

Report

Build Instructions

Upgrade compiler and CMake (only needed when using ZID computers)

```
> module load gcc/7.2.0
> module load cmake/3.5.2
```

Run CMake (from project directory)

```
> mkdir build
> cd build
> cmake ../
```

Build project using Make

```
> make
```

Run program

```
> ./Assignment1
```

Overview

Comparison numerical solution to exact analytical solution.

We figured out that the stiffness and the step size are the most crucial parameter for the behavior of the spring. The experiments containing the borders of instability for each Method.

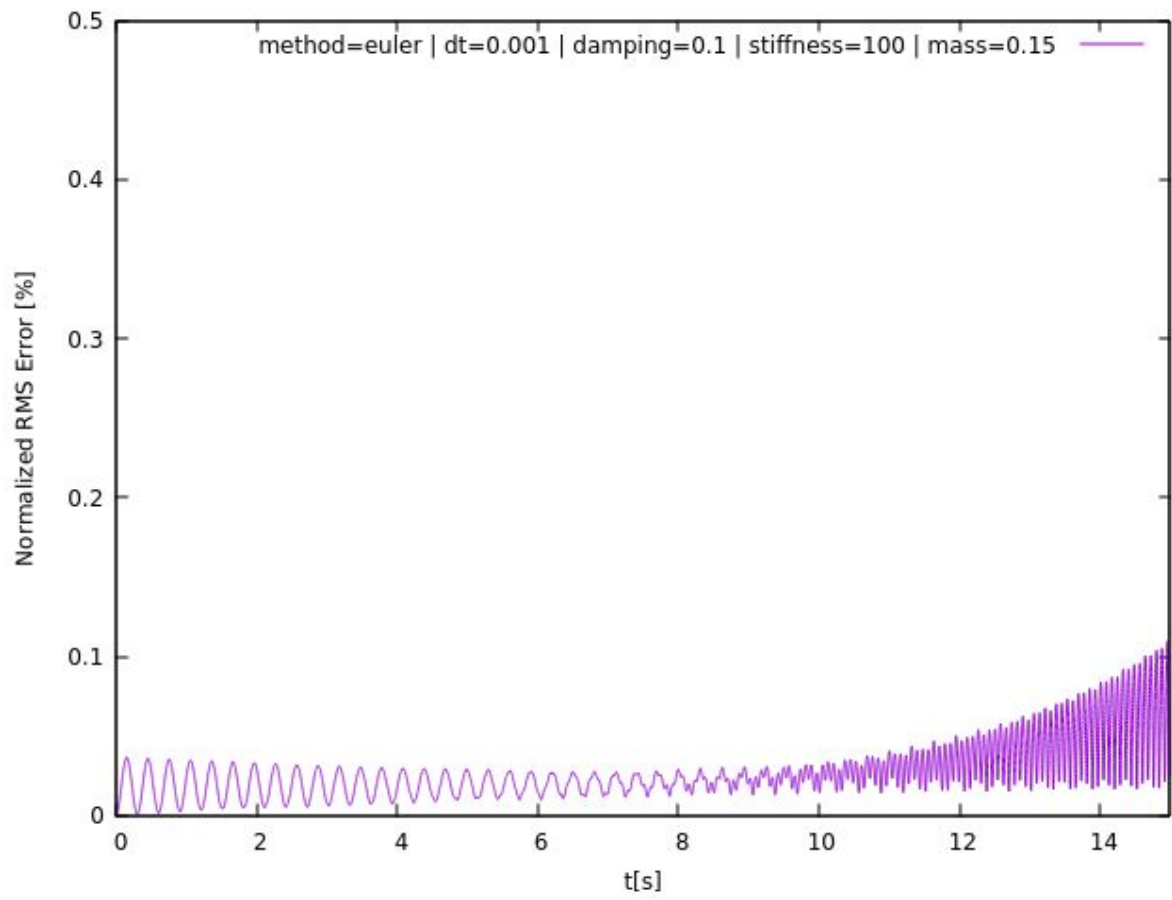
The plots are showing the normalized RMS error (compared to the analytical solution) as values between 0 and 1 and not in percent as depicted on the legend. We noticed this error only shortly before submitting the report so we decided to put this note here to avoid changing every plot. In the following tables the columns represent different stiffness configurations whereas the rows represent different values for the size of one timestep.

