Parabolic/Projectile Motion:

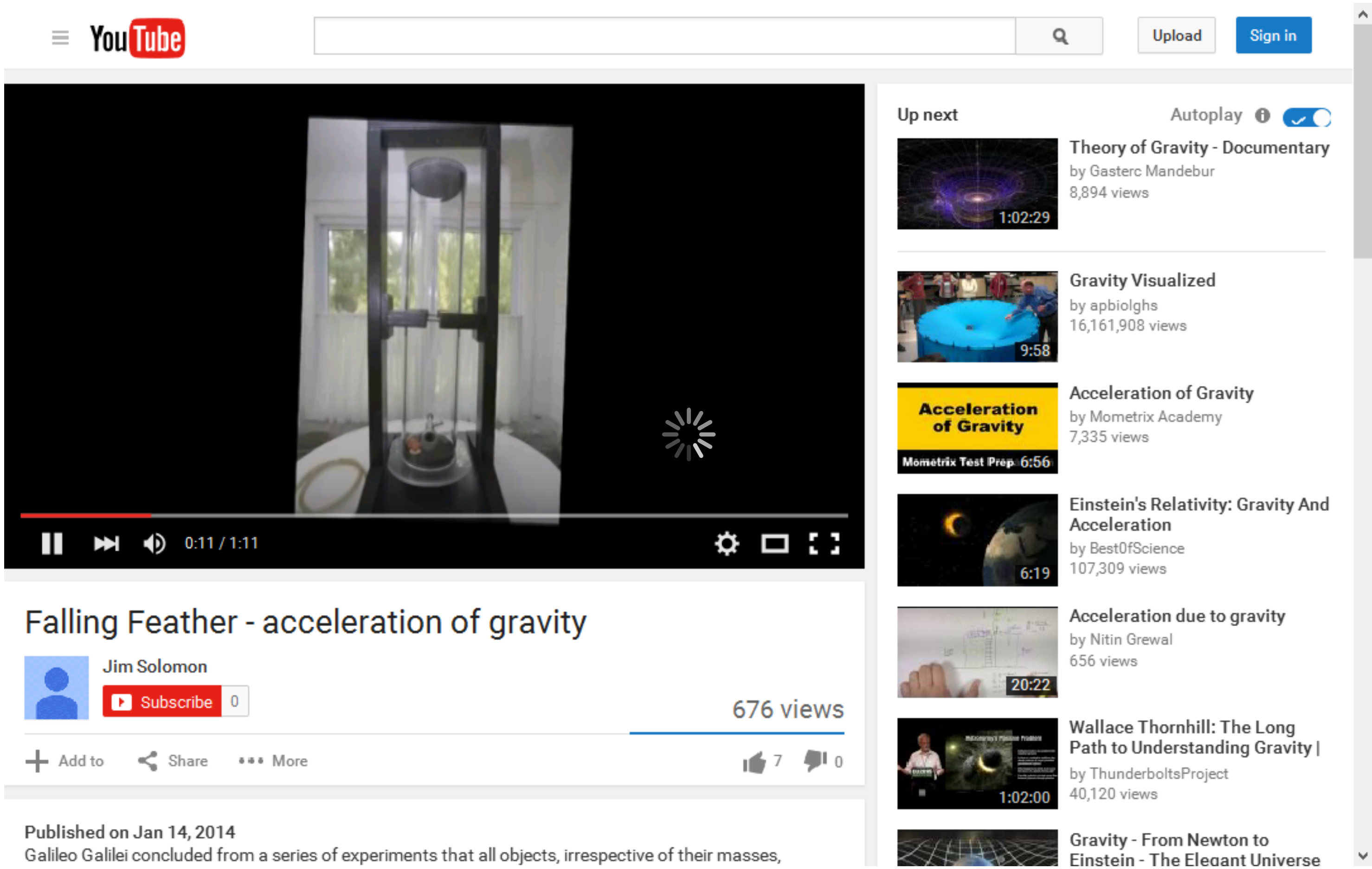
Two dimension motion of objects in free fall.

