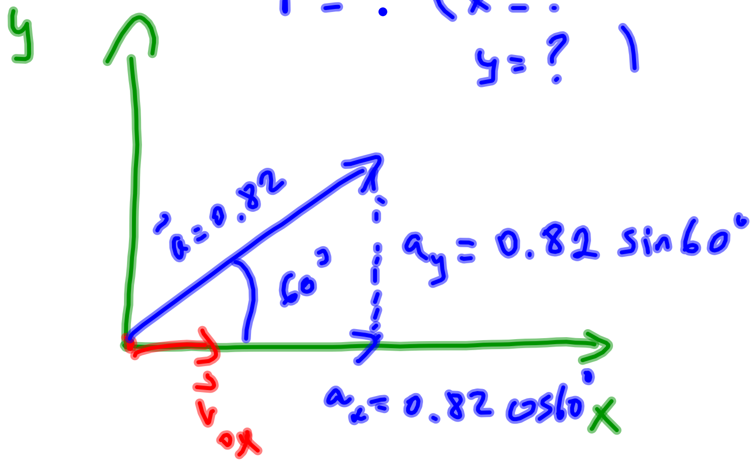
You are surfing at 7.3 m/s when a wind gust hits accelerating your sailboat at 0.82 m/s^2 at 60° angle to your original direction. If the gust lasts 8.7 s what is the board's net displacement during this time?

- chose a coordinate system so that

$x_0, y_0 = 0$

$\vec{r} = ?$ $\left(x = ?, \; y = ? \right)$



$v_{ox} = 7.3 \ m/s$

$v_{oy} = 0 \ m/s$

$x_o = y_o = 0$

$|\vec{a}| = 0.82 \ m/s^2$

$a_x = 0.41 \ m/s^2$

$a_y = 0.71 \ m/s^2$

$\vec{r} = ?$

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

$$|\vec{r}| = ?$$

$$|\vec{r}| = \sqrt{x^2 + y^2} = 84\,m$$

in x direction

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

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

$$x = 7.3\,\frac{m}{s} \cdot 8.7\,s + \frac{1}{2} \cdot 0.41\,\frac{m}{s^2} \cdot 8.7^2\,s^2$$

$$= 79\,m$$

$$y = \frac{1}{2} \cdot 0.71 \cdot 8.7^2 s^2 = 26.9\,m$$

0.71 m/s^2

$$\vec{r} = 79\,m \cdot \hat{i} + 26.9\,m \cdot \hat{j}$$

Projectile motion

- when an object is launched into the air & moves predominantly under the influence of gravity
- 2 simplifications
  - we neglect $\vec{g}$ variations
  - air resistance