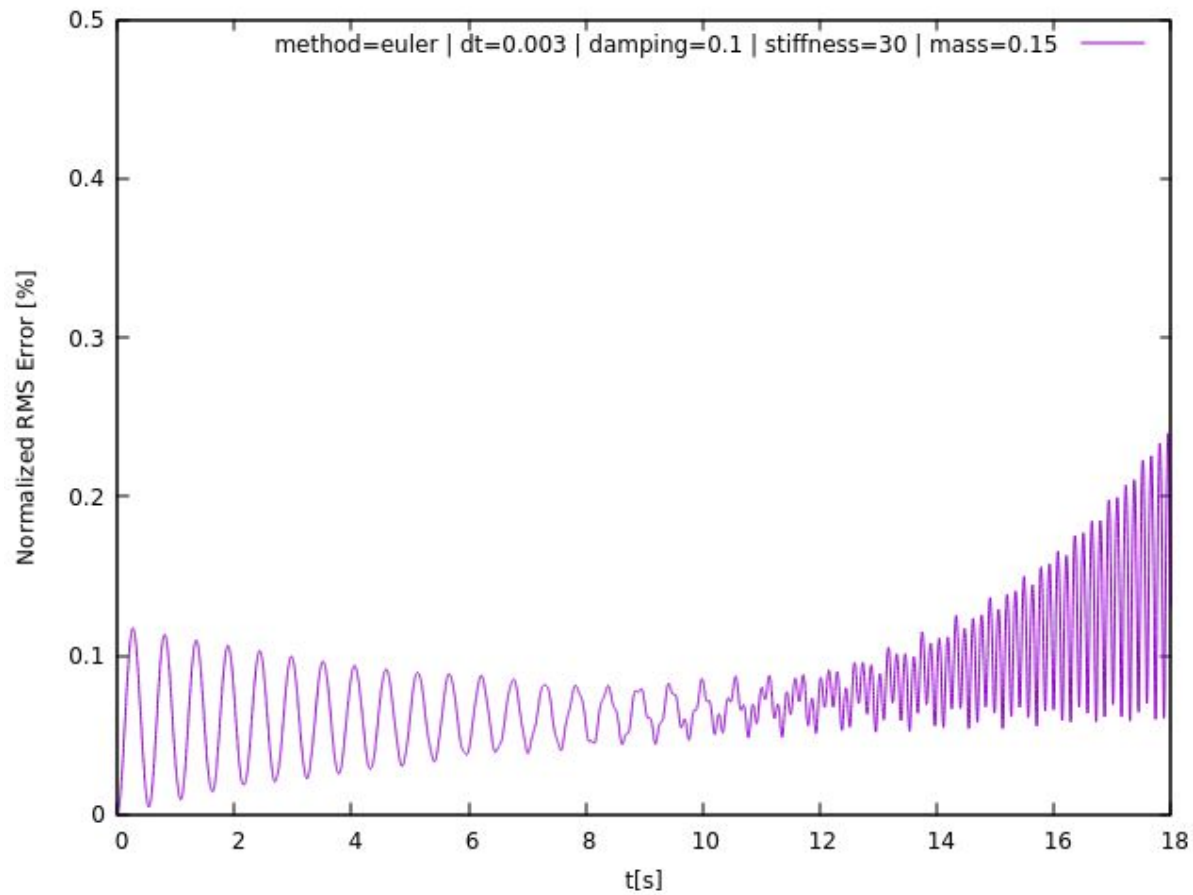
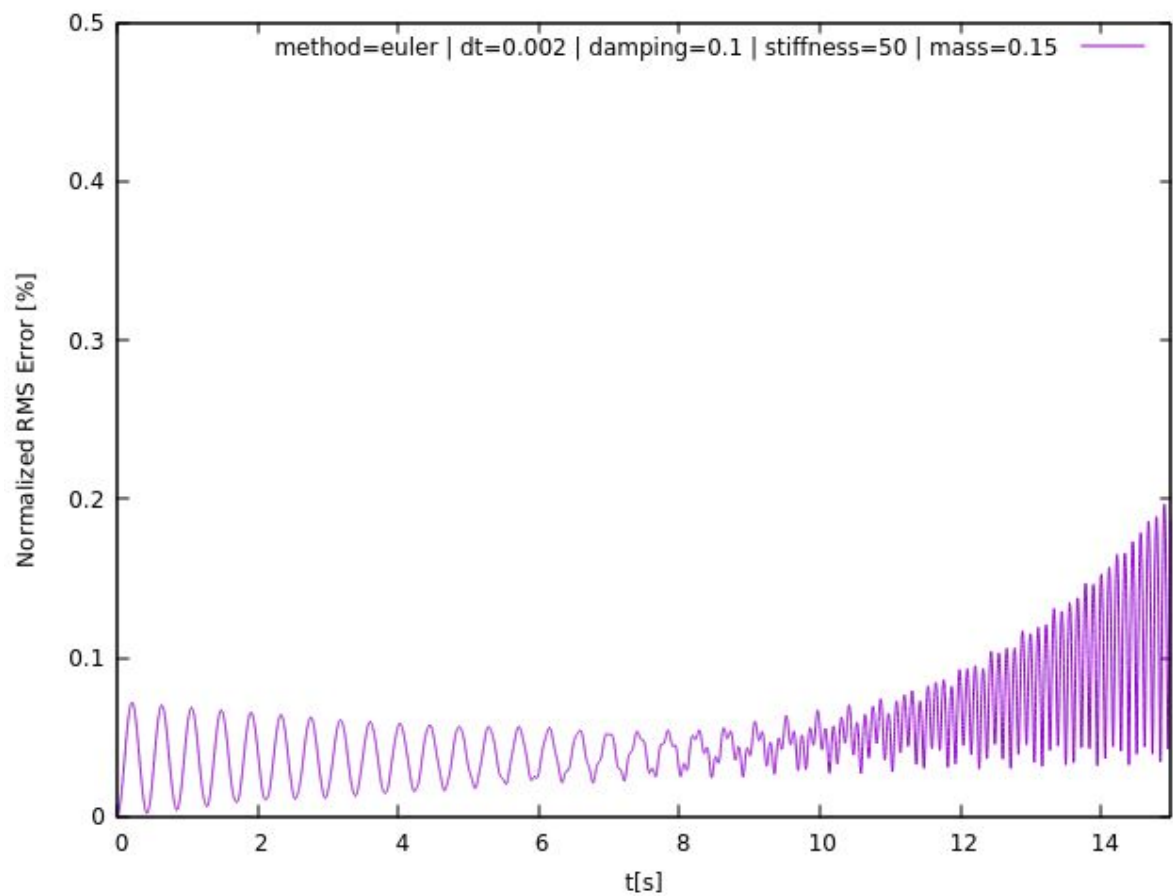
Euler:

