Physically-Based Simulation Exercise Session

Exercise 1 & Project Introduction

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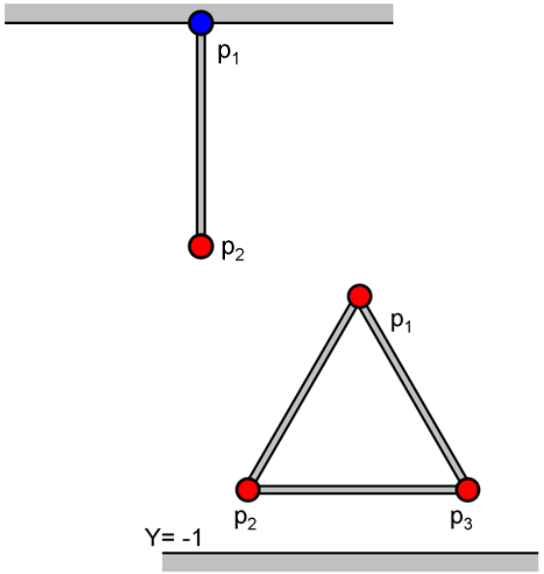
Exercise 1



- Mass-spring systems and numerical integration
- In each time step, update position $\mathbf{p}$ and velocity $\mathbf{v}$ of all mass points
  - e.g., explicit Euler

$$\mathbf{p}(t+h) = \mathbf{p}(t) + h\dot{\mathbf{p}}(t) = \mathbf{p}(t) + h\mathbf{v}(t)$$

$$\mathbf{v}(t+h) = \mathbf{v}(t) + h\dot{\mathbf{v}}(t) = \mathbf{v}(t) + h\frac{\mathbf{F}(t) - \gamma\mathbf{v}(t)}{m}$$

Problem 1

- Integration Schemes:
  - This week: Explicit Euler, Midpoint
  - Next week: Symplectic Euler, (Semi-) Implicit Euler

Problem 2

- Analytic Solution
  - $y(t) = c_1 e^{\alpha t} \cos(\beta t) + c_2 e^{\alpha t} \sin(\beta t) - L - \frac{mg}{k}$
  - with $\alpha = -\frac{\gamma}{2m}$, $\beta = \frac{\sqrt{4km - \gamma^2}}{2m}$

- Error Convergence & Stability Analysis

Problem 3

- Collision Handling
  - Apply repulsive spring force
  - Try with Explicit Euler
  - Changes to Symplectic Euler are minimal

Flags

- `-method` flags
  - `euler`
  - `symplectic_euler`
  - `midpoint`
  - `backwards_euler`
  - `analytic`
- `-testcase` flags
  - `Spring1d`
  - `falling`
  - `error_measurement`
  - `stability_measurement`

Numerical parameters: `-step`, `-damp`, `-mass`, `-stiff`

Submission

- Hand-in
  - CPP and PDF (or DOC/TXT)
  - email to: *kimby@inf.ethz.ch* (with [PBS17] header)
  - until October 11 (midnight)
- Groups
  - work in groups of 2 or 3 people (groups of 3 preferred)
  - same groups for all exercises and project
  - if you cannot find a group: contact me as soon as possible

Project

- Occupies second half of the semester
- Timeline
  - November 1: Project Plan Due
  - November 29: Milestone Presentations
  - December 20: Project Due & Final Presenations