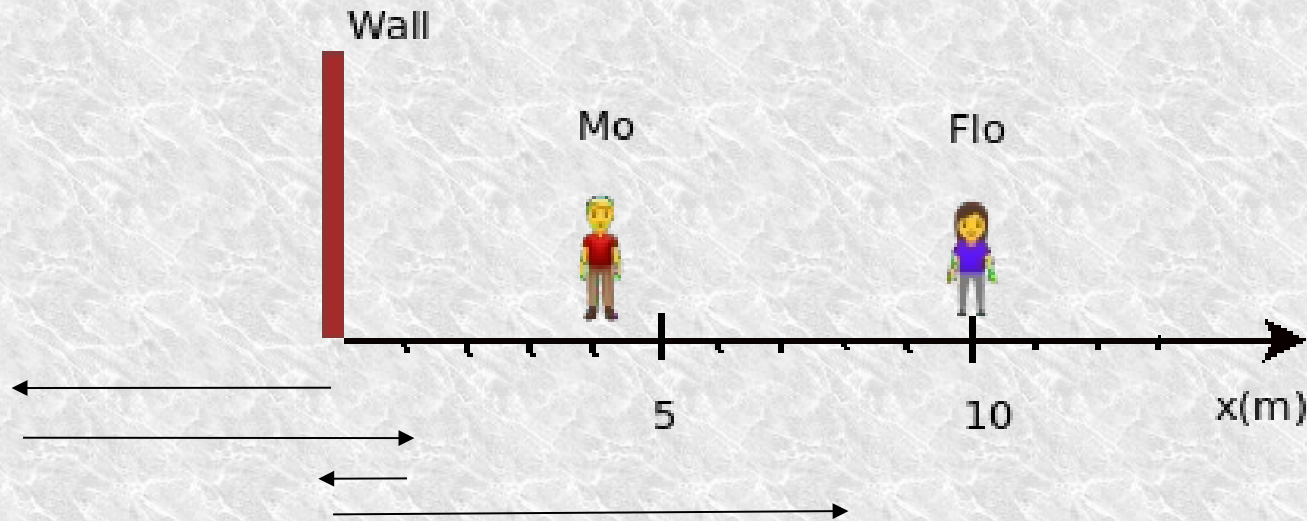
$$\mathbf{v}_{\text{avg}} \equiv \Delta \mathbf{x} / \Delta t$$

\mathbf{v}_{avg} is a vector – it has magnitude and direction.

\mathbf{v}_{avg} 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 $s_{\text{avg}} = 20'/40\text{sec} = 0.5 \text{ ft/sec}$.

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

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

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

Physics 2311 – Physics I, Week 23

Dr. J. Pinkney

Outline for Day W3, D1

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

Last 15 min: Quiz 1.

Homework (Due Wednesday)

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

Notes: Return Hwk 1. Means=9.2, 9.3

Tutoring on Wed, Thu 7-9 (2nd floor Heterick).

Last day to Drop is Feb 9.

Week 2 (cont.)

Motion in 1-Dimension (cont.)

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

- Definition: $s \equiv \lim(\Delta t \rightarrow 0) \Delta \ell / \Delta t$ or $s \equiv \frac{d\ell}{dt}$
- s is a scalar and so it is always positive
- Dimensions: L/T

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

- Definition: $\mathbf{v} \equiv \lim(\Delta t \rightarrow 0) \Delta \mathbf{x} / \Delta t$ or $\vec{v} \equiv \frac{d\vec{x}}{dt}$
- \mathbf{v} is a vector, and so it can be positive or negative
 - Dimensions: L/T

Ex) A racecar moves obeying $\mathbf{x}(t) = 3 - 6t^2 \text{ m } \hat{i}$. What is its instantaneous velocity at $t=3$ seconds?

Ans: $\mathbf{v}(t) = d\mathbf{x}/dt = -12t \hat{i}$, so $\mathbf{v}(t=3) = -36 \text{ m/s } \hat{i}$.

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

Ans: not necessarily!

