Unit Two: Accelerated Motion; Acceleration due to gravity

Skills 12-14

Acceleration occurs when an object speeds up, slows down, or changes direction (a_c)

Acceleration always agrees with net force
- if $a = 0$, $F_{net} = 0$
- if F_{net} is positive (based on direction) a is positive
- if acceleration is negative, F_{net} is negative

> object moving to right slowing down, "a" is left, F_{net} is left

Acceleration, velocity & displacement are vector quantities
IF initial velocity and acceleration don't agree in direction make sure you substitute into equation with opposite signs

Head Problems
Use simple equations but in several steps. For long answer questions be sure to show all steps

Free Fall Projectiles: The only force acting on a projectile is F_g (weight) for the entire fall. $F_{net} = F_g = weight$ $a = g = 9.8 m/s^2$ or $9.8 N/kg$

Falling from rest: displacement, final velocity, acceleration are all in same direction (down)
OK to consider down +

Approximate Values for $g = 10 m/s^2$ for falling from rest

V_i	V_f	$\bar{V}$	d	a	t
0	10 m/s	5 m/s	5m		1s
	20 m/s	10 m/s	20m	10 m/s²	2s
	30 m/s	15 m/s	45m		3s
	40 m/s	20 m/s	80m		4s
	50 m/s	25 m/s	125m		5s
	60 m/s	30 m/s	180m		6s
	70 m/s	35 m/s	245m		7s

remember $d = \frac{1}{2}at^2$ so for every change in "t" that squared happens to "d"
$t \div 10$ means $d \div 100$
$t = .1s$ $d = 5cm$
$t = .2s$ $d = 20cm$

Equations, Variables, Units

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

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

a = acceleration (m/s^2)
d = distance or displacement (m)
t = time (s)
g = acceleration due to gravity (m/s^2) = $9.8 m/s^2$ on Earth
= gravitational field strength (N/kg) directly related to mass of planet

For head problems: triangles $\frac{d}{\bar{V} \mid t}$ & $\frac{\Delta V}{a \mid t}$ usually require "t"

ΔV	Vi	Vf	$\bar{V}$	d	a	t

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

when $V_i = 0$ (rest)
$V_f = at$ $V_f = \sqrt{2ad}$ $d = \frac{1}{2}at^2$ $t = \sqrt{\frac{2d}{a}}$

Graphs   free fall from rest, down (+)

$d = \frac{1}{2}at^2$
d & t direct square
$t = \sqrt{\frac{2d}{a}}$
if $t \times 2$ $d \times 2^2$
if $d \times 2$ $t \times \sqrt{2}$
$d \times 4$ $t \times \sqrt{4}$

$V_f = at$
V direct to t
acceleration = slope
distance or displacement = area

$a \neq 0$
acceleration is constant non-zero
F_{net} present

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

Skills 15-18

Projectiles launched upward

- launch velocity equal & opposite landing velocity
- acceleration equals 9.81 m/s² downward the entire time of flight
- Speed at the high pt = 0, occurs at ½ total time
- distance up equals distance down, overall displacement = 0

You can choose the time frame to solve

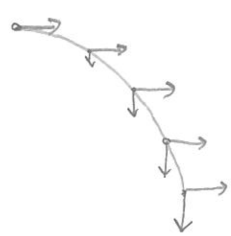
Whole flight	½ flight UP	½ flight DOWN
$a = g = -9.81 m/s^2$	$a = -9.81 m/s^2$	$a = 9.81 m/s^2$
V_i = launch v	$V_f = 0$	$V_i = 0$
V_f = landing v	V_i = launch v	V_f = landing v
$t = \frac{-2v_{iy}}{g}$		

treat as object falling from rest

up is mirror of down

Horizontal Projectiles

- Horizontal axis in equilibrium $a_x = 0$ use $\bar{V}_x = \frac{d_x}{t}$ Horizontal velocity constant
- Vertical Axis experience net force equal to F_g; $g = 9.81 m/s^2$



$V_{iy} = 0$
$a_y = 9.81 m/s^2$
$V_{fy} = at$
$d_y = \frac{1}{2}at^2$
$V_{fy} = \sqrt{2ad_y}$

time is scalar: same value in "x" & "y"
axes are independent
time is dependent on height
$t = \sqrt{\frac{2d_y}{a}}$

Projectiles at an angle

Vertical experiences net force = F_g
Horizontal at equilibrium

45° greatest d_x (or closest to 45°)
equal difference from 45° land in same place
30° & 60° same range
40° & 50° same range

Equations, Etc

- For total flight — Object launched upward landing on level ground: $t = \frac{-2v_{iy}}{g}$, $d_y = 0$

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

$V_{fy} = V_{iy} + a_y t$ — V_{iy} +, V_{fy} −, a_y −

For fall only: $t = \sqrt{\frac{2d}{a}}$

- For max height: $d_y = \frac{1}{2}a_y t^2$ (t = ½ flight time)

horizontal $d_x = v_x t$ where t is total time

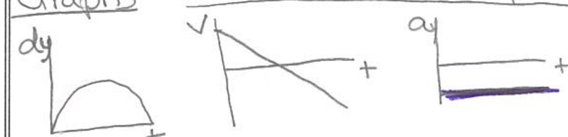
Projectiles at angle

$t = \frac{-2v_{iy}}{a}$

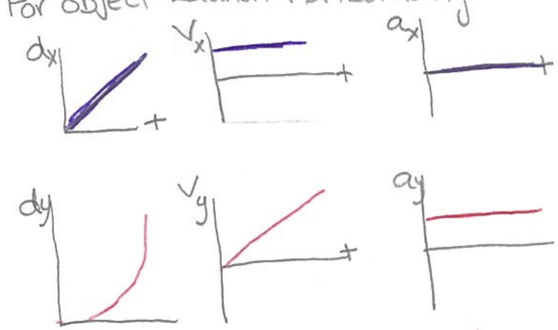
$V_{ix} = V_i \cos\theta$ (remains constant)
$V_{iy} = V_i \sin\theta$
$\theta = \tan^{-1}\left(\frac{V_{iy}}{V_{ix}}\right)$
$V_{fy} = -V_{iy}$ V at top = 0

45° launch = greatest range d_x
Highest angle greatest time of flight

Graphs OBJECT Launched Upward



For object Launch horizontally



assuming down is (+)