Controller Performance

You will have seen that at best only 3 controllers perform adequately, using *ad hoc* test data.

It is likely that 2 out of the 3 are particularly good.

A strategy for assessing performance could be as follows:

Data:

1. **Gains** – you have explored the gains numerically for some chosen set-points and will now subjectively understand the effects that they have on the control of the speed of the vehicle. You will probably also have done this for a physically realistic speed set-point and a physically realistic gradient, so you will know approximately what seems to work for the gains within your best controllers. These gains are your starting point for the next phase.

2. **Gradient** – you initially started out considering a zero gradient and then added in a realistic value. You now need to think about a more realistic way of expressing road gradient, so consider a way of numerically representing <u>a changing gradient scenario</u> over a section of road. You are free to implement whatever you like here.

3. **Speed set-point** – this is very frequently given as a step function, because a sudden change from zero to a fixed finite value allows us to see visually from the time response how the controller performs. We see characteristics such as oscillation, over and under shoot, and steady-state error very obviously when we subject the system to a step change. Having explored that form of speed set-point you may wish to explore more physically realistic functions for this. You are free to try whatever you like for this, as long as it is physically reasonable.

Stability and performance:

1. You will be able to write down the system transfer function for your chosen controller, and from that you will obtain the characteristic equation for the *no disturbance* case, although you may find that you can do it for both – see the new document on this ('notes on stability calculation') just posted on MyPlace in the week 5 section.

2. Note the degree of the polynomial and proceed to calculate the entries for the first column of the Routh-Hurwitz array, and note if there's the potential for a zero valued element at any point in that column of the array – check with the Lecture 9 & Lecture 10 notes on this. Find the Routh-Hurwitz criterion for stability, noting that this will involve all the controller gain constants. You should then see how the gain constant values that emerged from your recent subjective work fit within this criterion, and tune them accordingly.

3. The root locus can be plotted in Matlab, using **rlocus**, from the transfer function. You will find examples of how to use this in the *MathWorks* online support documentation. Evaluate what this calculation gives you, perhaps by referring to your lecture notes on root locus in Lecture 8 and Lecture 9.

4. Compare what you get from the Routh-Hurwitz and root locus calculations and decide what you will now do with the gains for the system, using your chosen gradient and speed set-point functions.

5. Consider now how your controller performs with the gradient disturbance function added in.

6. Finally consider calculating further performance metrics such as percentage overshoot, damping, and sensitivity to a key parameter.

General notes:

1. Keep a log of all that you do.
2. Start to think about what will go into your report – remember the page limit.
3. Use the time you have in the next few weeks to work systematically so that you get the project research and development finished well in time, to allow you to write it up properly.