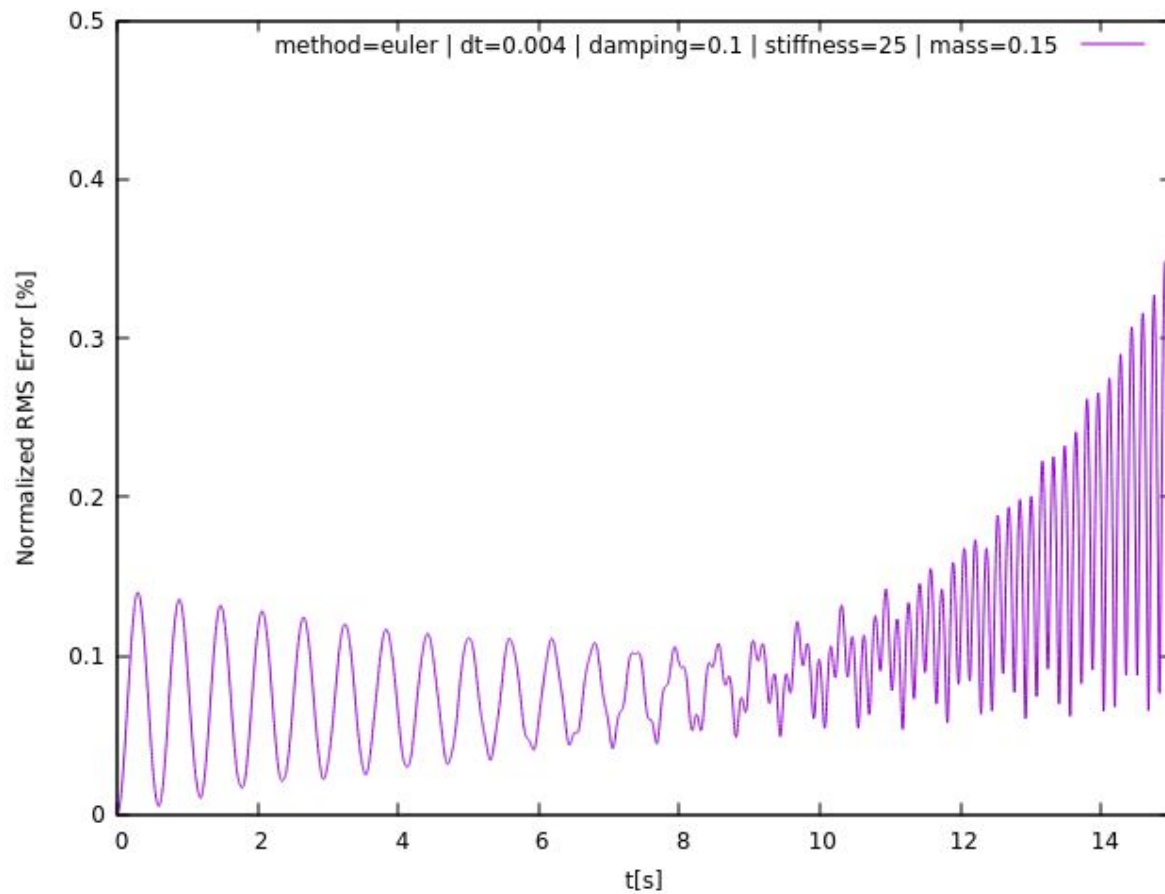
For the Euler method, the parameters have to be very small to have a stable spring-mass-system, especially the step size.

