Physics 113 - September 10, 2013

- Still getting organized w/ TA's
- Workshops begin next week
- Hope to start offering TA office hours next week too
- Posted last week's lectures (No audio for 9/3, 9/5 ... Sorry)
- Any other questions/issues regarding class?

Review of last class

Kinematic variables

x (or y or z) $\equiv$ position

$v \equiv$ velocity

$a \equiv$ Acceleration

$t \equiv$ time

in 1-d motion direction given by Algebraic sign

units (MKS)

meters

meters/second

meters/second^2

seconds

Have $x(t)$, $v(t)$, $a(t)$ — Not Independent

Average Speed $= \frac{\Delta x}{\Delta t}$ — Distance Traveled

Average velocity $\bar{v} = \frac{\Delta x}{\Delta t}$ — Displacement over time interval in limit $\Delta t \to 0$

Average velocity → instantaneous velocity

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

Also known as "velocity"

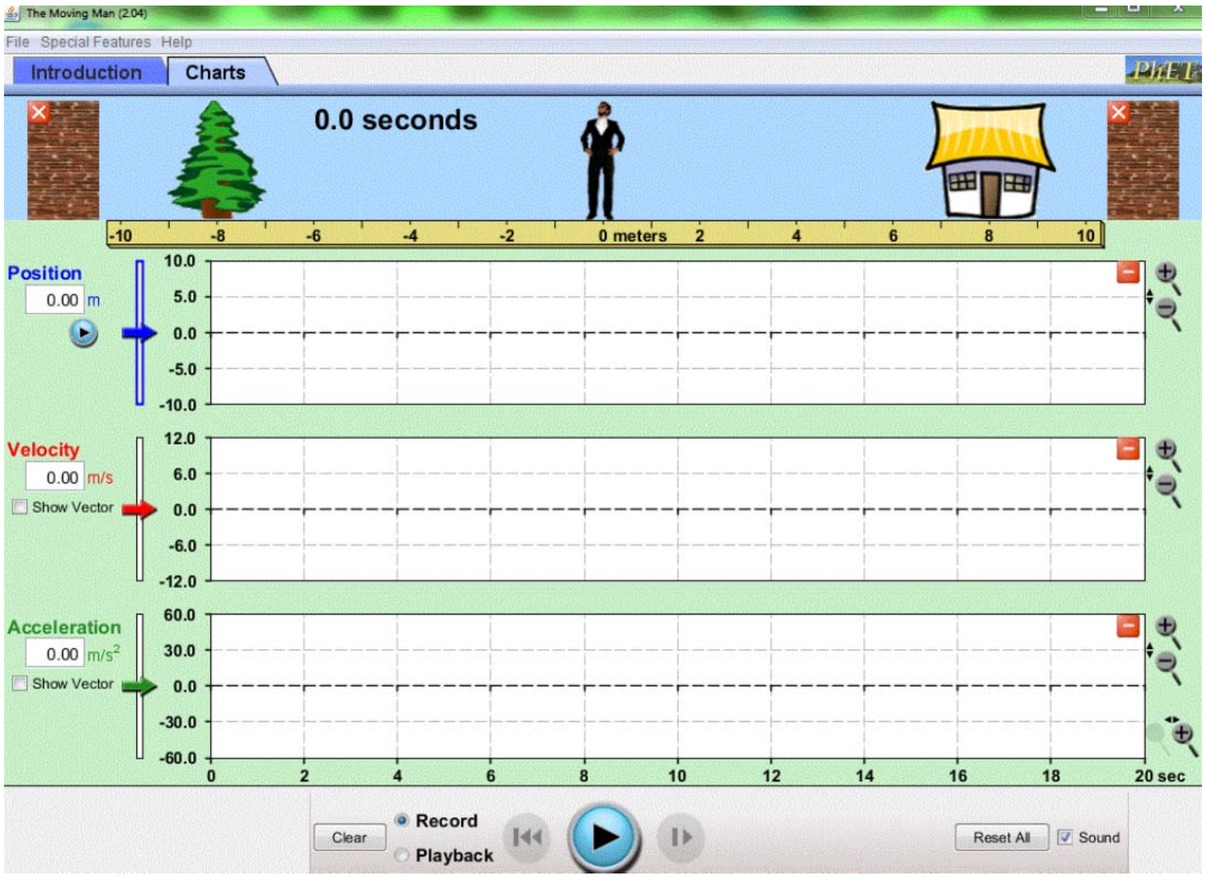
Similarly,

$$\text{Average Acceleration} = \frac{\Delta v}{\Delta t}$$

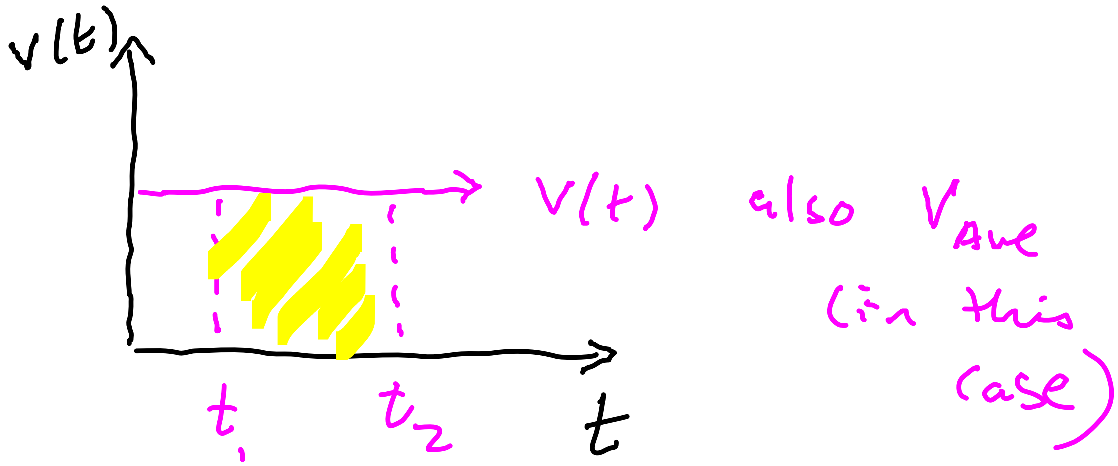
$$\text{instantaneous Acceleration or acceleration} = \frac{dv}{dt}$$

