Tennis Ball Exercise

STATIC Units
Coordinate system
Significant figures
errors
Appropriate quantifiable variables
position vs. feeling

Moving vectors vs. scalars

Beauty and the Trouble w/ physics

Melissa vs. Maxwell

Bird Example → Estimation, Conversion, Sanity check

To Physics

Start by studying World around you

Sit on quad: what do you see/notice
for 2 hours

→ Motion ... change ... what causes change
→ If understand change and its cause
do we "understand" the universe?

→ 1d Kinematics

How Many birds in NY STATE

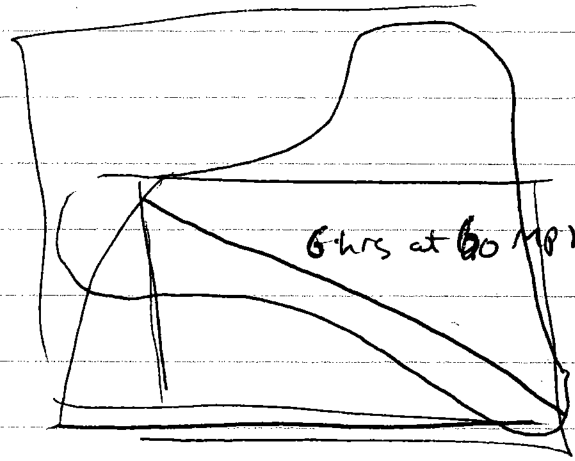
10 birds in ~~two~~ Football field area

↙

100 × 50 yards

yahoo 333

in NY STATE



Assume

$(\frac{1}{2})\, 360^2 \text{ mi}^2$

6 hrs at 60 mph ~ 360 miles

$1 \text{ yard} \times 3 \frac{\text{ft}}{\text{yard}} \times \frac{1}{5280} \frac{\text{mi}}{\text{ft}} = .0006 \text{ mi}$

Conversion

$100 \text{ yd} \times 3 \times \frac{1}{5280} = 0.0568 \text{ mi}$

$50 \text{ yd} = 0.0284 \text{ mi}$

True 49576 mi^2

football Field Area $= (0.0568)(0.0284) = 0.0016 \text{ mi}^2$

10 birds ~~in~~ 0.0016 mi^2 ~ x birds ~~in~~ 64800 mi^2

$\cancel{x = \frac{(10)(.0016)}{64800}}$

$\frac{10}{.0016}(64800) = 405$ million birds

Units

Two Teams, Two Measures Equaled One Lost Spacecraft

By ANDREW POLLACK

LOS ANGELES, Sept. 30 — Simple confusion over whether measurements were metric or not led to the loss of a $125 million spacecraft last week as it approached Mars, the National Aeronautics and Space Administration said today.

An internal review team at NASA's Jet Propulsion Laboratory said in a preliminary conclusion that engineers at Lockheed Martin Corporation, which had built the spacecraft, specified certain measurements about the spacecraft's thrust in pounds, an English unit, but that NASA scientists thought the information was in the metric measurement of newtons.

The resulting miscalculation, undetected for months as the craft was designed, built and launched, meant the craft, the Mars Climate Orbiter, was off course by about 60 miles as it approached Mars.

"This is going to be the cautionary tale that is going to be embedded into introductions to the metric system in elementary school and high school and college physics till the end of time," said John Pike, director of space policy at the Federation of American Scientists in Washington.

Lockheed's reaction was equally blunt.

"The reaction is disbelief," said Noel Hinners, vice president for flight systems at Lockheed Martin Astronautics in Denver, Colo. "It can't be something that simple that could cause this to happen."

The finding was a major embarrassment for NASA, which said it was investigating how such a basic error could have gone through a mission's checks and balances.