	100	50	30	25
0.001	unstable	stable	stable	stable
0.002	unstable	unstable	stable	stable

0.003	unstable	unstable	unstable	stable
0.004	unstable	unstable	unstable	unstable



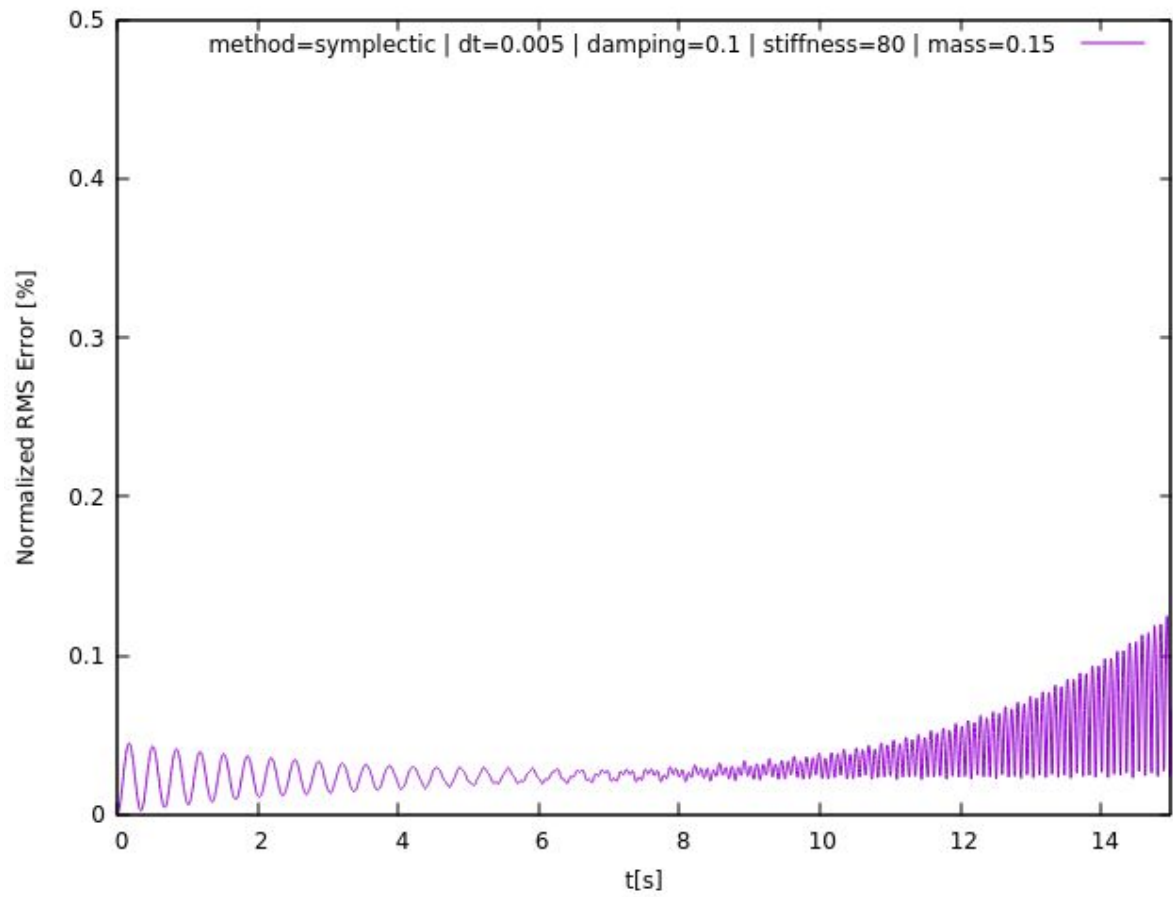
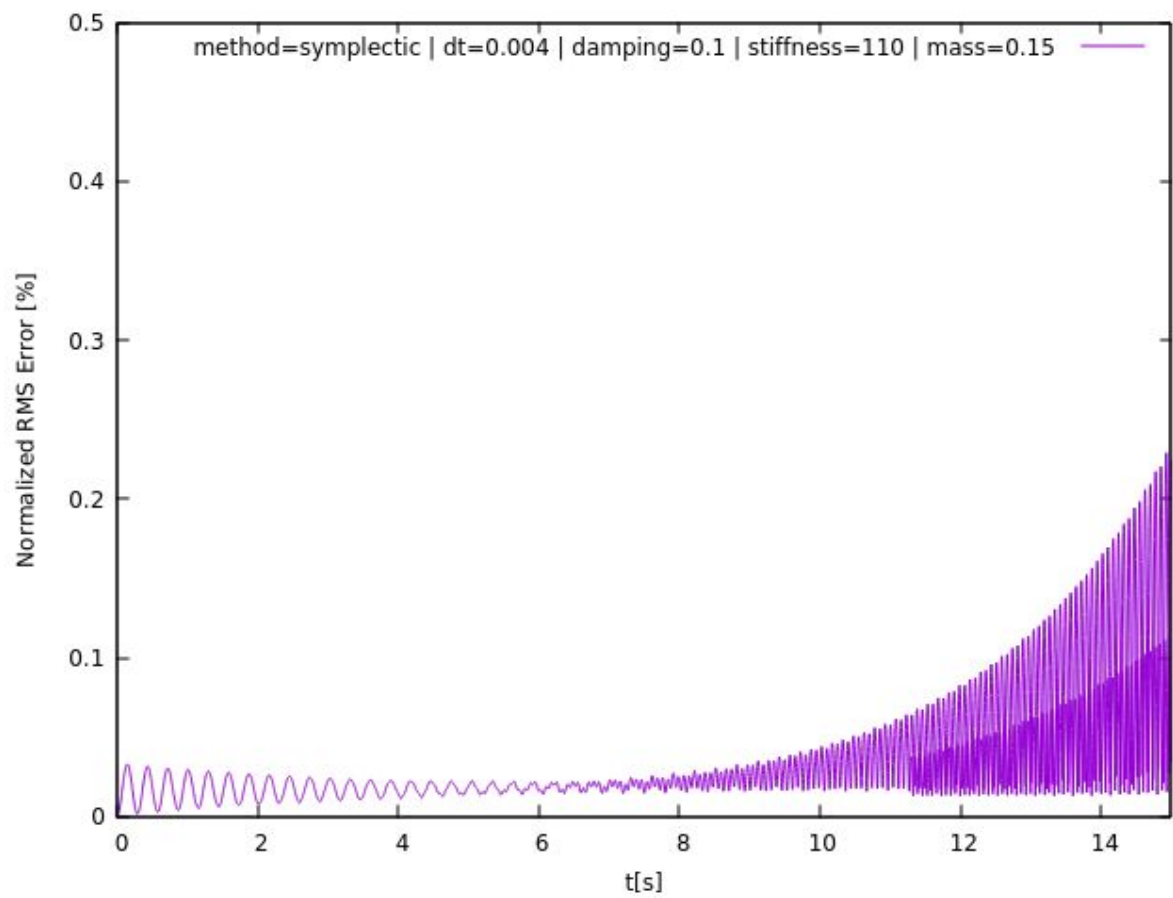