$$= \frac{d}{dt}\frac{dx}{dt} = \frac{d^2x}{dt^2}$$

http://phet.colorado.edu/en/simulation/moving-man

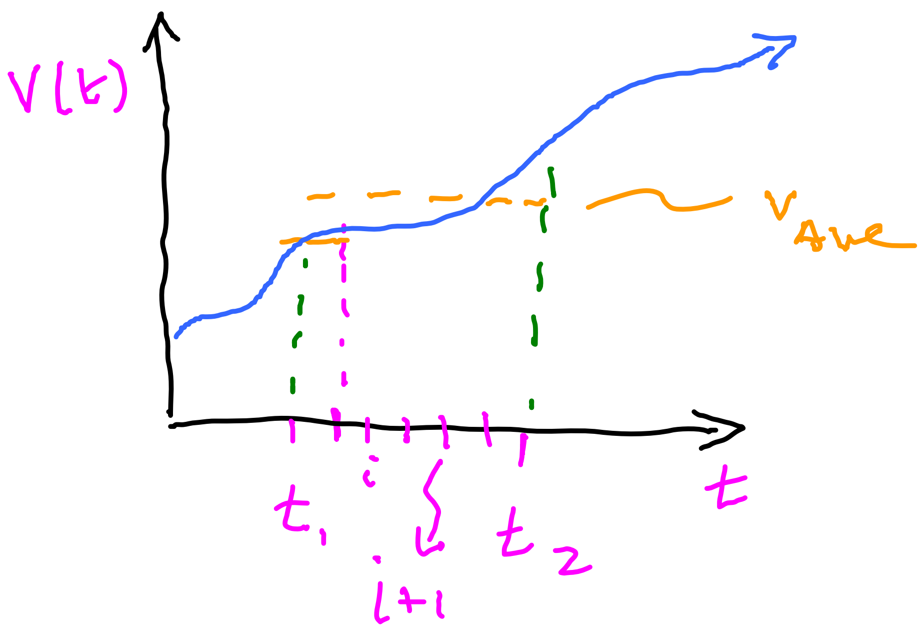


$$V_{Ave} = \frac{\Delta x}{\Delta t}$$



$$\Delta x = V_{ave} \, \Delta t$$

Area under V - t graph



$\Delta x = V_{Ave} \Delta t$

↳ imperfect description $\neq V(t)$

$\Delta x = \sum V_{Ave,i} \Delta t_i$

go to limit where $\Delta t_i \to 0$

$$\Delta x = \lim_{\Delta t \to 0} \sum V_{Ave,i} \Delta t_i$$

$\Delta t \longrightarrow dt$

$V_{Ave} \longrightarrow V$

$\Delta x = \int_{t_1}^{t_2} v\, dt$

$g = \int f\, dt$ then $f = dg/dt$

$\Delta x = x - x_0 = x = \int v\, dt$ ($x_0 = 0$)

$v = \frac{dx}{dt}$

$\Delta x = x_2 - x_1$

$$x_2 - x_1 = \int_{t_1}^{t_2} v\, dt$$

general

$x - x_0 = \int_{t_0}^{t} v\, dt$

Similarly $\frac{\Delta v}{\Delta t} = a_{Ave} \equiv$ Average Acceleration

$\frac{dv}{dt} = a$ $\qquad v - v_0 = \int_{t_0}^{t} a\, dt$ general

Suppose a is CONSTANT

This is a special case

$$v - v_0 = \int_{t_0}^{t} a\,dt = a\int_{t_0}^{t} dt = a\,t\Big|_{t_0}^{t} = a(t - t_0)$$

$$v = v_0 + a(t - t_0)$$

Assume $t_0 = 0$

$$\boxed{v = v_0 + at}$$

only for a const

v, a, t no x

$$x - x_0 = \int_{t_0}^{t} v\,dt$$ True in general

a constant

$$x - x_0 = \int_{t_0}^{t} (v_0 + at)\,dt$$

$$x - x_0 = \int_{t_0}^{t} v_0\,dt + \int_{t_0}^{t} at\,dt$$

$$x - x_0 = v_0 \int_{t_0}^{t} dt + a \int_{t_0}^{t} t\,dt$$

$$t \Big|_{t_0}^{t} \qquad \frac{t^2}{2} \Big|_{t_0}^{t}$$

$$x - x_0 = v_0(t - t_0) + a\left(\frac{t^2}{2} - \frac{t_0^2}{2}\right)$$

let $t_0 = 0$

$$\boxed{x = x_0 + v_0 t + \frac{1}{2} a t^2}$$

a is const

x, a, t

No v

$$V_{ave} = \frac{\Delta x}{\Delta t} \longrightarrow \Delta x = V_{ave}\,\Delta t$$

