Chaos Theory Explored Through Double Pendulums

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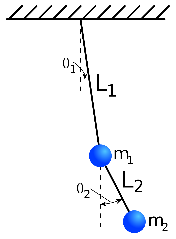
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The purpose of this project is to study chaos theory and nonlinear dynamic systems through double pendulums. Chaos theory is a branch of physics that studies randomness and butterfly effect. The butterfly effect states that a very small change to initial conditions will lead to a set of completely unpredictable changes in the result. For example, a butterfly flapping its wings here can cause a hurricane on the other side of the world (henceforth the name). A double pendulum is a pendulum with another pendulum attached to its mass (refer to figure 1). They are the simplest system that will deliver chaotic results making them ideal for studies like this one. For my project, I will use a computer simulation to research how initial conditions impact a double pendulum over the course of 120 seconds. To do this I will first test the “sensitivity” of the system by testing how close the two pendulums can be before they stop delivering chaotic results. My prediction is that after a certain point, my computer will stop trying to calculate numbers that small, making the system will no longer chaotic. Another parameter I will test is how the initial angles affect the system. My prediction is that as angles approach 180°, they will reach a chaotic stage faster. Next, the effect of mass on the system will be tested. Here my prediction is that as the ratio of mass on the first pendulum’s endpoint to the other pendulum decreases, it will reach a chaotic stage slower. Lastly, the length will be modified. Here, I believe that the length of the pendulum’s shaft will not affect when the chaotic stage sets in. To do this project, one would need a computer with a 2+ core 1.6+Ghz processor running Windows[[1]](#footnote-1) macOS[[2]](#footnote-2) or Linux[[3]](#footnote-3) and the code, found at <https://github.com/Tharthar2/sci-fair-2020>. This code does require Python 3.7 [[4]](#footnote-4) and modules NumPy[[5]](#footnote-5), SciPy[[6]](#footnote-6) and Matplotlib[[7]](#footnote-7) to run. Figure out a way to execute this code (for me what worked was an editor called Spyder[[8]](#footnote-8)). First, the sensitivity of the system is tested. To do this, find the variable called “sensitivity” and modify it by going from 1e1, 1e2, 1e3 until the system doesn’t diverge. From here change th1 to 80 and add 10 to th1 and record when the pendulums diverge in seconds. Next, test all unique mass ratios using numbers 1-3 e.g. m1 = 1 m2 = 2 for their minimum divergence angle. After that, set th1 and th2 to 90 and find when the pendulums diverge in seconds. Next, the length ratios will be changed the same way mass ratios were changed.

Figure 1 (θ1 θ2 L1 L2 M1 M2 can be changed)



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# Citations

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