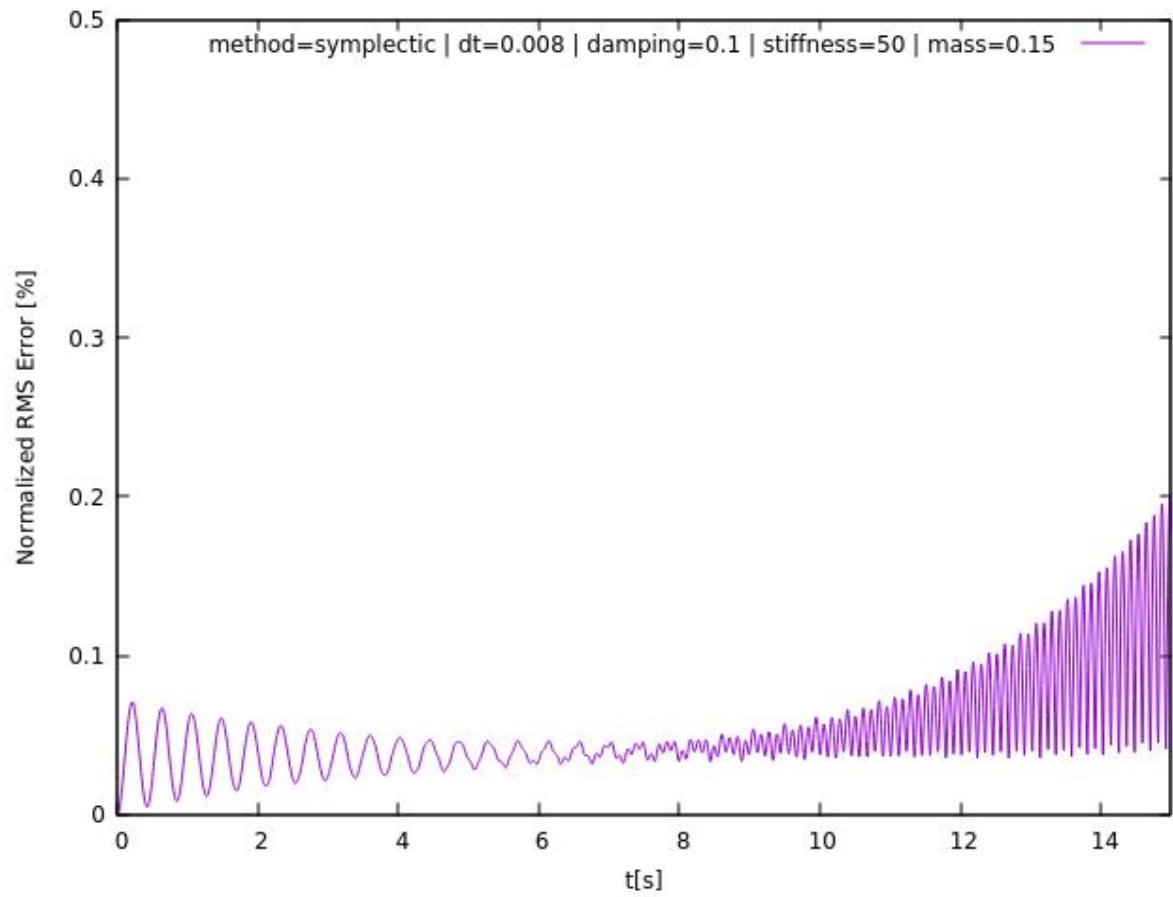
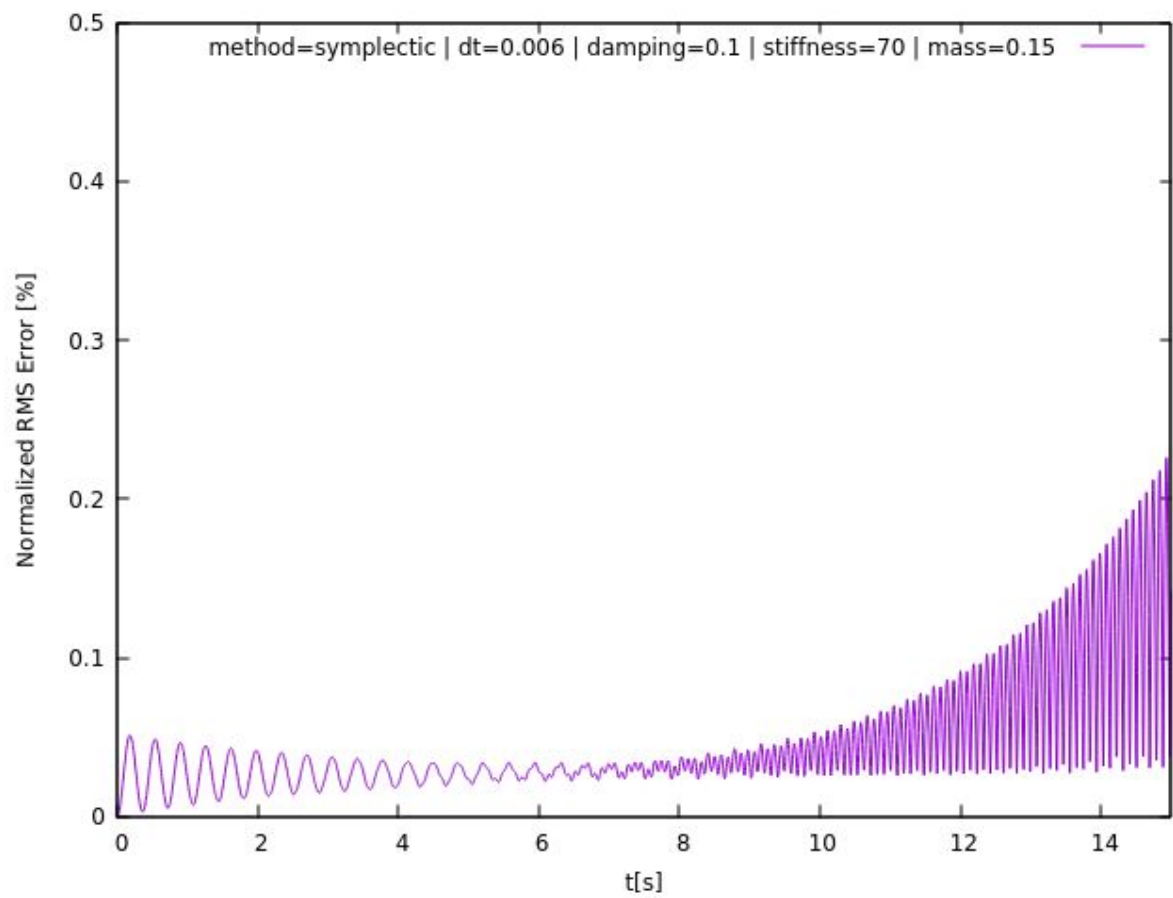


