Javascript where the initial conditions can be adjusted (ADD WEBSITE REFERENCE) and the path of the end of the second pendulum is drawn out. The Javascript simulation used the Euler method to calculate the rate of change of the angles and the momenta "on the fly." From this simulation an interesting property was observed: with different starting angles for both pendulums the time for the bottom pendulum to "flip" varied in an unpredictable way where a flip is defined as the bottom pendulum goes from $\theta_2 > 0$ to $\theta_2 < 360$ or vice versa. This is the property that was measured in this investigation.

To measure the time to flip based on the initial angles θ_1 and θ_2 the simulation was re-written in Python (and Fortran) and the scipy.integrate.odeint package was used to numerically integrate the characteristic equations from 0 seconds to 100 seconds, generating graphs with the flip time labelled (INSERT TIME GRAPH WITH FIRST FLIP AND ADJUST CONDITIONS AND CODE METHOD FOR ODEINT AND USE CAPTION RATHER THAN DESCRIPTION) with $l = 100, m = 5, \theta_1 = \pi, \theta_2 = \pi$ for example:

From this the time for the pendulum to flip could be measured based on the initial conditions by seeing where the solution crossed the conditions for a flip. To vary the initial conditions and visualise the flip time a colour map was created where θ_1 and θ_2 were varied from $-\pi$ to π and the time to flip was displayed as a colour:

This was then repeated over a range of length values to see how the behaviour of the flip time based on the two angles changed as the ratio of the lengths of the double pendulum to their masses was varied.

4. Results

N

5. Analysis

Talk about the chaotic regions in the colour maps and how they become more "ordered" as the length to mass ratio decreases, why? Refer back to equations and relevance with the data.

6. Conclusion