Vehicle Longitudinal Model in Simulink – Daniel Taylor

**Model**

In Simulink, I modeled the Vehicle Longitudinal Model according to the equations given in the assignment instructions. For the engine speed and velocity, I began with them as Integrator blocks, so I could specify the initial 100 rad/s engine speed and initial 5 m/s velocity. After adding the constants I would be using, I proceeded to model the engine torque equation first, then the powertrain dynamics second to create a feedback loop for the engine speed. The angular velocity was modeled next, followed by the tractive force. For the tractive force, I used an if-statement block with two if-action subsystems to determine if the tractive force was Fmax or c\*s. Afterwards, I modeled the aerodynamic force, force of gravity, and rolling resistance to make up the total resistive force. I found the acceleration using x’’ = (fx-fr)/m, and connected it to the velocity integrator to complete the feedback loop. Afterwards, I could integrate the velocity with the Integrator block to find the vehicle’s position. Then I used scopes to graph the acceleration, velocity, and position.

One thing to mention are that I compared my simulation with the notes I took from Dr. Adla’s simulation and found that in the one she showed to us in class, the wheel radius was around 0.254, not 10, as per the directions. In submission, I will change this accordingly, but for the sake of the simulation I used the same parameters as Dr. Adla.

A diagram of a computer network

Description automatically generated

**Model Testing Results**

A screen shot of a graph

Description automatically generatedTest 1: Throttle Input is around 0.3471

A screen shot of a graph

Description automatically generated

A screen shot of a graph

Description automatically generated

Test 2: Throttle Input is 1 (Flooring It)A screen shot of a graph

Description automatically generatedA screen shot of a graph

Description automatically generated

A screen shot of a graph

Description automatically generated

Test 3: Throttle Input is 0 (Coasting)A screen shot of a graph

Description automatically generatedA screen shot of a graph

Description automatically generated

A screen shot of a graph

Description automatically generated

**Test Results Analysis**

**Test 1 (Throttle is ~0.347)**

When the throttle is being pushed at around 35%, the velocity graph starts with a very slight quadratic increase, and then linearly increases as time goes on. The acceleration graph quadratically decreases and then levels out at around 0.8m/s^2, and remains constant. The position graph seems to be a very, very slight quadratic increase, but it also does seem to be linearly increasing.

These graphs make sense when you consider the car is hitting the gas. At the beginning, the car is speeding up and accelerating, but as time goes on the acceleration rate is lower, but positive, and then eventually levels out. Since it levels out, the velocity linearly increases, and the position would quadratically increase.

It would make more sense that the position graph has a more dramatic quadratic increase, however. This may be due to the fact Simulink only graphs for the first 10 seconds.

**Test 2 (Throttle is 1)**

When flooring it, the velocity and position graphs remain relatively the same, just with higher magnitudes, which makes sense since the throttle is being pushed farther, so the car is traveling faster. The acceleration graph is also around the same, starting with a quadratic decrease, and then a very slight linear decrease. It will most likely become constant and level out.

The position graph is also more apparent that it is a quadratic increase, which makes sense since the car’s velocity is increasing linearly. However, it would make more sense for the quadratic increase to be sharper. Much like the previous test, this may be due to the fact Simulink only graphs the first 10 seconds.

**Test 3 (Throttle is 0)**

When coasting the vehicle, meaning there is no throttle being pushed, the acceleration has a sharp, dramatic decrease, and levels out below the x-axis, around -0.1m/s^2. The velocity graph starts with a linear increase, and then what seems to be a quadratic decrease that leads to a linear decrease. The position seems to be a linear increase with a slope of around 8.

These graphs make sense considering the situation. Since there is no throttle input, the car is simply coasting and would be slowing down after a while. This is seen in the acceleration graph, as the graph decreases and then levels out at a negative value. This means the car is slowing down. The velocity graph is also decreasing after the initial increase due to the initial engine speed and velocity. The position graph being a linear increase also seems correct; however, it would make sense that it would quadratically start to decrease as the velocity and acceleration decrease. Once again, this may be due to the fact Simulink only graphs the first 10 seconds.

**Conclusion**

Overall, I am satisfied with my Simulink model and its results. I believe my results make sense depending on the normal throttle, full throttle, and no throttle tests. It was interesting implementing the equations we learned in class all combined together into one Simulink model, including feedback loops for the engine speed and velocity.