"The real issue is not that the data was wrong," said Edward C. Stone, the director of the Jet Propulsion Laboratory in Pasadena, Calif., which was in charge of the mission. "The real issue is that our process

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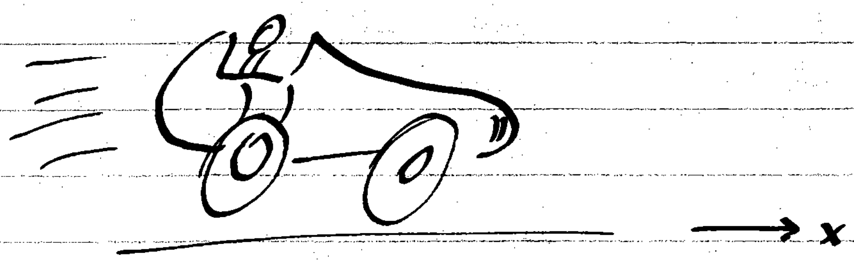
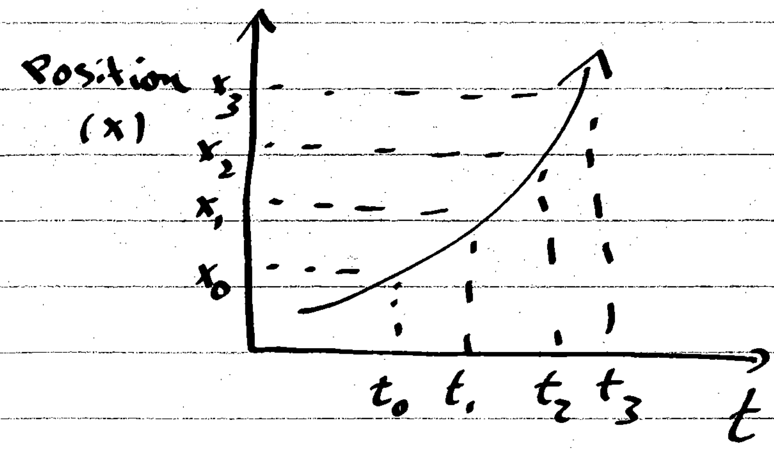
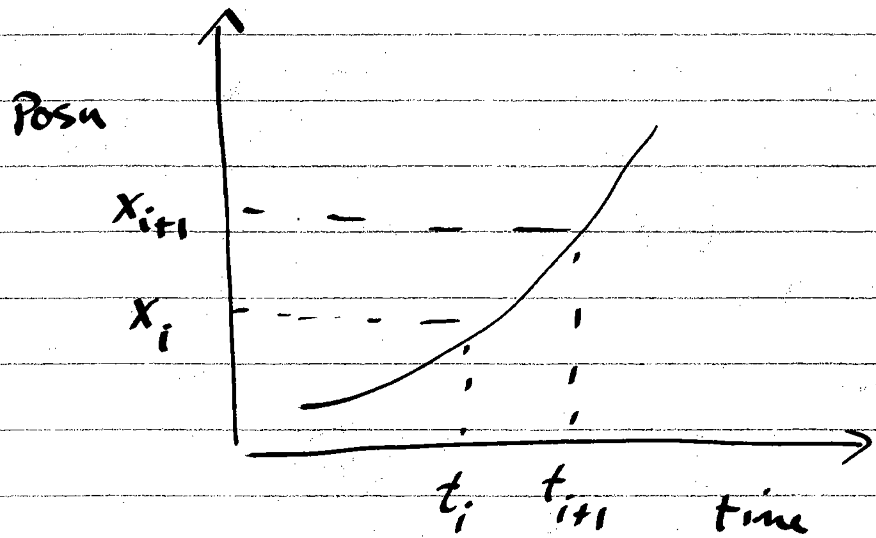
9/6/01

1 dimensional Motion (1d Kinematics)







