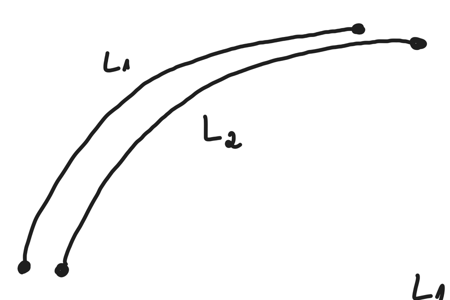
In 1 km races, runner 1 on track 1 (with time 2 min, 27.95 s) appears to be faster than runner 2 on track 2 (2 min, 28.15 s). However, length L_2 of track 2 might be slightly greater than length L_1 of track 1. How large can L_2 - L_1 be for us still to conclude that runner 1 is faster?

$v = \frac{s}{t}$



Runner 1 >>> Runner 2 >>

$t_1 = 147.95 s$ $t_2 = 148.15 s$

$L_1 = 1 \cdot 10^3 m$ $L_2 = ??$

$\frac{L_1}{t_1} > \frac{L_2}{t_2}$ $t_2 > 0$

$L_2 - L_1 = 1,35 m$

$\frac{L_1 \cdot t_2}{t_1} > L_2$

$\frac{1000 \cdot 148.15}{147.85} = L_2$

$L_2 \approx 1001,35 m$

A car travels from Zabrze to Katowice at a speed *u*=40 km/h and immediately returns at a speed *v*=30 km/h. What was the average velocity speed of the car during the whole route?

avarge velocity:

$\bar{v}_{avg} = \frac{\Delta x}{\Delta t}$

$\bar{v}_{avg} = 0$

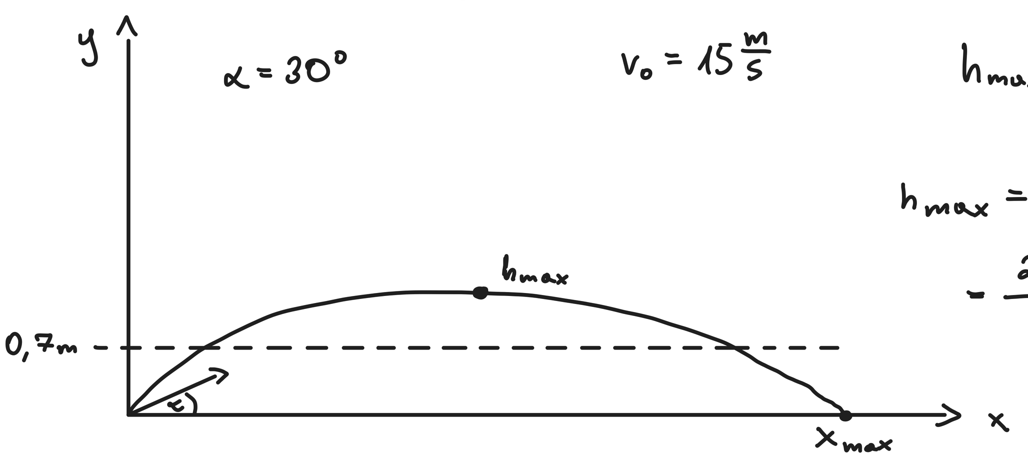
avarge speed:

$v_{avg} = \frac{x_t}{t_t}$

$v = \frac{s}{t}$, $vt = s$, $t = \frac{s}{v}$

$v_{avg} = \frac{2x}{\frac{x}{30} + \frac{x}{40}} = \frac{2x}{\frac{70}{1200}} = 2x \cdot \frac{120}{7} \approx 34,3$

A jet of water leaves a water canon at an angle α=30° to the horizontal with a speed of 15 $\frac{m}{s}$. After what time will it reach the height H=0.7 m from the level it leaves the canon? What velocity does it have at this point? Which maximum height will it reach and after what time? How far from the canon does the water hit the ground and after what time?