Downward acceleration is 9.8 m/s^2.

Horizontal acceleration is 0!

All vectors (displacement, velocity, acceleration) can be broken into x- and y-components (true for ANY two-dimensional motion).

Variables in the x- and y-dimensions can be considered completely independently (i.e., the Big 4 can be used for each)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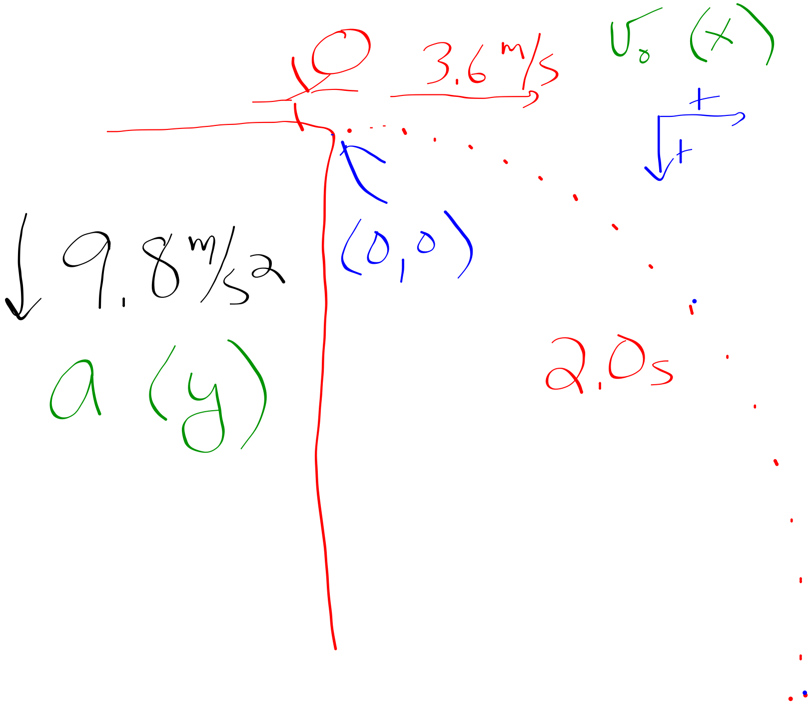
A diver running at 3.6 m/s dives out horizontally from the edge of a vertical cliff and reaches the water below 2.0 s later. How high was the cliff and how far from its base did the diver hit the water?



$x_0 = 0\,m$	$y_0 = 0\,m$
$x =$	$y =$
$v_{0x} = 3.6\,m/s$	$v_{0y} =$
$v_x =$	$v_y =$
$a_x = 0$	$a_y =$
$t = 2.0\,s$	$t =$

Look who knows so much.

Steps for solving 2-D Kinematics Problems:

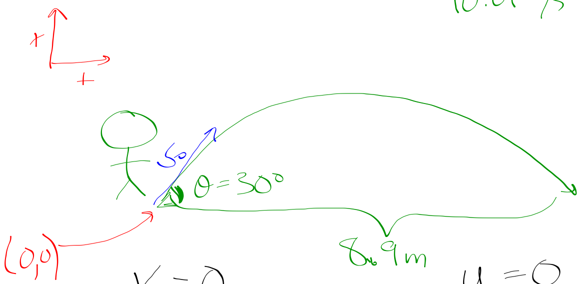
Same as for 1-D problems except:

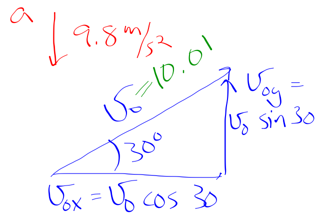
Before variable inventory, break all vectors into x- and y-components

Make TWO variable inventories - one for each dimension

If necessary, after using the Big 4, resolve component vectors into resultants

An athlete executing a long jump leaves the ground at a 30° angle and travels 8.90 m horizontally. What was the takeoff speed? 10.01 m/s