Ave. Speed over interval is $\dfrac{X_{i+1} - X_i}{\cancel{X_{i+1} - X_i}\; t_{i+1} - t_i} = \dfrac{\Delta X}{\Delta t}$ m/s

units

Table A-4 Properties of Derivatives and Derivatives of Particular Functions

Linearity

1. The derivative of a constant times a function equals the constant times the derivative of the function:

$$\frac{d}{dt}[Cf(t)] = C\frac{df(t)}{dt}$$

2. The derivative of a sum of functions equals the sum of the derivatives of the functions:

$$\frac{d}{dt}[f(t) + g(t)] = \frac{df(t)}{dt} + \frac{dg(t)}{dt}$$

Chain rule

3. If f is a function of x and x is in turn a function of t, the derivative of f with respect to t equals the product of the derivative of f with respect to x and the derivative of x with respect to t:

$$\frac{d}{dt}f(x) = \frac{df}{dx}\frac{dx}{dt}$$

Derivative of a product

4. The derivative of a product of functions $f(t)g(t)$ equals the first function times the derivative of the second plus the second function times the derivative of the first:

$$\frac{d}{dt}[f(t)g(t)] = f(t)\frac{dg(t)}{dt} + \frac{df(t)}{dt}g(t)$$

Reciprocal derivative

5. The derivative of t with respect to x is the reciprocal of the derivative of x with respect to t, assuming that neither derivative is zero:

$$\frac{dx}{dt} = \left(\frac{dt}{dx}\right)^{-1} \quad \text{if} \quad \frac{dt}{dx} \neq 0$$

Derivatives of particular functions

6. $\frac{dC}{dt} = 0$ where C is a constant

7. $\frac{d(t^n)}{dt} = nt^{n-1}$

8. $\frac{d}{dt}\sin \omega t = \omega \cos \omega t$

9. $\frac{d}{dt}\cos \omega t = -\omega \sin \omega t$

10. $\frac{d}{dt}e^{bt} = be^{bt}$

11. $\frac{d}{dt}\ln bt = \frac{1}{t}$

Table A-5 Integration Formulas†

1. $\int A\,dt = At$

2. $\int At\,dt = \frac{1}{2}At^2$

3. $\int At^n\,dt = A\frac{t^{n+1}}{n+1} \qquad n \neq -1$

4. $\int At^{-1}\,dt = A\ln t$

5. $\int e^{bt}\,dt = \frac{1}{b}e^{bt}$

6. $\int \cos \omega t\,dt = \frac{1}{\omega}\sin \omega t$

7. $\int \sin \omega t\,dt = -\frac{1}{\omega}\cos \omega t$

†In these formulas, A, b, and ω are constants. An arbitrary constant C can be added to the right side of each equation.