$\alpha = 30°$ $v_0 = 15 \frac{m}{s}$

$h_{max} = \frac{v_0^2 \sin^2\alpha}{2g}$

$h_{max} = \frac{15^2 \cdot \sin^2 30°}{20} = \frac{225 \cdot \frac{1}{4}}{20} = 2.8125$

$x_{max} = \frac{v_0^2 \sin 2\alpha}{g}$

$x_{max} = \frac{225 \cdot \frac{\sqrt{3}}{2}}{10} = 19,486 m$

h_{max} { $\bar{v}(t) = [v_0 \cos\alpha ; v_0 \sin\alpha - gt]$, $v_0 \sin\alpha - gt = 0$, $t = \frac{v_0 \sin\alpha}{g}$ }

$t = \frac{15 \cdot \frac{1}{2}}{10} = \frac{7.5}{10} = 0,75 s$

$0,7 = 15 \cdot \frac{1}{2} \cdot t - 5t^2$

$\bar{r}(t) = [v_0 \cos\alpha t ; v_0 \sin\alpha t - \frac{gt^2}{2}]$

$v_0 \sin\alpha t - \frac{gt^2}{2} = 0$

$15 \cdot \frac{1}{2} t - 5t^2 = 0$

$7,5t - 5t^2 = 0$

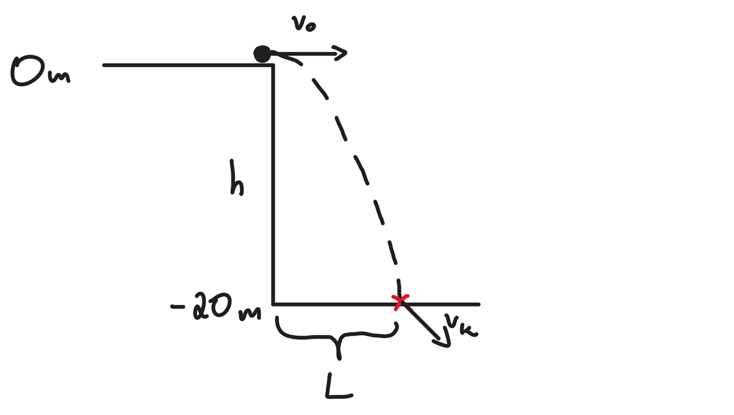
$t(-5t + 7,5) = 0$

$t = 0$ $-5t + 7,5 = 0$

$t = \frac{7,5}{5} = 1,5$

A body was launched horizontally from the top of a tower and it reached the bottom after time t = 2s at a distance of L = 10m from the base of the tower. Calculate the initial speed of the body, and speed with which is hit the ground. What was the height of the tower?

$\frac{s}{t}$



$v_0 = ?$, $L = 10 m$, $t = 2s$, $h = ?$

$v_0 = \frac{10}{2} = 5 \frac{m}{s}$

$\bar{v}(t) = [v_0 \cos\alpha t ; v_0 \sin\alpha t - \frac{gt^2}{2}]$

$h = -\frac{gt^2}{2}$

$h = -\frac{10 \cdot 4}{2} = -20$

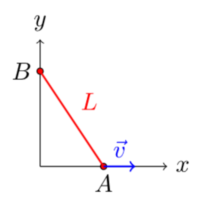
$10 = v_0 \cos 0° t$

$10 = v_0 \cdot 2$

$\frac{10}{2} = v_0 = 5 \frac{m}{s}$

$\bar{v}(t) = [v_0 \cos\alpha t ; v_0 \sin\alpha t - \frac{gt^2}{2}]$

A rod of length L rests its ends against the floor and a wall. The end A moves with a constant speed v from the position shown in the figure. (a) Find the relationship of the y coordinate of end B over time, (b) calculate the speed of point B.



