Projectile Motion

A projectile is an object upon which the only force acting is... gravity

Assuming air resistance is negligible, this includes:
- an object dropped from rest or thrown downwards
- an object thrown upwards or at an angle above the horizon
- an object thrown horizontally

While the only force acting on a projectile is gravity, many objects also experience horizontal motion.

BUT…remember that x and y components are perpendicular and therefore totally independent!

X – Components

There is no net force working on the projectile in the x and the acceleration is always 0. As such, the only equation we use is:

$v = \frac{\Delta d}{\Delta t}$ now $V_x = \frac{d_x}{t}$

Y – Components

There is a constant acceleration of -9.8m/s². Because of this we use the Big 3 equations.

$V_{fy} = V_{iy} + at$

$V_{fy}^2 = V_{iy}^2 + 2ad_y$

$d_y = V_{iy}t + \frac{1}{2}at^2$

The only value that can ever be used on both sides is time. → b/c its scalar

Example: A teacher sits on the roof on her school which is 12 m high. She uses a sling-shot to launch water balloons at a speed of 14.0 m/s at the poor unsuspecting students below. Assume air resistance is negligible. If she fires a water balloon directly horizontally:

Given:

a. How long will it be airborne for?
This depends on: d_y

$t = 1.6s$

b. How far forward will it travel?
This depends on: V_x, t

$d_x = 22m$

x	y
$V_x = 14$m/s	$V_y = 0$m/s
$t = 1.565s$	$a_y = -9.8$m/s²
	$d_y = -12$m

(b) $d_x = V_x \cdot t$

$= \frac{14m}{s} \cdot 1.565s$

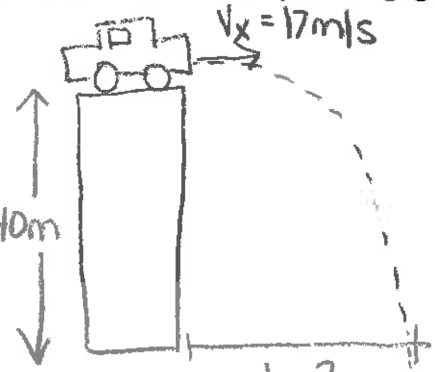
$= 22m$

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

$t = \sqrt{\frac{2d_y}{a}} = \sqrt{\frac{2(-12)}{-9.8}} = 1.565$ s

Example: A driver (accidently) backs out straight out of a 40.0 m tall parking garage at 17.0 m/s.

Given:



a. Assuming air resistance is negligible, how long will it take the car to reach the ground?

$t = 2.9 s$

b. How far from the base of the garage will the car hit the ground?

$d_x = 49 m$

c. What is the speed of the car just before it strikes the ground?

need: V_{fy} (c) $V_{fy} = V_{iy} + at$

$= 0 + -9.8 m/s^2 (2.86 s)$

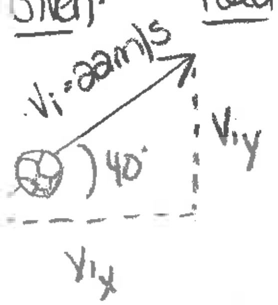
not done yet ← $V_{fy} = -28 m/s$

x	y
$V_x = 17 m/s$	$d_y = 40 m/s$
$t = 2.86 s$	$V_{iy} = 0 m/s$
(b) $d_x = V_x \cdot t$	$a_y = -9.8 m/s$
$= 17 m/s \cdot 2.86 s$	(a) $t = \sqrt{\frac{2d_y}{a}}$
$= 48.6 m$	$t = \sqrt{\frac{2(-40m)}{-9.8 m/s^2}}$
$d_x = 49 m$	$= 2.86 s$
	$t = 2.9 s$

Example: A soccer ball is kicked at an angle of 40° above the horizon. The initial speed of the ball is 22 m/s. What is the maximum height of the ball? Assume air resistance is negligible.

└ $V_{fy} = 0 m/s$

Given: need: d_y



x	y
	$a_y = -9.8 m/s$
	$V_{fy} = 0 m/s$
	$V_{iy} = 14.1 m/s$

① solve for components

$\sin\theta = \frac{O}{H}$

$O = H \cdot \sin\theta$

$= 22 m/s \sin 40$

$V_{iy} = 14.1 m/s$

② $V_{fy}^2 = V_{iy}^2 + 2ad_y$

$d_y = \frac{V_{fy}^2 - V_{iy}^2}{2a}$

$= \frac{0 - 14.1 m/s^2}{2(-9.8 m/s^2)}$

$= 10.1 m$

$d_y = 1.0 \times 10^1 m$

(c)

$$V = \sqrt{V_x^2 + V_y^2}$$

$$= \sqrt{17^2 + 28^2}$$

$$= -32.8$$

$$\boxed{V = -33\,m/s}$$