Ave Velocity is $\frac{\Delta x}{\Delta t}$ $\frac{m}{s}$ in $+x$ direction

Speed has magnitude only

Velocity has magnitude + direction

1 d Motion ... direction determined w/ sign

Suppose you want the instantaneous velocity at time t_i

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

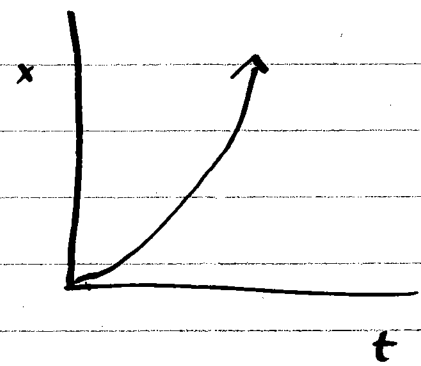
$t_{i+1} \to t_i$

$\to$ standard definition of derivative

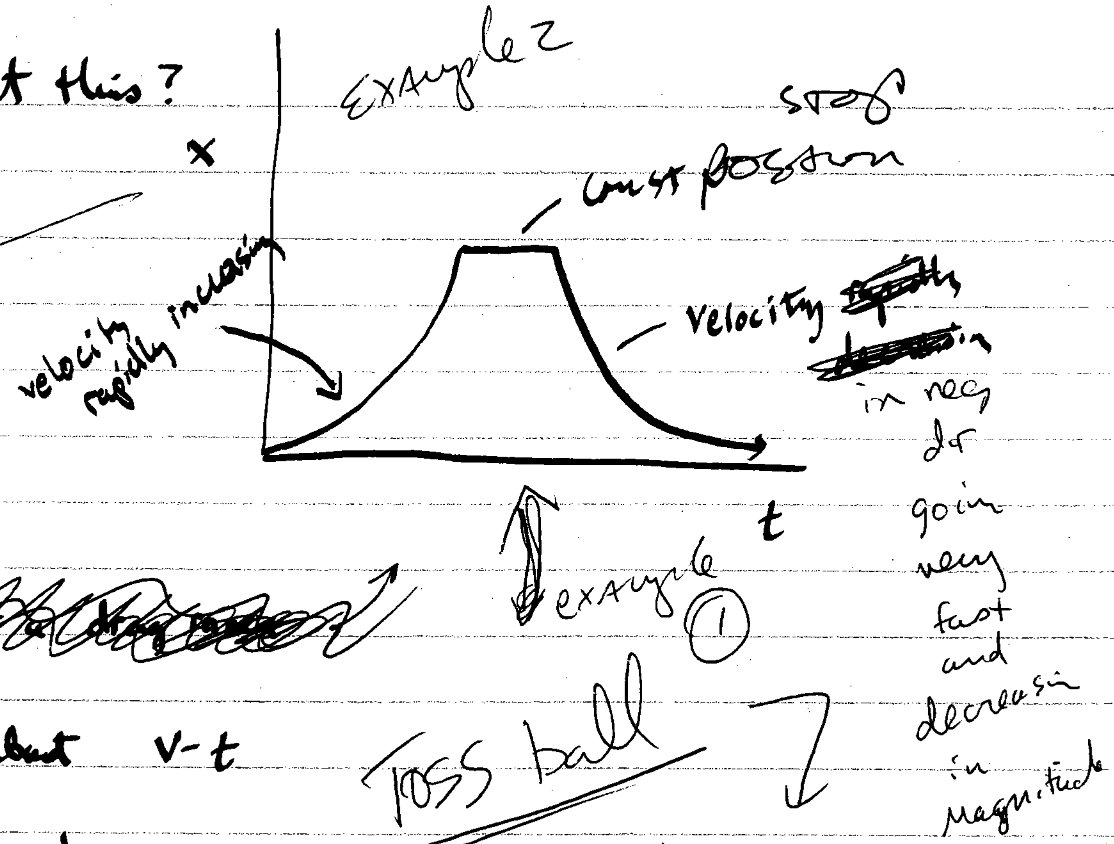
~~Suppose we look at a drag race~~

what does this look like

Motion

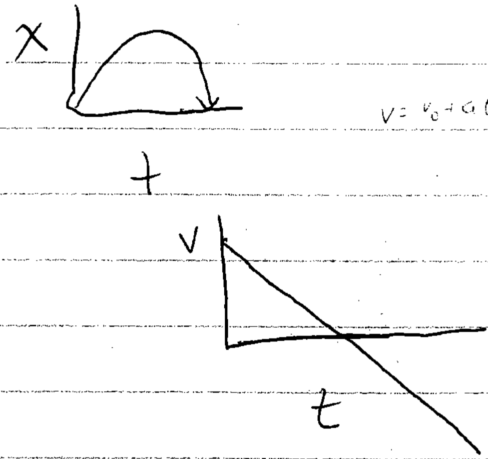


How about this?

