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'Cause the same-old stuff just ain't good enough

Instructions for using the Spread Sheet PIDv4A.

This spreadsheet is designed for playful learning. It is a painless way to look at the concepts I taught in the blog and try things.   Have fun.

First a note about the colors on the spreadsheet. When I describe the colors these are the colors displayed on my spreadsheet and this has been checked on a recent version of Excel as well as LibreOffice 3. However, I have got burned before between the newer version of Excel and the older version of it where colors did not match. So the colors may not match those displayed on your screen.   It is not all that important, but just makes things easier.

Second, this spreadsheet is calculation intensive and may not run on all computers. I had one case where I increased the derivative gain too high and threw the output into oscillations and the computer ground down and pretty much locked up.   It did not hurt the computer other than a hard reboot. My recommendation is to not run it while other programs are running.   I killed it when I had derivative gain set at 20, but I have run derivative gain as high as 10 successfully.   However, the goal of the whole thing for this very flexible and open spreadsheet is to try things and rebooting the computer is not the end of the world.   HAVE FUN.

The spreadsheet consists of two parts and these are chosen by the two tabs. CALCS is the actual spreadsheet doing the calculations and the GRAPHS is a series of graphs displaying the results.

CALCS sheet

Row 3 has several colored cells.   The purpose and name of each of these cells is displayed in the cell just to the left of the colored cell.

<u>The Green Cells</u> are the parameters to change the automobile.
<u>Car Mass:</u> This affects the weight of the car.   As I stated in the blog this is just a number that works and is not in any real unit.   The starting value for this is 10.

<u>Aero Coeff:</u> This affects the wind resistance and how well the car slips through the air. A value of 1 means the car will develop a wind resistance in our force units equal to the speed of the car. Less than one means it is more aerodynamic and can slide through the air better. Greater than one means we have tied a parachute to the back of the car or something similar.

Max Force: On this sheet this does two things. First it acts as a limit. The engine in the car maxes out at that value. Second it is also a multiplier to the force with 100 being the normal value. Effectively changing from 100 to 200 is the same has doubling the horsepower of our engine.

Interesting things you can do with this model is after you have tuned the controller to your satisfaction, change these values and see what effect it has on the way the car handles upsets. (Upsets are described later.)

The Yellow Cells are the three controller tuning values. Proportional Gain, Integral Gain and Derivative Gain for the PID controller.
Those are the values I have discussed in the blog. (The series of blogs starts at http://create-and-make.com/understanding-why-cars-reach-a-maximum-speed/ and pretty much runs consecutively.)

The two Cyan Cells are "upsets". These do not take effect until after 100 seconds when the car and controller have reached equilibrium, also called steady state values.

Hill force is the additional force the vehicle must overcome to climb a hill (from 110 to 130 seconds) and later (150 to 170 seconds) the negative value is the additional force moving the vehicle as the vehicle is going down hill.

Wind Gust: is the a head wind blowing toward the vehicle from 110 to 130 seconds and acting as a tail wind between 150 to 170 seconds.

The rest of the Calc Sheet is simply the calculations.

GRAPHS sheet

The Graphs sheet has 5 graph plots.

The top plot shows from -0.5 seconds to 80 seconds and shows the calculated value of each of the three controller functions, proportional, integral, and derivative, as well as the speed, force, and error.

The second plot is similar to the first plot except the output functions are removed. This was done so the automatic scaling of the Y axis would not expand so much that the error plot was unreadable.

The last three plots are from 100 to 200 seconds to look at how the tuning handles an upset from the hill or wind gust.

The first of these, the third plot, shows the changes in the force applied (gas pedal position- although if the limit is set above 100 this is just force) and the setpoint, speedlimit, and the error.

The next to last plot shows the upset forces applied and the error.

The final plot shows the change in the three outputs, P I and D, and the change in the total output from the stead-state value just before the upsets were applied. This was done to make a Y scaling that is appropriate if the P I and D gains are "reasonable" values. If you decide to increase these by a larger amount some of the graph lines will become very small.

Final Notes:

Although this is a fairly realistic model of a process and a controller it in no way is intended to be an accurate model of a car and especailly of a crusie control. It is designed just to play with and learn.

Very often real industrial controls use a little different implementation of the PID algorithum, but this is much cleaner to learn the three functions.

Some suggested tests are:

- First tune the process and then change one gain at a time and see what it did.
- First tune the process and then change some of the car functions such as weight, force limit, or aero coeff and see how that changes the way the car and tuning loop perform.

MOSTLY -- HAVE FUN!