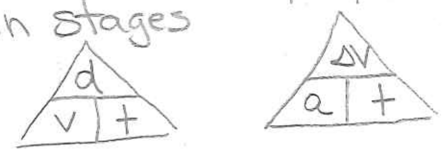
Unit Two: Accelerated Motion; Acceleration due to gravity

- Acceleration occurs when an object speeds up, slows down or changes direction (a_c)
- Acceleration always agrees with net force
  - If net force is zero; acceleration is zero
  - If net force is positive, acceleration is positive
  - If net force is negative, acceleration is negative
- To use head problem method solve smaller simple problems in stages

V_i	V_f	$\bar{V}$	d	a	t



- Acceleration, velocity & displacement are vector quantities
  - If initial velocity and acceleration don't agree in direction make sure they have opposite signs

- For projectiles in "free fall" the acceleration due to gravity is equal to gravitational field strength $(g) = 9.81 \, m/s^2$ downward
  - If object is falling from rest displacement, final velocity & acceleration are all in the same direction so down can be assigned as positive

Approximation using $g = 10 \, m/s^2$

$d = (5 \, m/s^2)t^2$ $\quad V_f = (10 \, m/s^2)t$

$t = \sqrt{\frac{2d}{10 \, m/s^2}}$

a	t	d	V_f
$10 \, m/s^2$	1s	5m	10 m/s
	2s	20m	20 m/s
	3s	45m	30 m/s
	4s	80m	40 m/s
	5s	125m	50 m/s
	6s	180m	60 m/s
	7s		

For
.1s d=5cm
.2s d=20cm

Equation, Variables, units

V_i = initial velocity (speed)
V_f = final velocity (speed)
$\bar{V}$ = average velocity (speed)
ΔV = Change in velocity (speed)
} m/s

a = acceleration (m/s^2)
d = distance/displacement (m)
t = time (s)

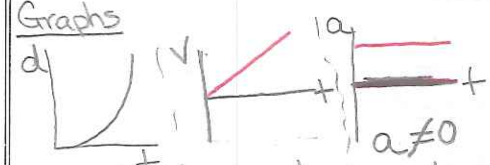
$\bar{V} = \frac{V_i + V_f}{2}$ $\quad \Delta V = V_f - V_i$ $\quad a = \frac{\Delta V}{t}$

$V_f = V_i + at$
$V_f^2 = V_i^2 + 2ad$
$d = V_i t + \frac{1}{2}at^2$

when $V_i = 0$

$V_f = at$
$V_f = \sqrt{2ad}$
$d = \frac{1}{2}at^2$
$t = \sqrt{\frac{2d}{a}}$

Graphs



$d = \frac{1}{2}at^2$
d & t show direct square

If t doubles d quadruples

Note if
$d \times 2$
$t \times \sqrt{2}$
$t = \sqrt{\frac{2d}{g}}$

$V_f = at$
- V & t show direct
- acceleration is slope $a = \frac{\Delta V}{t}$
- distance is area $d = (\frac{1}{2}V)(t)$

$a \neq 0$
acceleration is a constant non-zero

Unit Two (continued): Projectiles in 1 and 2 dimensions

For projectiles launched upward remember the following rules

- launch velocity equal and opposite landing velocity
- acceleration is $9.81 m/s^2$ downward for the entire time of flight
- The high point occurs at ½ the total time of flight
- Speed at the high point is zero
- distance up equal distance down, overall displacement is zero

Flight can be divided into parts

½ Flight (up)
$a = -9.81 m/s^2$
$V_f = 0$ at top
V_i = launch V

½ Flight (down)
$a = +9.81 m/s^2$
$V_i = 0$ top
V_f = landing V

whole flight
$a = -9.81$
V_i = launch V
V_f = landing V

ΔV	V_i	V_f	$\bar{V}$	d	a	t
				-		

For Horizontal Projectiles

Vertical motion follows free fall $g = 9.81 m/s^2$

horizontal motion is in equilibrium. The horizontal velocity of a projectile does not change as the object falls

d_x	V_x	t

V_{iy}	V_{fy}	$\bar{V}_y$	d_y	a_y	t

$\boxed{\text{time in x equals time in y}}$

For Projectiles launched at an angle

gravity only acts on the vertical axis
mix of object launched upward with Forward constant velocity

- Break initial velocity into V_{ix} & V_{iy} using $V_{ix} = V_i \cos\theta$ $V_{iy} = V_i \sin\theta$

d_x	V_{ix}	t

ΔV_y	V_{iy}	V_{fy}	$\bar{V}_y$	d_y	a_y	t

The maximum range for a projectile launched at an angle is 45°
Objects will land in the same location if launched at angles equal difference from 45° ie 30° & 60°; 40° & 50°

Equations

For ½ time of flight $t = \sqrt{\frac{2d_y}{g}}$ $t = \frac{\Delta V}{a}$

For object launched upward (vertical axis)
total flight $t = \frac{2V_{iy}}{g}$

$\Delta V = V_f - V_i$ $(V_f = -V_i)$
$\Delta V = -V_i - V_i$
$\Delta V = -2V_{iy}$
$g = -9.81 m/s^2$

$V_{fy} = V_{iy} + a_y t$
$(V_{fy})^2 = (V_{iy})^2 + 2a_y d_y$
$d_y = (V_{iy})t + \frac{1}{2}a_y t^2$

Horizontal Motion

$d_x = V_x t$

$\frac{V}{d_x \mid t}$

t is the same in x & y

$V_x = V_i \cos\theta$ $V_{iy} = V_i \sin\theta$

$\theta = \tan^{-1}\left(\frac{V_{iy}}{V_{ix}}\right)$

45° launch greatest range

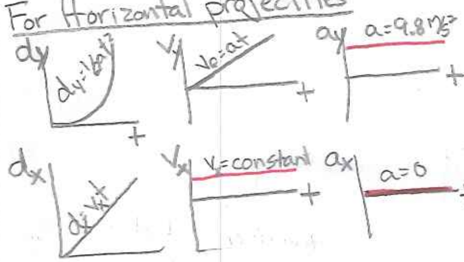
Highest angle is greatest time of flight

Graphs

For projectiles launched upward

down is negative

For Horizontal projectiles



down is positive
a_y = constant positive

a is zero