

Exercise Sheet #8

Problem 1 (*Numerical Solution of Differential Equations*) 10 Pts

The Kepler problem, namely a point mass in a plane under a $-k/r$ potential, was introduced in the lecture as an example for a differential equation that can be solved with different numerical methods.

- (a) Implement solvers of the Kepler problem using Euler's method, fourth-order Runge-Kutta, the leapfrog scheme and the Adams-Bashforth scheme. Since the trajectories lie on a plane, only consider two dimensions.
- (b) For initial conditions with negative energy, the trajectories are bounded and closed. Plot the trajectories for the different algorithms. Are they bounded and closed? Also, plot the total energy and angular momentum over time to check whether they are conserved.
- (c) What happens to the orbits with a potential $V(r) = -k/r^\alpha$ with $\alpha \neq 1$? Use $\alpha = 1/2, 3/2$.
- (d) Also experiment with an harmonic potential, i.e. with $\alpha = -2$ and $k < 0$. (Optional)

Problem 2 (*Console animation*) 10 Pts

Using this code, create a visual simulation of a bouncing ball to be displayed in the console.

1. Create an animation of a ball falling in a physical trajectory (according to Newton's equations of motion). The ball should bounce back when it hits the bottom of the screen.
2. Upon reaching the bottom, the ball should be squeezed and change its color.
3. Add text to the animation, making 'BOING' appear on the screen when the ball hits the bottom.

Problem 3 (*Exceptions*)

5 Pts

Setting exceptions manually can be crucial to avoid unexpected behaviour. Run the following code and see what happens when a non-integer input is passed to the program:

```
#include <iostream>

using namespace std;

int main()
{
    int x;
    cin >> x;
    cout << "input = " << x << endl;
    cin.clear();

    return 0;
}
```

Fix this by making sure the program throws an exception when given non-integer input. Set an exception with `cin.exceptions(ios::failbit)` and use `try` and `catch` to print out an error message when an exception is caught.