

# Computational Science 1

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Seminar  
Exercises

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Exercise 2 (5.11.2019):

## Trajectory of a pendulum in phase space

from *An Introduction to Computer Simulation Methods*,  
Chapter 4, Problem 4.11

- a) We explore the phase space behavior of a pendulum by simulating  $N$  initial conditions simultaneously. Write a program to compute the trajectory ( $\omega$  vs.  $\theta$ ) for  $N$  identical pendula each of which is represented by a small circle centered at its angle  $\theta$  and angular velocity  $\omega$  in phase space. One way to do so is to adapt the `class BouncingBallApp` from Chap. 2 (see examples). Choose  $N = 16$  and consider random initial  $\theta$  and  $\omega$ . Plot several phase space trajectories for different values of the total energy. Are the phase space trajectories closed? Do they cross for different initial conditions? Does the shape of the trajectory depend on the total energy?
- b) Choose a set of initial conditions that form a rectangle in phase space, and plot the state of each pendulum as a circle. Does the shape of this area change with time? What happens to the total area?