Elina Murtazina, homework 3

1 Task

1.1 Tools

Overleaf, google collab

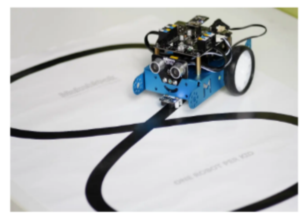
1.2 Task description

Task description

We have a mobile vehicle, which should survive after the track. We have some predefined trajectory, which is given in $y(x)$ format.

The **goal** is to pass this trajectory as fast as possible. But at the end of the path, there is a drop-off. It means that the vehicle should stop in the end.

We have to establish some constraints, such as max tangent acceleration (max power on the motor), normal acceleration (road adhesion).



How the vehicle should move (speed and acceleration) for solving such a task?

Report:

1. Vehicle simulation on the path. You should show a $\vec{v}$, $\vec{a}$, $\vec{a}_\tau$, $\vec{a}_n$ on the simulation.
2. plots: $y(t)$, $v(t)$, $a_t(t)$, $a_n(t)$, — t is time in seconds.

Parameters:

$y(x) = Ax\ln(\frac{x}{B})$, where $A = 3$, $B = 5$, $x \in [0..4]$

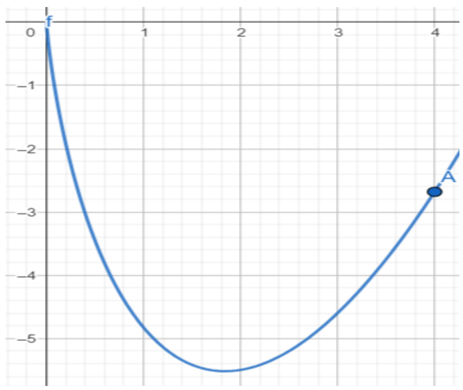
$a_{t_{max}} = 2$, $a_{n_{max}} = 3$, $v_{max} = 3$

1.3 Link

Click here!

1.4 Task explanation

Our task is minimize the time consumed to pass the trajectory y(x). The trajectory is (from (0,0) to point A):

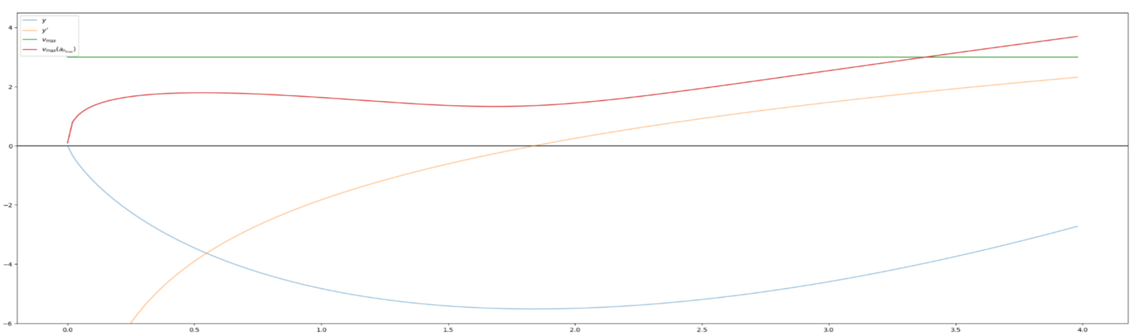


From given values only 2 affecting required time: v_{max} and $a_{\tau max}$. $a_\tau = v^2/\rho$, ρ is the radius of the curve. In that case we've got: $v^2/\rho \leq 2$ and $v \leq 3$.

The formula of the radius of the curve is: $\rho = \frac{(1+y(x)'^2)^{\frac{2}{3}}}{y(x)''}$. Since $v^2/\rho \leq 2$ we can convert it in the more specific form, like: $v^2 \leq 2\rho$ and then make it $v \leq \sqrt{2|\frac{(1+y(x)'^2)^{\frac{2}{3}}}{y(x)''}|}$

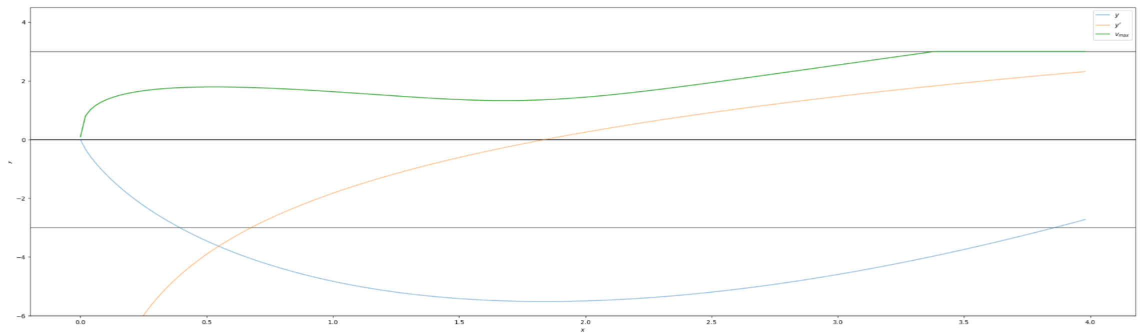
In code we find derivative and derivative of the second order, to then substitute and store value in the list named R. Plot the functions. When y(x)' = 0 that means that such x is the extremum of y.