2) The average speed is greater than or equal to the magnitude of \vec{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 W3, D1

Return Quiz 1

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 (Due ~~Wednesday~~ → Friday)

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

Notes: Quiz 1 means = 7.4, 6.6 / 10

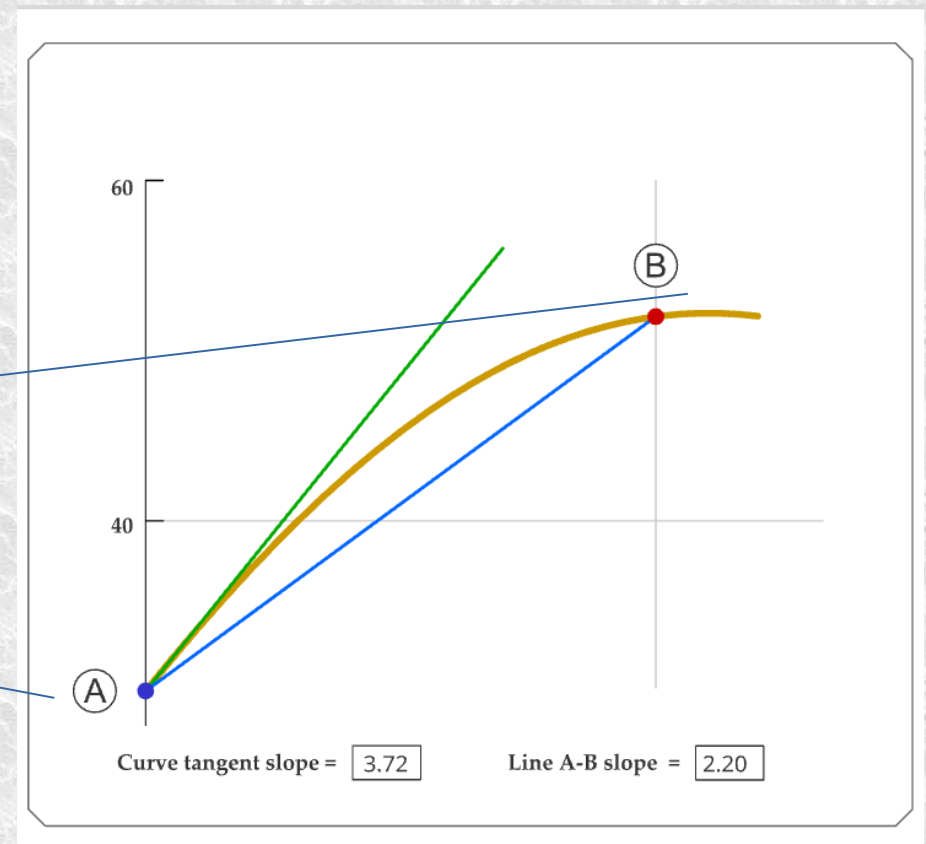
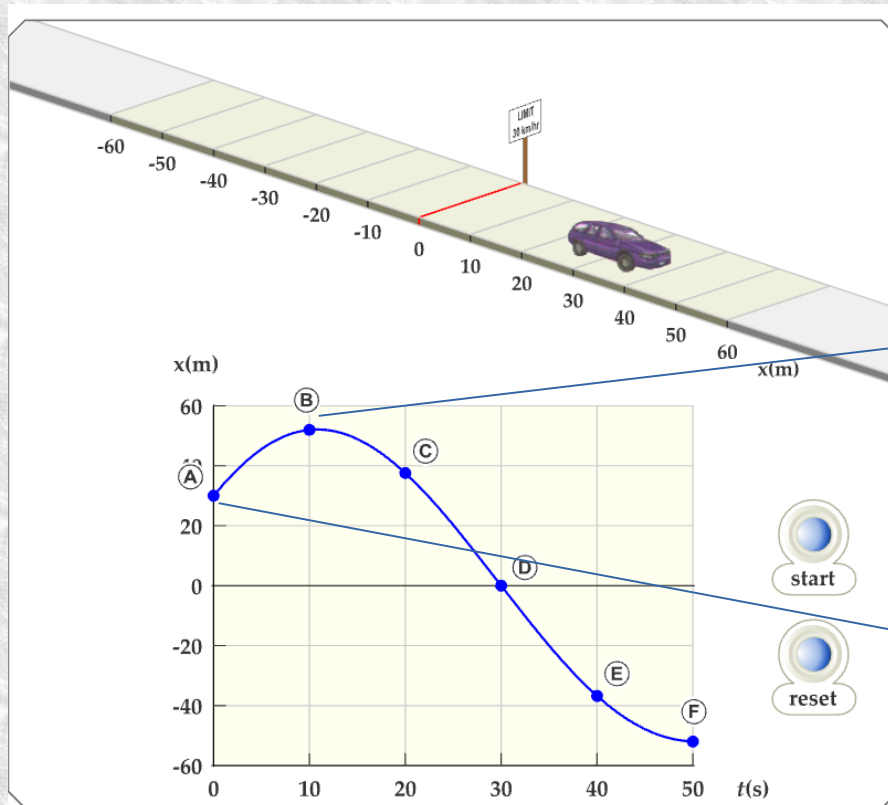
Tutoring 7-9 pm (2nd floor Heterick).