$$\vec{v} = \vec{v}_0 + \vec{a}\,t$$

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

a constant motion equs

Projectile motion

$$a_x = 0$$

$$v_x = v_{x0}$$

$$x = x_0 + v_{y_0} t$$

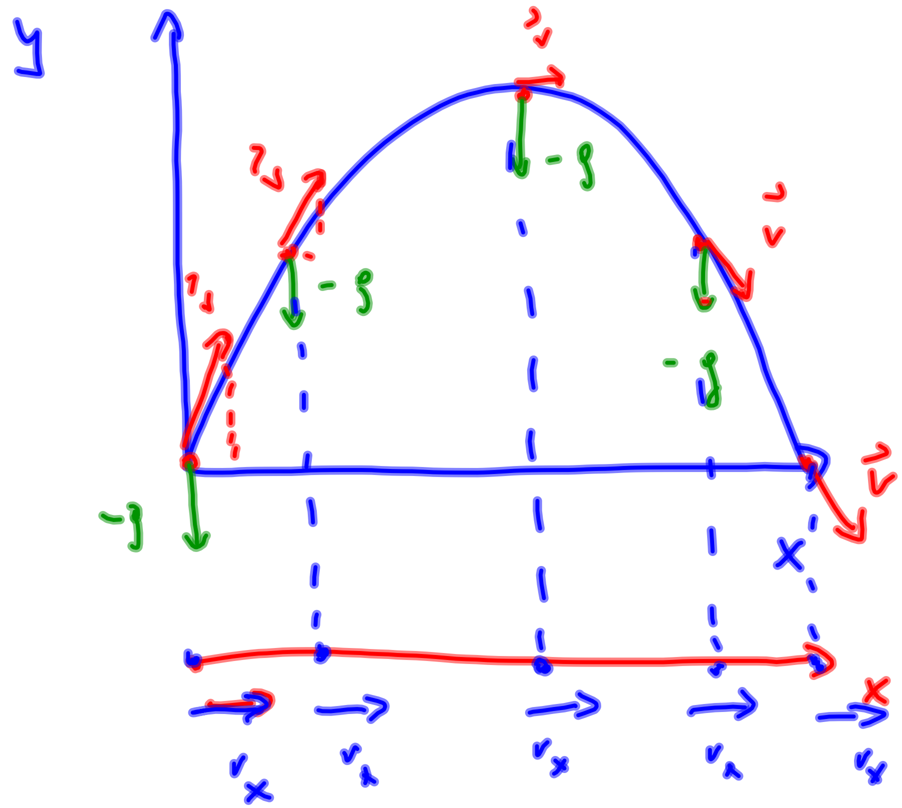
in x direction

$$a_y = -g$$

$$v_y = v_{y0} - gt$$

$$y = y_0 + v_{y_0} t - \frac{1}{2}gt^2$$

in y direction



a is cte −g

horizontal motion has constant velocity

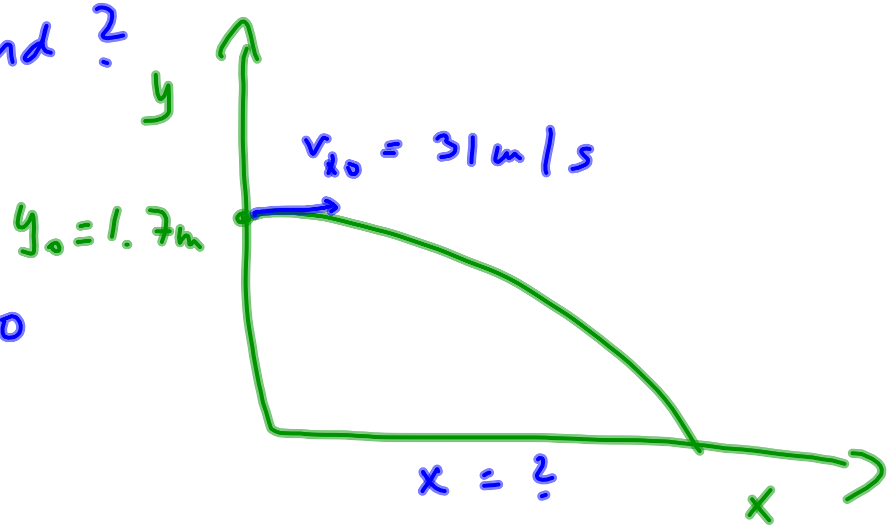
vertical motion has constant acceleration

A raging flood has washed a section of highway creating a gash 1.7 m deep. A car moving at 31 m/s goes straight over the edge. How far from the edge of the washout does it land?

$y_0 = 1.7\,m$

$v_{x0} = 31\,m/s$

$x = ?$ when $y = 0$



$y = y_0 + \cancel{v_{y0} t} - \frac{1}{2} g t^2$

we a looking for a common variable for x & y direction => time (scaler -> awesome)