$x_0 = 0$
$x = 8.9\text{m}$
$v_{0x} = v_0 \cos 30$
$v_x = v_0 \cos 30$
$a_x = 0$
$\boxed{t} = \boxed{\dfrac{8.9}{v_0 \cos 30}}$

$x = \cancel{x_0}^{0} + v_{0x}t + \cancel{\tfrac{1}{2}a_x t^2}^{0}$

$x = v_{0x} t$

$t = \dfrac{8.9}{v_0 \cos 30}$

$\dfrac{8.9}{v_0 \cos 30} = \dfrac{v_0 \sin 30}{4.9}$

$v_0^2(.5)(.87) = (8.9)(4.9)$

$v_0 = \sqrt{\dfrac{(8.9)(4.9)}{(.5)(.87)}}$

$\boxed{v_0 = 10.01 \text{ m/s}}$

$y_0 = 0$
$y = 0$
$v_{0y} = v_0 \sin 30$
$v_y =$
$a_y = -9.8 \text{ m/s}^2$
$\boxed{t} = \boxed{\dfrac{v_0 \sin 30}{4.9}}$

$y = \cancel{y_0}^{0} + v_{0y}t + \tfrac{1}{2}a_y t^2$

$\boxed{0 = (v_0 \sin 30)t + (-4.9)t^2}$

$ax^2 + bx = 0$

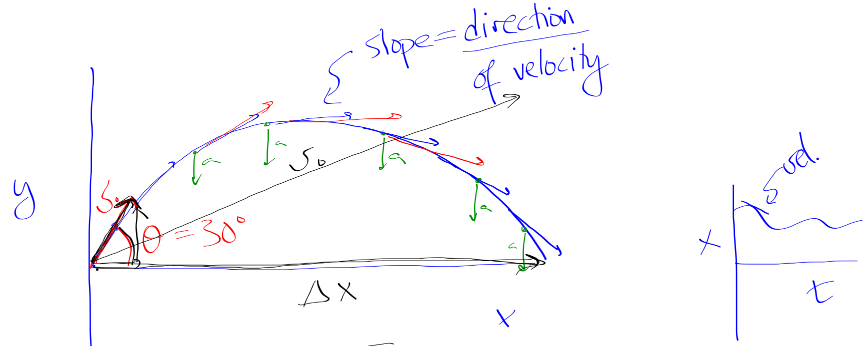
$t(v_0 \sin 30 + -4.9t) = 0$

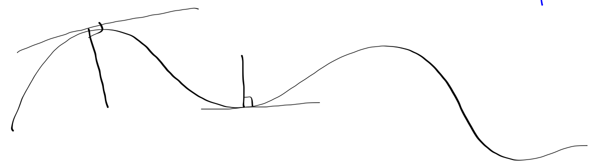
$\cancel{t = 0}$

$\boxed{v_0 \sin 30 + -4.9t = 0}$

$-4.9t = -v_0 \sin 30$

$t = \dfrac{v_0 \sin 30}{4.9}$


slope = direction of velocity
y
v_0
v_0
$\theta = 30°$
a
Δx
x
vel.
x
t



A ball is kicked from the ground at an angle of 62°. It lands, back on the ground, 5.1 seconds later. Find:

a) The ball's initial velocity $= 28.3\ m/s\ @\ 62°$

b) How far the ball traveled horizontally $= 67.8\ m$

c) The ball's final velocity $= 28.3\ m/s\ @ -62°$

d) The ball's maximum height $= 31.9\ m$

e) The ball's x- and y- coordinates after 4 seconds $(53.2, 21.6)$

f) The time(s) at which the ball is 14 m above the ground

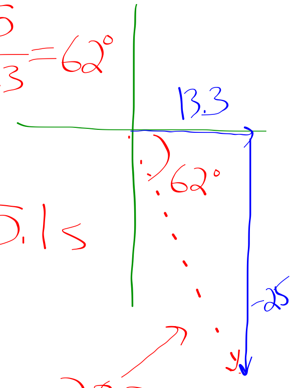
$0.64\ s,\ 4.46\ s$

$5.1\ s$

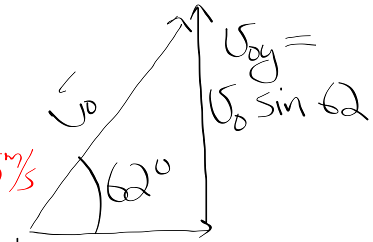
$\theta = 62°$

(v_0)

