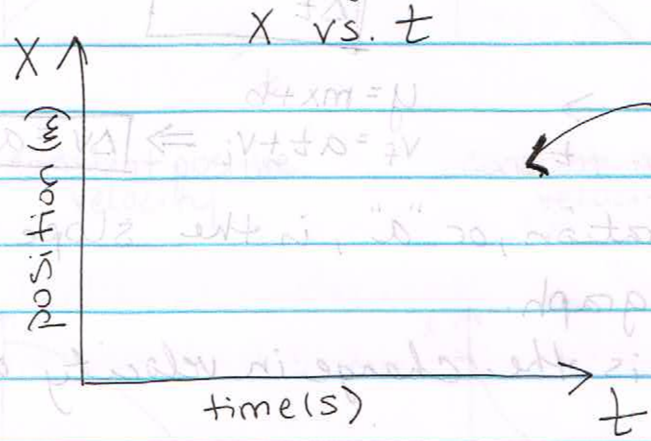
1D Motion

Position-time graphs : Velocity

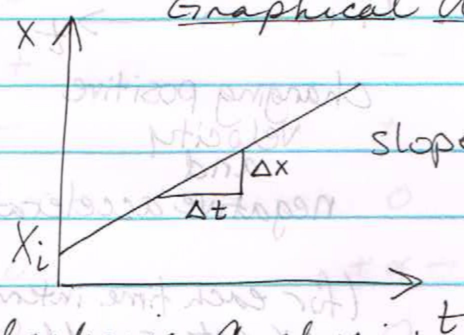


plot an object's position at specific times.

x is instantaneous position of object.
t is time.

☆ The intersection of 2 lines on a position-time graph tells you when objects have the same position.
☆ The slope of a line on a position-time graph can determine the velocity of an object.

Graphical Analysis:



slope $= \frac{\text{rise}}{\text{run}} = \boxed{\frac{\Delta x}{\Delta t} = v}$ ☆

same result different form of eqn. 7

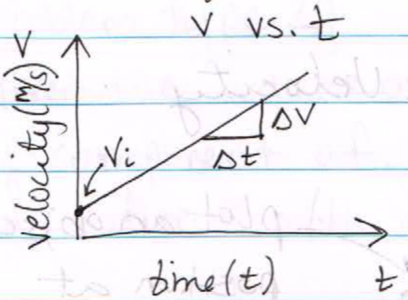
Algebraic Analysis:

Eqn of straight line: $y = mx + b$

$x_f = vt + x_i \Rightarrow \boxed{\Delta x = vt}$ ☆

$-x_i \quad\quad -x_i$

Velocity-time graphs : Acceleration.



$$\text{Slope} = \boxed{\frac{\Delta v}{\Delta t} = a.}$$

$$y = mx + b$$

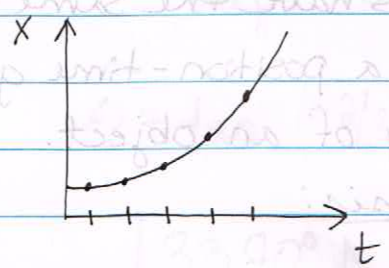
$$v_f = at + v_i \Rightarrow \boxed{\Delta v = at}$$

☆ The acceleration, or "a", is the slope of a ~~position~~ velocity-time graph.

Acceleration is the change in velocity over time

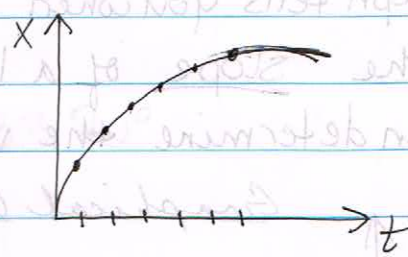
Acceleration on a position-time (x vs. t) graph

☆ changing velocity, or acceleration, plotted on an x vs. t graph, will result in a graph with a changing slope.



Changing positive velocity and positive acceleration

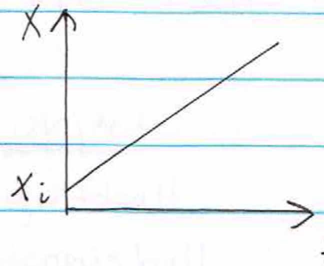
(for each time interval, Δx gets larger, so object is speeding up)



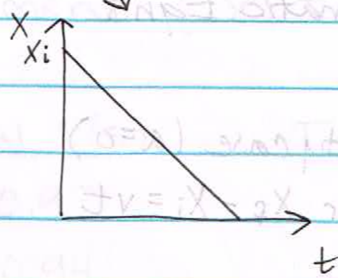
changing positive velocity and negative acceleration

(for each time interval, Δx gets smaller, so object is slowing down)

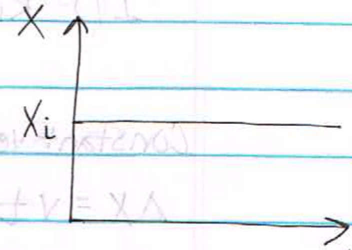
Note that avg. speed is the absolute value of the slope of an x vs. t graph. (not pos or neg).