$t = ?$ when $y = 0$

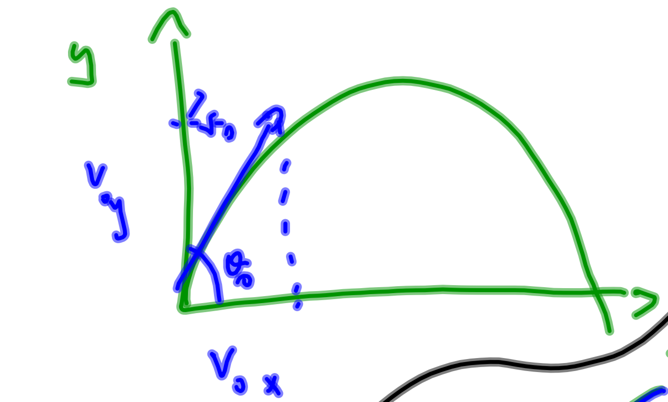
$0 = 1.7 m - \frac{1}{2} \cdot 9.81 m/s^2 \cdot t^2$

$t = 0.589 s$

$x = v_{x0} \cdot t = 31 m/s \cdot 0.589 s = 18 m$

When looking for a path or trajectory it means that we are looking for $y(x)$

Consider



$$\sin\theta_0 = \frac{v_{0y}}{v_0} \Rightarrow v_{0y} = v_0 \sin\theta_0$$

$$\cos\theta_0 = \frac{v_{0x}}{v_0} \qquad v_{0x} = v_0 \cos\theta_0$$

$$x = x_0 + v_{x0} t = t \cdot v_0 \cos\theta_0 \rightarrow \text{express } t$$

$$y = y_0 + v_{y0} t - \frac{1}{2} g t^2$$

$$t = \frac{x}{v_0 \cos\theta_0}$$

$$y = t \cdot v_0 \sin\theta_0 - \frac{1}{2} g t^2$$

$$y = \frac{x}{v_0 \cos\theta_0} \cdot v_0 \sin\theta_0 - \frac{1}{2} g \cdot \frac{x^2}{v_0^2 \cos^2\theta_0}$$

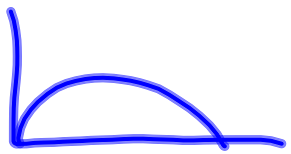
$$y = x \tan\theta_0 - \frac{1}{2} g \frac{x^2}{v_0^2 \cos^2\theta_0}$$

projectile trajectory

The range of a projectile (x)

at y = 0

- how far can I kick the ball?
- horizontal range?



x = ? when y = 0

$$y = x\tan\theta_0 - \frac{1}{2} g \frac{x^2}{v_0^2 \cos^2\theta_0}$$

x = ? when y = 0

1st solution

$x_1 = 0$

2nd solution

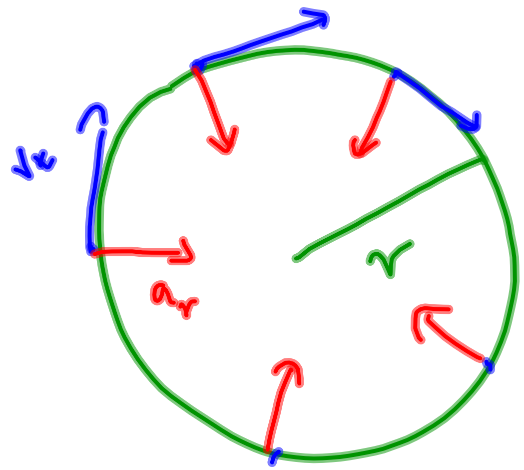
$$\tan\theta_0 - \frac{1}{2} g \frac{x}{v_0^2 \cos^2\theta_0} = 0$$

$$x_2 = \frac{2\tan\theta_0 \cdot v_0^2 \cdot \cos^2\theta_0}{g}, \quad \tan\theta_0 = \frac{\sin\theta_0}{\cos\theta_0}$$

horizontal range

$$x_2 = \frac{2\sin\theta_0\cos\theta_0 \cdot v_0^2}{g} = \frac{v_0^2}{g}\sin 2\theta_0$$

Uniform circuler motion



$v_{tangental}$

a_r radiel

$$v_t = \frac{2\pi r}{T}$$ — path circumference

$$a_r = \frac{v^2}{r}$$

nonuniform circuler motion

$$a_{tangental} = \frac{dv}{dt}$$