Symplectic:

Similar to the Euler method the symplectic method is unstable for relatively small parameters.

	110	80	70	50
0.004	unstable	stable	stable	stable
0.005	unstable	unstable	stable	stable
0.006	unstable	unstable	unstable	stable
0.008	unstable	unstable	unstable	unstable

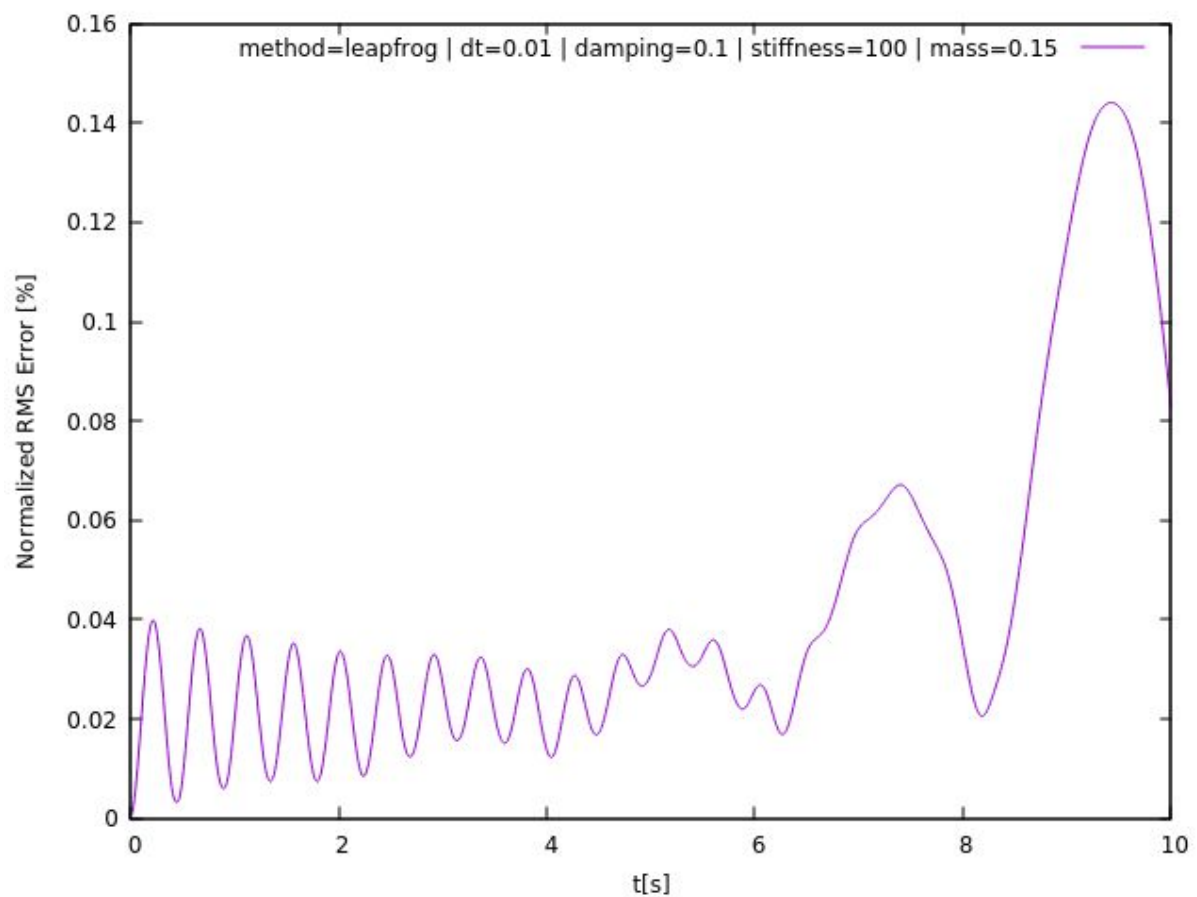


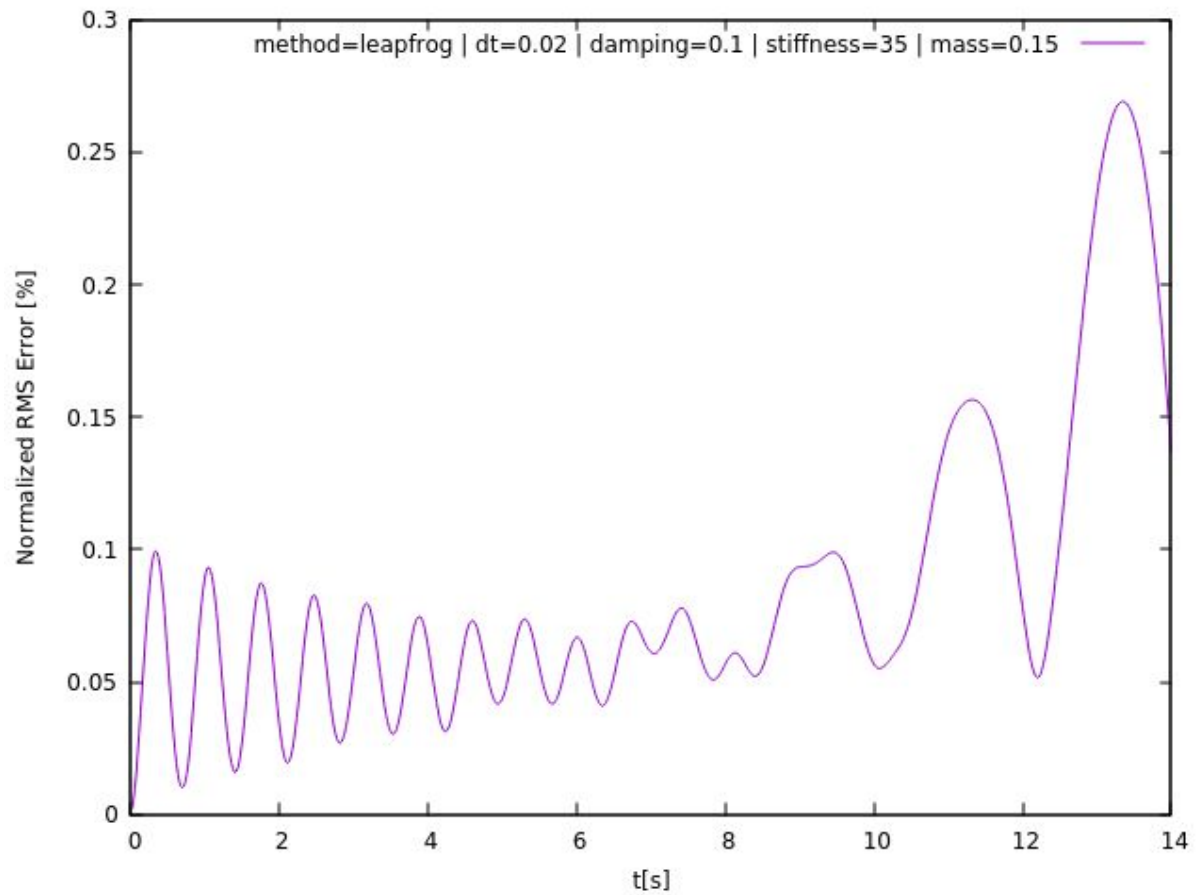
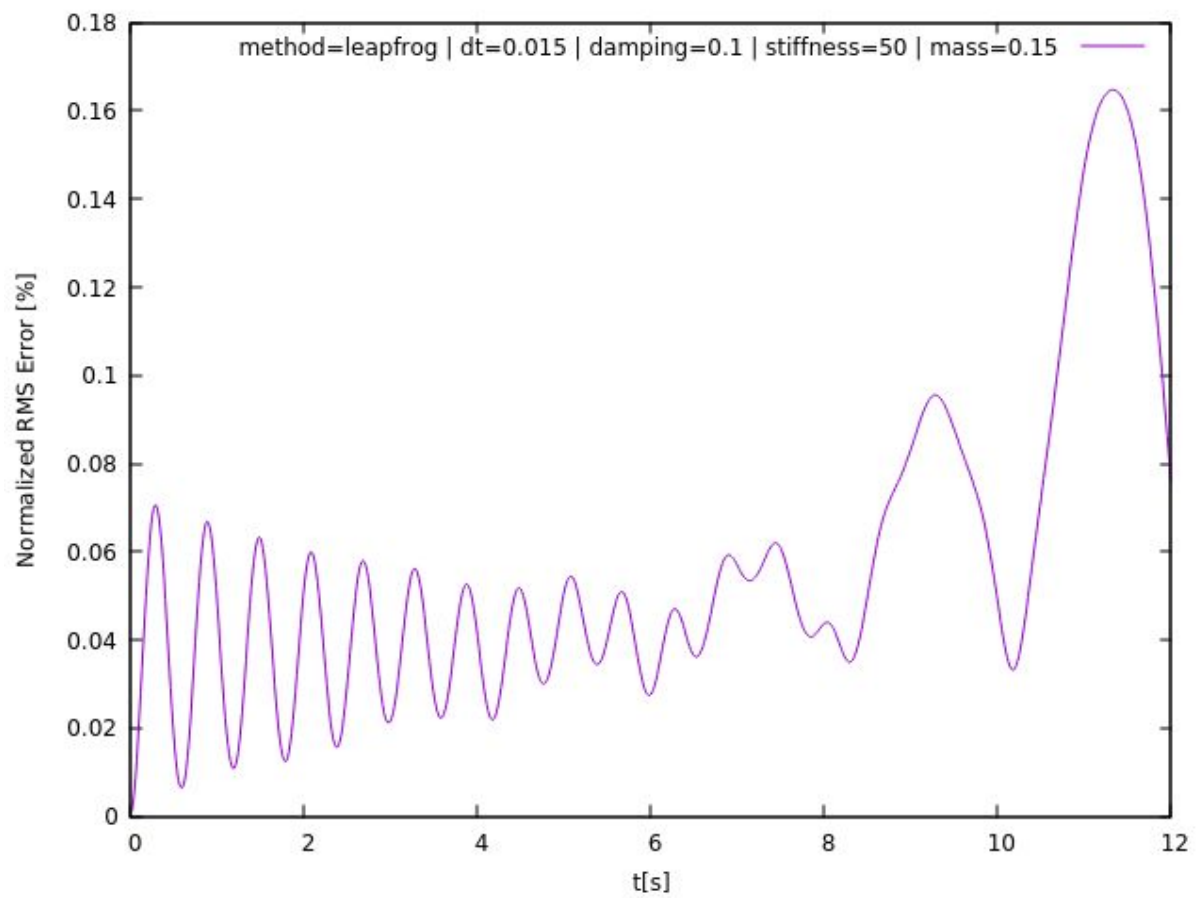


Leapfrog:

The Leapfrog is pretty stable also at high parameters, interesting is the way the spring behaves when it gets unstable. It's also visible in the plot of the RMS Error.

	100	50	35	25
0.01	unstable	stable	stable	stable
0.015	unstable	unstable	stable	stable
0.02	unstable	unstable	unstable	stable





Midpoint:

The midpoint method had the best results and it was pretty hard to find the instability threshold. Until the step size of 0.045 this method was almost “unbreakable”. The midpoint method doesn’t crash like the other methods after a few seconds, it crashes immediately after 1 second. With a step size of 0.048 and a stiffness of 190 the spring-mass system goes totally crazy just after 1 second.

	210	200	185	100	90
0.045	unstable	stable	stable	stable	stable
0.046	unstable	unstable	stable	stable	stable
0.048	unstable	unstable	unstable	stable	stable
0.065	unstable	unstable	unstable	unstable	stable