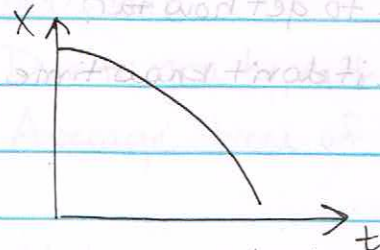
constant positive velocity



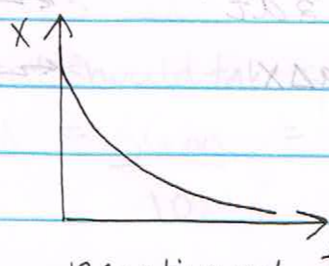
constant negative velocity



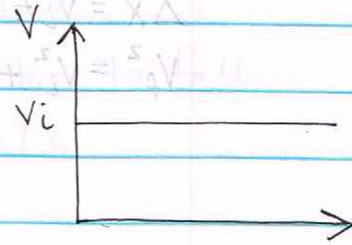
constant position
zero velocity



negative velocity
positive acceleration



negative velocity
negative acceleration



constant velocity
no acceleration

Signs of Velocity and Acceleration

v	a	motion
+	+	speed up
−	−	speed up
+	−	slow down
−	+	slow down
+ or −	0	constant velocity ($a=0$)
0	+ or −	speed up from rest ($v_i=0$)
0	0	At rest ($v=0, a=0$)

1D Kinematic Eqns

Constant velocity case $(a=0)$

$\Delta X = vt$ or $X_f - X_i = vt$

constant acceleration case

$\Delta V = at$ or $V_f - V_i = at$

$\Delta X = V_i t + \frac{1}{2}at^2$ ← use to get how far.

$V_f^2 = V_i^2 + 2a\Delta X$ ← use if don't know time.

Free Fall Experiment (Sept 18 & 19)

Object	Trial 1 (s)	Trial 2 (s)
golfball	0.93	1.01
tennisball	0.94	1.01
football	0.94	1.07
basketball	0.95	1.00
beachball	1.13	1.13

Due to gravity, each object should take same time to fall.

Average time of fall $= \frac{\text{sum}}{10} = 1.01\,s$

Notes and Analysis

Acceleration due to gravity $= 9.8\ m/s^2$

Use special symbol g : $a = g = 9.8\ m/s^2$.

We know: $a = \frac{\Delta v}{t}$ and $\Delta x = v_i t + \frac{1}{2}at^2$.

So substitute g for a and use d for distance instead of Δx (since we are technically moving in the y direction).

$\boxed{g = \frac{\Delta v}{t}}$ and $\boxed{d = v_i t + \frac{1}{2}gt^2}$

For our experiment, each ball started out at rest, so $v_i = 0$.

Therefore, $d = \frac{1}{2}gt^2$.

We can use to find out how high we dropped the balls from using our average time of fall:

$$d = \frac{1}{2}(9.8\,m/s^2)(1.01\,s)^2 = 5.0\,m.$$

Is this right? We measured with a measuring tape and found the true distance was 17 ft 10 in

Convert to meters to compare!

$$17\,ft\left(\frac{12\,in}{1\,ft}\right) + 10\,in = 214\,in$$

$$214\,in\left(\frac{2.54\,cm}{1\,in}\right)\left(\frac{0.01\,m}{1\,cm}\right) = 5.4\,m.$$

$\Rightarrow$ We were off in our determination of d due to experimental error.

We can calculate the time we should have measured using our known distance of 5.4 m:

$d = \frac{1}{2}gt^2$ get in terms of t first.

$\frac{d}{\frac{1}{2}g} = \frac{\cancel{\frac{1}{2}g}t^2}{\cancel{\frac{1}{2}g}}$ divide by $\frac{1}{2}g$ to get t^2

$\frac{2d}{g} = t^2$ division by $\frac{1}{2}$ is same as mult. by 2 (the recipro

$\sqrt{\frac{2d}{g}} = \sqrt{t^2} = t$ take square root to get t by itsel

Now plug in values of g + d to get t:

$$t = \sqrt{\frac{2d}{g}} = \sqrt{\frac{2(5.4m)}{9.8 m/s^2}} = \boxed{1.05 s}$$

the time we would have measured if we had perfect senses.

Instantaneous Velocity

the velocity at an instant in time.

We can calculate the velocity at any point during the balls' fall.

How fast right before the ball hit the floor ($t = 1.05s$)?

$g = \frac{v}{t}$. Solve for v: $v = gt$

$= (9.8 m/s^2)(1.05s)$

$\boxed{v = 10.3 m/s}$

How fast at $t = 0.5s$?

$v = gt = (9.8 m/s^2)(0.5s) = \boxed{4.9 m/s}$

Notice that the velocity increases the longer the object is in the air b/c gravity is continuing to accelerate or speed up the object's descent.

Physics Variables and Units

Page #	Variable	Units	Variable Name	Notes
23	x	m	position	
23	Δx	m	displacement	Δ means final − initial
23	t	s	time	
23	v	m/s	velocity	
24	a	m/s^2	acceleration	
27	g	m/s^2	gravitational acceleration	a constant $= 9.8\ m/s^2$