Course: Physics Simulations
Lecture Notes

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1 Introduction

1.1 Why are Simulations Used?

1.2 Python

1.3 A Bit About Git

1.4 Some Mathematical Background

1.5 Harmonic Oscillator

Many system in physics present a simple, periodic (repeating) motion. One such system is a simple mass-less spring connected to a mass m and allowed to move in a single dimension only. If we ignore the effects of gravity, the only force acting on the mass arises from the spring itself: the more we pull or push the spring, the stronger it will resist to that change. This resistant force is given by

$$F = -kx, \tag{1}$$

where k is the **spring constant**, and x is the amount by which the spring contracts or expands relative to its rest length L. In Figure 1 we

2 Simulating Simple Mechanics

2.1 Forward Euler Method

2.2 Backward Euler Method

2.3 Verlet Integration

2.4 Runge-Kutta Method

3 Thermodynamics

4 Waves

5 Molecular Dynamics

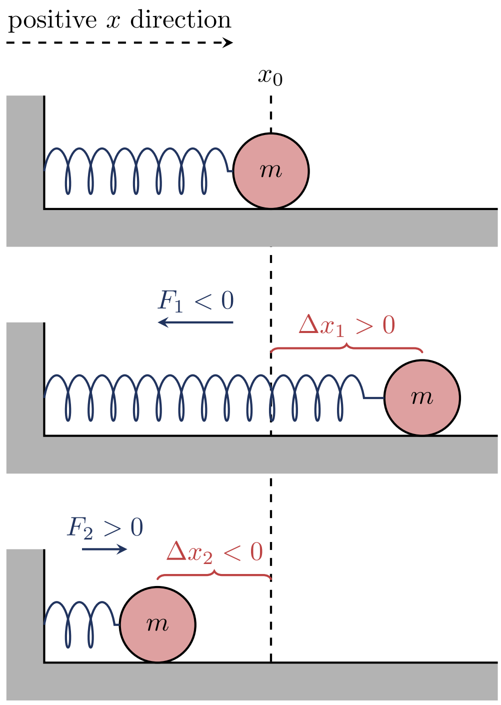

Figure 1: A simple spring-mass system with spring constant k and a mass m. The top figure shows the spring at rest - i.e. when the mass is located at position x_0 the spring applies no force on the mass (since $\Delta x = x_m - x_0 = 0$). The middle figure show the spring being at a *positive* displacement $\Delta x_1 > 0$, causing the spring to pull back with a negative force $F_1 = -k\Delta x_1$. The bottom picture shows the spring contracting by $\Delta x_2 < 0$, casing the spring to apply a positive force $F_2 = -k\Delta x_2$ on the mass.