

Possible topics for computational projects

Coupled oscillators

Kuramoto model: https://en.wikipedia.org/wiki/Kuramoto_model

Neuron dynamics

Hodgkin-Huxley model: https://en.wikipedia.org/wiki/Hodgkin%E2%80%93Huxley_model

Fitzhugh-Nagumo model: https://en.wikipedia.org/wiki/FitzHugh%E2%80%93Nagumo_model

Chaotic systems

Universality in chaos (Feigenbaum constant):

https://en.wikipedia.org/wiki/Feigenbaum_constants

Strange attractors: <http://www.stsci.edu/~lbradley/seminar/attractors.html>

Evolutionary dynamics

Lotka-Volterra equations: https://en.wikipedia.org/wiki/Lotka%E2%80%93Volterra_equations

Replicator-mutator model:

<http://www.princeton.edu/~naomi/publications/2011/PaiLeoCDC2011.pdf>

Viral spreading: <https://www.pnas.org/content/pnas/111/46/E4911.full.pdf>

Quantum mechanics

Finding eigenstates of harmonic oscillator (and other potentials)

Wave packet dynamics in 1D potentials

Astronomy

N-body simulations, e.g. simulation of the solar system (multi-body orbital mechanics) -- make sure you include gravitational interactions between 3+ masses if you choose this

General Relativity

Numerically solving for geodesics on manifolds: <https://en.wikipedia.org/wiki/Geodesic>

<https://cs.stanford.edu/people/jbaek/18.821.paper2.pdf>

Mechanics

Pool-like game with collisions: <https://www.cs.hmc.edu/twiki/bin/view/CS5/PeachyPool17>

Double pendulum, triple pendulum, Kapitza's pendulum:

https://en.wikipedia.org/wiki/Kapitza%27s_pendulum

Statistical Mechanics

Ising model: <https://vixra.org/pdf/1710.0021v2.pdf>

Simulation of ideal gas using particles bouncing in a closed container--adding collisions let's you "derive" the ideal gas law and/or Maxwell distribution

Biophysics

Basic molecular dynamics (Leonard-Jones potential):

<http://www.physics.drexel.edu/~valliere/PHYS305/MolecularDynamics/MolecularDynamics/MolecularDynamics.html> <http://udel.edu/~arthij/MD.pdf>

Brownian motion (with bias, interactions, ...)

Data analysis

Answer questions about a large dataset from some field: COVID, elections, [global warming](#), particle physics (ask YGK), demographics, stock market, etc.

Quantum computing

Simulate a quantum circuit (using built-in linear algebra libraries, numpy, or [cirq](#))

Games

Animated: pong, snake, PacMan, ...

Card games: poker, blackjack, bridge, ...

Dice/craps

Others

nonlinear curve-fitting algorithm

fourier algorithms and signal processing: multi-band graphic equalizer, clean up/filter an audio recording, clean up/filter an image

basic fluid mechanics: shock wave propagation in 1 dimension