Plot #1



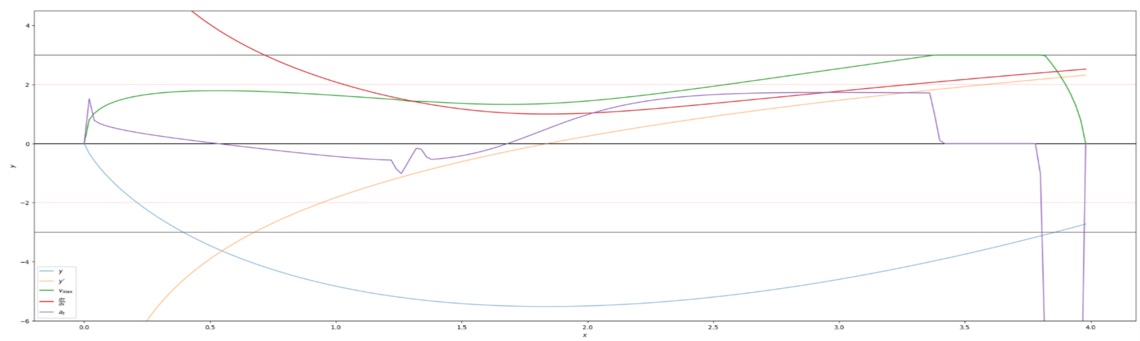
After plotting Starting information we can notice that calculated v goes over it's limits, where red line is higher than green line. Let's fix it:

Plot #2



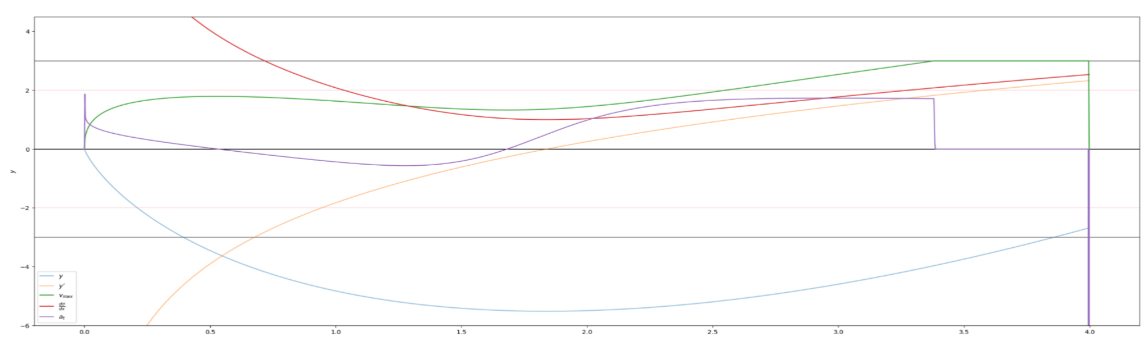
Now we have to apply limit on the a_τ. We remember from our lessons that $a_\tau = \ddot{\sigma} = \frac{dv}{dx}\frac{dx}{d\sigma}v$. $\frac{d\sigma}{dx} = \sqrt{1+(\frac{dy}{dx})^2}$. $a_\tau = \frac{dv}{dx}\frac{1}{\sqrt{1+(\frac{dy}{dx})^2}}v$ => $dv = \frac{a_\tau\sqrt{1+(\frac{dy}{dx})^2}}{v}dx$

Plot #3



Looking at the plot 3 we see that a_τ only crosses it's limits (pink lines) somewhere at the end (and it drops significantly, to be fair for a "long time". But I experimented with Δx, making it much smaller, and got new plot, which shows drop on the very small section. Here is this new plot:)

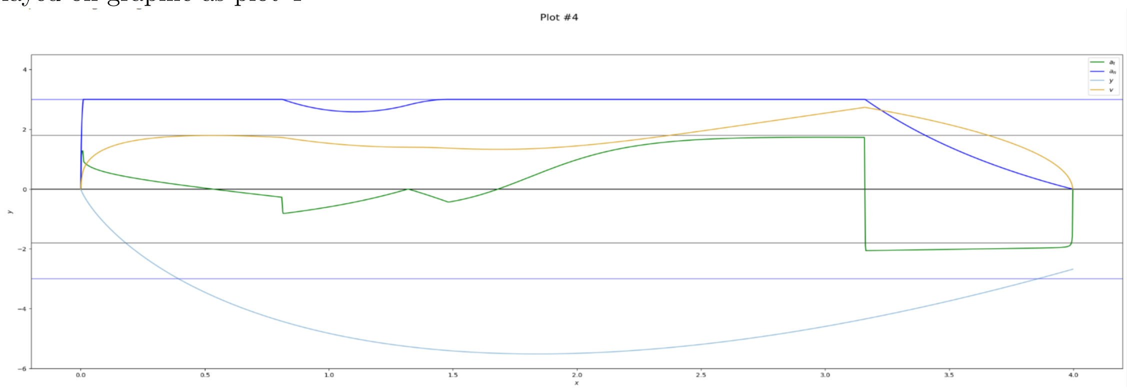
Plot #3



To fix this, we need to make the velocity curve smoother. Since we can't make v higher, we go for another solution - discrete analysis.

$dv = \frac{a_\tau \sqrt{1+(\frac{dy}{dx})^2}}{v} dx$. This equation can be transformed into $\frac{dv}{dx} = \frac{a_\tau \sqrt{1+(\frac{dy}{dx})^2}}{v}$.

Now we can find v at certain point as $v_i = v_{i-1} + \frac{a_\tau \sqrt{1+(\frac{dy}{dx})^2}}{v_i} dx$ which can be displayed on graphic as plot 4



For the meme of the week (Idk how appropriate memes should be, destroy me if it's too much pls):