Steps in setting up your basic control system block diagram

Start by considering that the **input** to the controller (whatever the form of the controller is) will be the **error**.

The error is:

$$e(s) = v_r - v(s)$$

The first RHS term, v_r is the set-point, and the second term is the response, this being the thing we're controlling which is the actual speed of the car.

Then we consider the **output** from the controller – so what's that going to be?

It's what we loosely call the 'control', and that's whatever we choose it to be. The control operates on the input, $e(s)$, so it's this in general:

$$u(s) = CONTROL[e(s)]$$

So, what's inside the $CONTROL$ function?

This can be whatever you like: P, I, D, PI, PD, ID, or PID.

You can generate any one, or all, of these controls by creating them in *Simulink*. So, for example, for integral control, 'I', you'll need to do this:

$$CONTROL = k_i \int e(s)\, ds$$

So, now you have created a diagram that generates $u(s)$ for you, for the case of an integral controller, noting that you need to run $e(s)$ through a gain block (k_i) and then that goes into an integrator block, and the output of the controller is then $u(s)$.

What next? You need to see that the output of the controller is **not** necessarily what drives the plant, although in an ideal world it should be! In our case we know that we'll have a disturbance, in the form of a slope so we'll have this:

$$E(s) = u(s) - g\ sin\theta$$

The quantity $E(s)$ is the modified controller output, and is the controller output minus the disturbance, so we need to set that subtraction up in *Simulink*.

Finally, we can generate the output speed of the car, $v(s)$, bearing in mind that the car (or the plant, more generally) is represented by its transfer function, and this is given here by:

$$\frac{v(s)}{E(s)} = \frac{1}{s + 0.02}$$

So,

$$v(s) = \frac{1}{s + 0.02} E(s)$$

Now you have generated the output speed, $v(s)$, and so you can feed this back, as required!