$\tan^{-1}\frac{25}{13.3} = 62°$



28.3



$v_{0y} = v_0 \sin 62$

$v_{0x} = v_0 \cos 62$

$$v_y = v_{0y} + a_y t = 25 + (-9.8)(5.1) = -25$$

$x_0 = 0$	$y_0 = 0$
$x = (v_0 \cos 62)(5.1)$ $\; 67.83\ m$	$y = 0$
$\boxed{v_{0x} = v_0 \cos 62}$ $\; 13.3\ m/s$	$\boxed{v_{0y} = v_0 \sin 62} = 25\ m/s$
$\boxed{v_x = v_0 \cos 62}$	$\boxed{v_y} = -25\ m/s$
$a_x = 0$ $\; 13.3\ m/s$	$a_y = -9.8\ m/s^2$
$t = 5.1$	$t = 5.1\ s$

$$x = \cancel{x_0} + v_{0x} t + \cancel{\tfrac{1}{2} a_x t^2}$$

$$x = (v_0 \cos 62)\,5.1$$

$$x = \cancel{x_0} + v_{0x} t + \cancel{\tfrac{1}{2} a_x t^2}$$

$$x = (13.3)(5.1) = 67.83$$

$$y = \cancel{y_0} + v_{0y} t + \tfrac{1}{2} a_y t^2$$

$$0 = (v_0 \sin 62)(5.1) + \tfrac{1}{2}(-9.8)(5.1)^2$$

$$v_0 = \frac{4.9\,(5.1)^{\cancel{2}}}{\cancel{5.1}\,(\sin 62)} = 28.3\ m/s$$

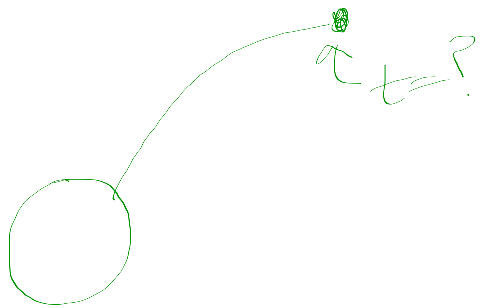
$v_0 = 28.3\ m/s$

$v_{0x} = 28.3 \cos 62$

$= 13.3\ m/s$

$v_{0y} = 28.3 \sin 62$

$= 25\ m/s$



$y_0 = 0$

$y =$

$v_{0y} = 25\ m/s$

$v_y = 0$

$a_y = -9.8\ m/s^2$

$t =$

$$\cancel{v_y^2}^{\,0} = v_{0y}^2 + 2a_y(y - \cancel{y_0}^{\,0})$$

$$y = \frac{-v_{0y}^2}{2a_y} = \frac{-625}{-19.6}$$

$y = 31.9\,m$

$$x = \cancel{x_0}^{0} + v_{0x}t + \cancel{\tfrac{1}{2}a_x t^2}^{0}$$

$$x = (13.3)(4) = 53.2m$$

$$y = \cancel{y_0}^{0} + v_{0y}t + \tfrac{1}{2}a_y t^2$$

$$y = (25)(4) + -4.9(4)^2$$

$$= 21.6m$$

$$y = \cancel{y_0}^{0} + v_{0y}t + \tfrac{1}{2}a_y t^2$$

$$14 = 25t + -4.9t^2$$

$$-4.9t^2 + 25t - 14 = 0$$

$$t = 0.64s \quad t = 4.46s$$