Thur Lab is Exp. 2. Last day to Drop is Feb 9.

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.

$$\lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d \vec{x}}{dt}$$

Week 2 (cont.)

Motion in 1-Dimension (cont.)

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

$$\mathbf{a}_{\text{avg}} \equiv \Delta \mathbf{v} / \Delta t = (\mathbf{v}_f - \mathbf{v}_i) / (t_f - t_i)$$

\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} , a): rate of change of velocity with time at an instant.

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

\mathbf{a} is a vector. We will NOT have a scalar version of acceleration which is always positive.

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

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

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

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

Need to convert units of $\Delta \mathbf{v} = (120 - 65 \text{ km/hr})$
 $= 55 \text{ km/hr} * (1 \text{ hr} / 3600 \text{ s}) * (1000 \text{ m} / \text{km}) = 15.28 \text{ m/s}$

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

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

Week 2 (cont.)

Motion in 1-Dimension (cont.)

More on graphing

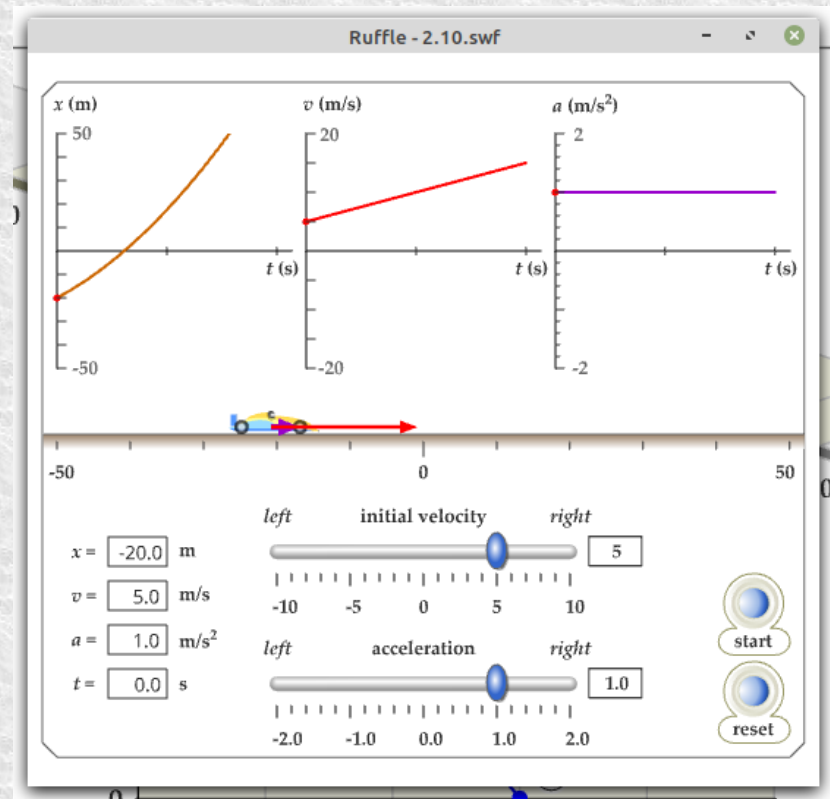
x vs t: $\mathbf{v_{inst}}$ is slope of x vs t (but area under x vs t is nothing!)

v vs t: $\mathbf{a_{inst}}$ is slope of v vs t

v vs t: $\Delta\mathbf{x}$ is area under v vs t

a vs t: $\Delta\mathbf{v}$ is area under a vs t

See 2.10.swf:



Week 2 (cont.)

Motion in 1-Dimension (cont.)

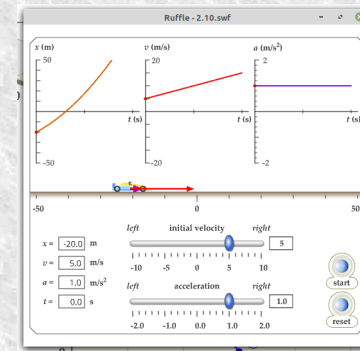
Equations of motion: equations which show x as a function of time.

$x = x_0$ Object is stationary!

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

$x = x_0 + v_0 t + \frac{1}{2}at^2$ Object has uniform acceleration.

Show graphs on board and with swf:



Week 2 (cont.)

Motion in 1-Dimension (cont.)

Next: Equations of uniform acceleration.