a is CONSTANT $\longrightarrow$ V changes at a CONSTANT rate

$$V_{Ave} = \frac{V + V_0}{2}$$

a is CONSTANT

$$x - x_0 = \left(\frac{V + V_0}{2}\right)(t - t_0)$$

$t_0 \to 0$

$$x = x_0 + \left(\frac{V + V_0}{2}\right) t$$

a is CONSTANT

x, V, t NO a

$v = v_0 + at$ solve for t

$$\frac{v - v_0}{a} = t$$

$$x = x_0 + \left(\frac{v + v_0}{2}\right)\left(\frac{v - v_0}{a}\right)$$

$$x = x_0 + \frac{v^2 - v_0^2}{2a}$$

$$\boxed{v^2 = v_0^2 + 2a(x - x_0)}$$

const. a only

v, a, x

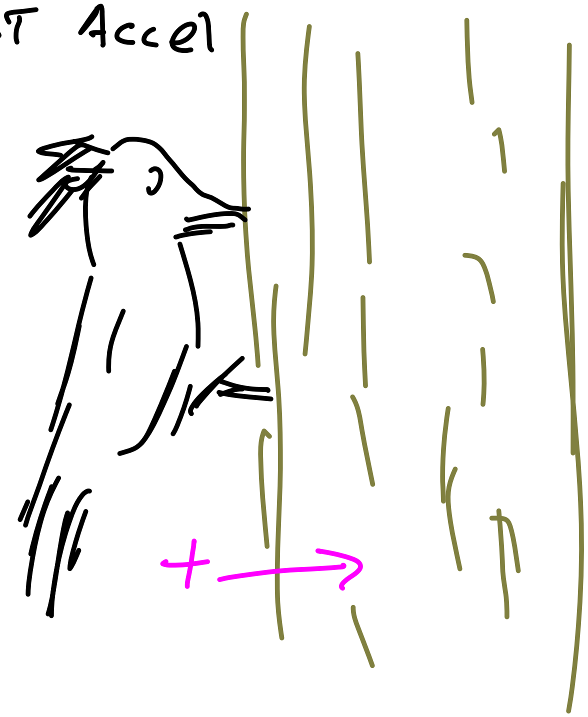
No t

Example

Assume const Accel

$V_0 = 0.6$ m/s

Comes to a stop in 2 mm



(a) What is the acceleration of head in units of g.

$g = 9.8\ \mathrm{m/s^2}$

Know V_0, $x - x_0$, $V = 0$

Want is a

$$V^2 = V_0^2 + 2a(x - x_0)$$

$0 \quad 0.6^2 \quad .002$

$a = -90\ \mathrm{m/s^2}$

$-90\ m/s^2 \sim -9\ g's$

$$\frac{|-90|}{9.8} \sim 9\ g's$$

(b) How much time does it take to stop the head

$$V = V_0 + at$$

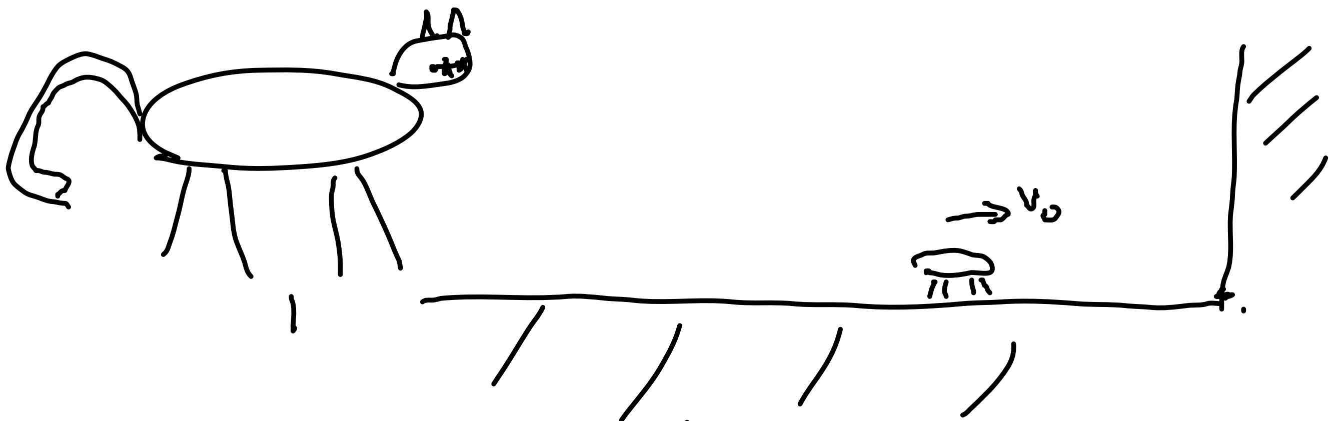
$$0 = .6\ m/s - (90\ m/s^2)\ t$$

$$t = \frac{-.6}{-90} = 6.7\ ms$$

Tendons stretch brain comes to a stop in 4.5 mm

$$V^2 = V_0^2 + 2a(x - x_0)$$

$a = -40\ m/s^2$ or $\sim 4\ g's$



t=0 cat sees bug

accelerate at a