Abstract

The purpose of this lab experiment is to understand the dynamical systems and modeling experience through MATLAB and SIMULINK simulation. The experiment consisted of a submarine to be towed by a large ship. The given values were weight, length, tension, forward velocity, speed, and elongation. Based upon the given conditions and a cable length of 300 ft. the maximum force in the tow cable is 8,1200 lb/f at the time of 2 seconds. The maximum velocity reached 5.95 ft/s. The damping ratio was equal to 1, therefore it was critically damped. With the new applied information, the length of the cable grew to 1,388.9 ft. The maximum velocity was 5.95 ft/s at 2.7 seconds. The maximum force is determined to be 6000 lbf.

In conclusion, what was learned is the relationship between the second order system and how you can manipulate the equation to help give you the maximum force and maximum velocity. Using those equations, you can determine another set of force and velocity with the conditions of a critically damped system and natural frequency.

Discussion and conclusion

The experiment consisted in setting up a second order differential equation with one degree of freedom for a submarine being towed by a ship. The first step was to set up a free body diagram describing the forces acting on the submarine and the ship. Setting up the free body diagram allowed us to set up the differential equation that we solve numerically. Once we calculated the differential equation we proved our findings by solving the equation analytically using Simulink.

The physical significance of the damping ratio equaling to 1 in a dynamical system in relation to the shape of the response when the damping ration equals to one the graph looks like a line with a growing slope that eventually reaches its max and then starts to form into another line with no slope. This graph is representing that when the submarine is being towed it does experience a jerking motion. Unlike the other conditions where the submarine did experience a jerking motion, the graph displayed was a fluctuating wave that eventually decreased to a horizontal line. The wave in the line represents that the damping ratio did not equal 1 and the submarine is experience a jerking force when being towed.

The gathered results from the calculations displayed in the graph “elongation vs. time” displays that k1 is represented by a blue line and that tells us the damping value is greater than one which vibrates and fluctuates before elongating. For the red line that represents k2 we observe that the damping value is equals to one therefore critically damped hence it does not fluctuate or vibrate before elongating.

From the results displayed in the graph “velocity vs. time” we observed that for the spring constant k1 the slop increased as well as the acceleration before settling to a constant speed. On the other hand the spring constant k2 did not increase as fast.

For the results gathered on the displacement vs. time. We compared the displacement of the submarine numerically and analytically. The results showed that there is a small difference between the two graphs. This is because analytically it is based off the more accurate results calculated by the Simulink. Numerically, the values were rounded to the closest whole number. This yielded a minor difference between the two graphs.

The displayed results for the towing force versus time, the graphs show how the spring constant k1 had a higher momentum change that fluctuated before becoming constant. The k2 value the momentum increased gradually before becoming constant.