

In this assignment you will be simulating rigid bodies with contact and collision.

## 1 Implementation

On the ground plane, stack four or more blocks in roughly the shape of a house (you can pick their shapes and how to put them together). A ball will then come sliding, rolling, or bouncing along and knock the house down.

For advancing the rigid bodies, use the simple explicit method from class (with quaternions for representing the orientations of the rigid bodies in the system). The only external force in this simulation is gravity.

You will need to do rigid body collisions. For this assignment, just use interference detection, with the level set plus point sample representation (the point samples from a mesh used in rendering). You needn't implement shock propagation; instead allow for the fact that there may be some interpenetration after your elastic collision and inelastic contact iterations. That is, after the contact iterations, do a final round of checks for points inside other objects; if there are any, add a repulsion impulse to move the points towards the surface. The repulsion impulse should look like a damped spring between the interfering point and the closest point on the surface, but with the added twist that you will also do a frictional tangential impulse based (as usual) on the normal impulse.

Since there will only be a few simple objects in this simulation, you don't need to implement an acceleration structure to speed up interference detection.

As usual, I will provide sample code to get you started and for doing some rendering.

## 2 Analysis

Write down and explain the repulsion impulse (with friction) that you use in your simulation.

Write down the formula for signed distance (level set) of a rectangular block. You can do this in object space, where the block is aligned with the axes and is described by:

$$\begin{aligned} -a &\leq x \leq a \\ -b &\leq y \leq b \\ -c &\leq z \leq c \end{aligned}$$

## 3 Project Ideas

You can extend this assignment in a number of ways for your final project:

- speed up the interference detection with an acceleration structure
- implement shock propagation to get better stacking behaviour (perhaps comparing that with the repulsion force approach)
- add constraints (soft and/or hard) to connect some of the rigid bodies together
- do collision detection between triangle meshes (so you can robustly handle thin objects)