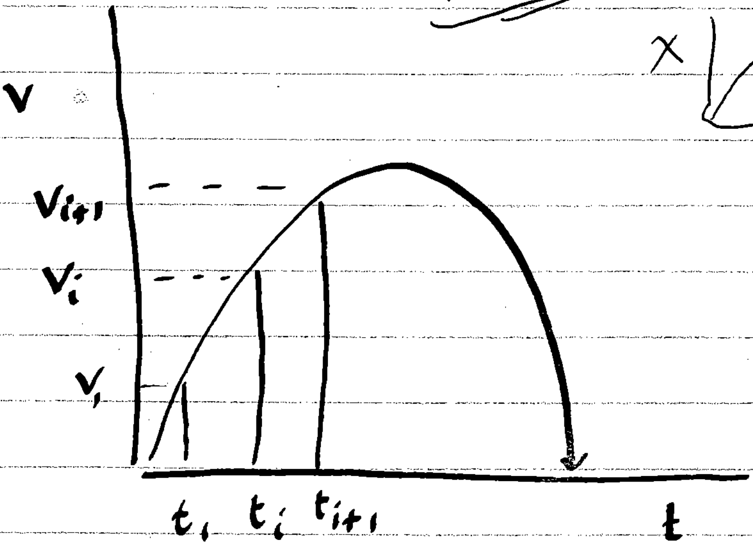


What about v-t

TOSS ball



$v = v_0 + at$



$$\text{Ave. Acceleration} = \frac{V_{i+1} - V_i}{t_{i+1} - t_i} = \frac{\Delta V}{\Delta t} \quad \text{in} \quad \frac{m/s}{s} = m/s^2$$

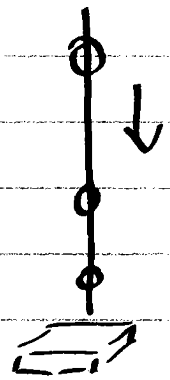
$$\text{inst. Accel.} = \lim_{\Delta t \to 0} \frac{\Delta V}{\Delta t} = \frac{dV}{dt}$$

Acceleration has magnitude and direction

$$a = \frac{dv}{dt} = \frac{d\left(\frac{dx}{dt}\right)}{dt} = \frac{d^2x}{dt^2}$$

deceleration vs. acceleration in negative direction

demo Mb-12



Time intervals of fall

Try Mb-11 strobe w/ accelerated and constant v motion

x	~ Position	m	ft	mi
v	~ velocity	m/s	ft/s	mi/hr
a	~ acceleration	m/s^2	ft/s^2	mi/hr^2
t	~ time	s	s	hr

These are the kinematic variables. If you know these . . . you know all there is to know about particle motion

Last class

$$V_{average} = \frac{\Delta x}{\Delta t}$$

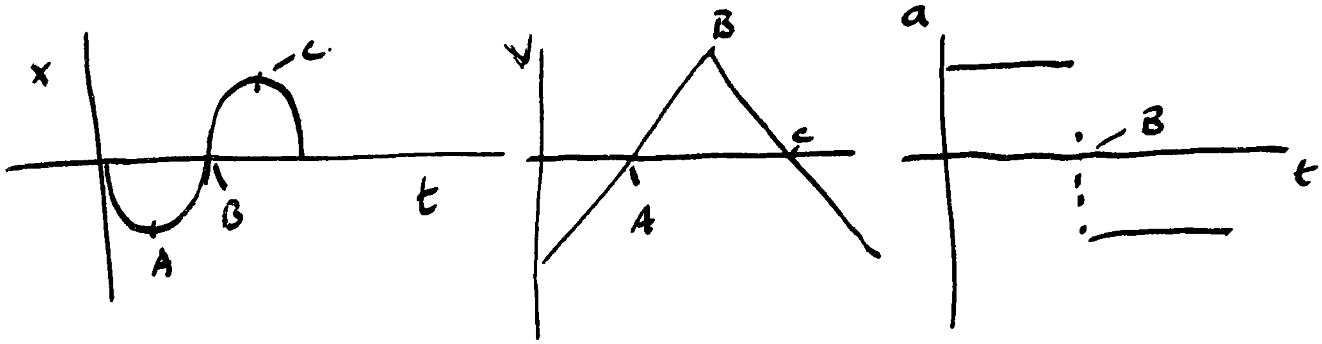
$$V_{instantaneous} = \frac{dx}{dt}$$

$$a_{average} = \frac{\Delta V}{\Delta t}$$

$$a_{instantaneous} = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

$x, a, v, t \rightarrow$ Kinematic Variables

These Are NOT independent Variables



Started an Example

$$x(t) = At^2 + Bt^3$$

$$x(t) = \left(3 \tfrac{m}{s^2}\right)t^2 + \left(0.3 \tfrac{m}{s^3}\right)t^3$$

~~$V(t) = 6t + (.3)(3)$~~

$$V(t) = 2At + 3Bt^2$$

$$a(t) = 2A + 6Bt$$