$x = vt$

$y^2 + x^2 = L^2$

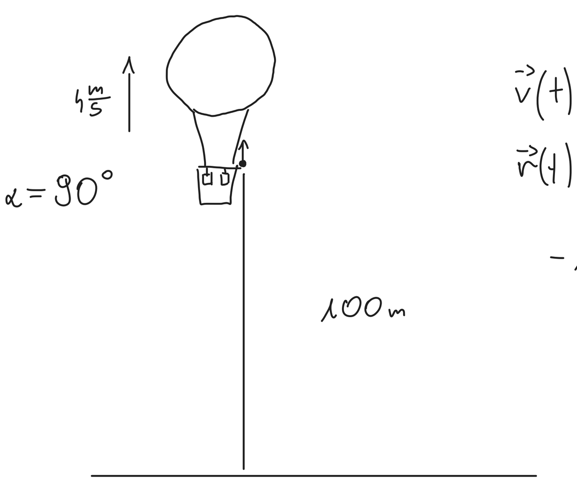
$y = \sqrt{L^2 - x^2}$

$y = \sqrt{L^2 - (vt)^2}$

$v_B = \frac{dy}{dt} =$

$\frac{dy}{dt} \sqrt{L^2 - (vt)^2} =$

$= \frac{1}{2\sqrt{L^2 - (vt)^2}} \cdot 2tv^2 = \frac{tv^2}{\sqrt{L^2 - (vt)^2}}$



$\vec{v}(t) = [v_0 \cos\alpha ; v_0 \sin\alpha - gt]$

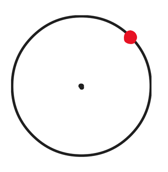
$\vec{r}(t) = [v_0 \cos\alpha t ; v_0 \sin\alpha - \frac{gt^2}{2}]$

$-100 = 4 - \frac{10t^2}{2}$

$-104 = -5t^2$

$20.8 = t^2$

$t = 4,561$



angular velocity $\omega = 3 \frac{rad}{s}$

???

Problem 4

A point mass moves in a circle with radius R at a constant linear velocity v. Calculate and illustrate the components of displacement vectors, average velocity, and average acceleration, as well as their lengths in the subsequent phases of motion shown in the figure:

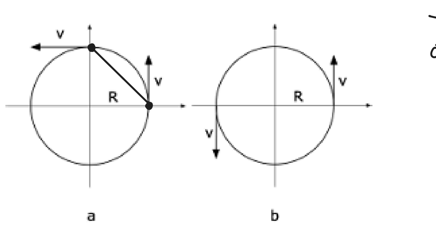
$\vec{displace} = [-R ; R]$

$\vec{len} = R\sqrt{2}$

$A_{avg} = \frac{\Delta v}{\Delta t}$

$\vec{v}_{avg} = \frac{\Delta x}{\Delta t} = \frac{R\sqrt{2}}{\Delta t}$

???



$\vec{displace} = [2R, 0]$

$\vec{len} = 2R$

$A_{avg} = \frac{2v}{\Delta t}$

$\vec{v}_{avg} = \frac{2R}{\Delta t}$

a) $v = \frac{s}{t}$, $s = vt$, $t = \frac{s}{v}$

$t = \frac{1200}{300} = 4h$

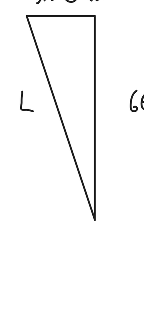
b) A • $v_w = 60 \frac{km}{h}$ • B

1) $v_{rel} = 240 \frac{km}{h}$ 2) $v_{rel} = 360 \frac{km}{h}$

$t_1 = \frac{600}{240} = 2,5h$ $t_2 = \frac{600}{360} = 1,(6)$

$t_t = 4,1(6) h$

c)



$\frac{600}{300} = 2h$

$L = \sqrt{120^2 + 600^2} = 611,9$

$t_t = \frac{1223,8}{300} \approx 4,1h$