CPSC 453: Introduction to Physically Based Modelling

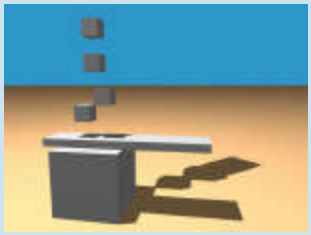
(Chapter 11.1-11.5)

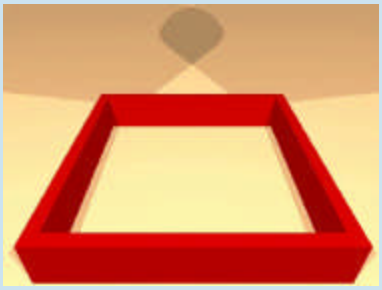
Mark Matthews
matthews@cpsc.ucalgary.ca
Office Hours: 3:15-4:00PM TR
Office: 680J
www.cpsc.ucalgary.ca/~sheelagh/courses/453

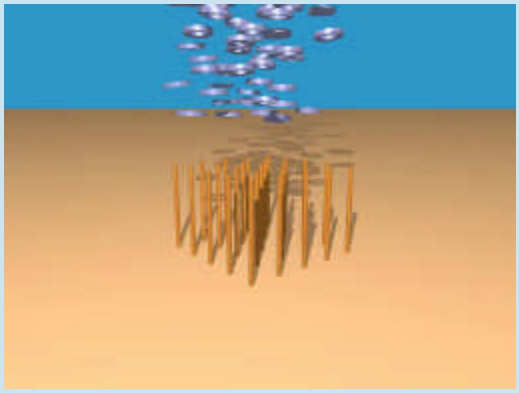
Physically Based Modelling (PBM)

- Procedural generation of animation
- Use physical laws to generate animation
- Uses:
  - Entertainment: less time spent animating
  - Gaming: greater realism (flight sim., etc.)
  - Science: determine the qualitative behavior of a system.

Solids

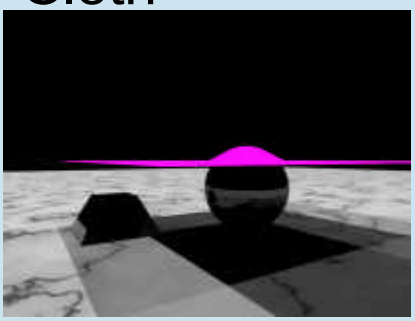




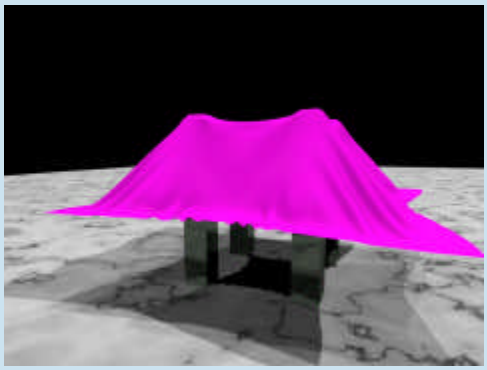


(E. Guendelman *et al*)

Cloth

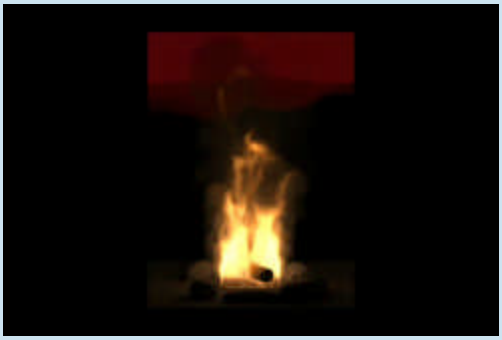


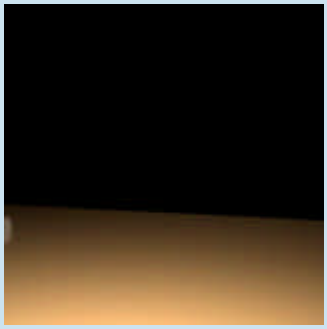
(R. Bridson *et al*)



Fire & Smoke

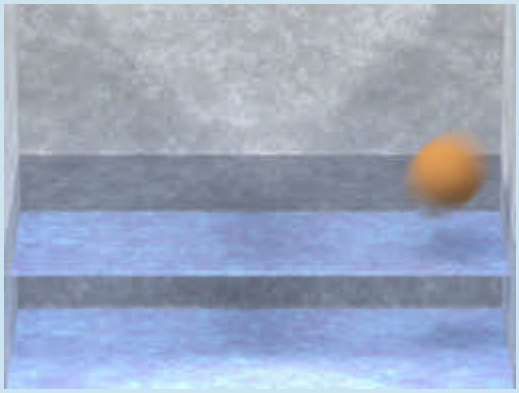
(D. Nguyen *et al*)



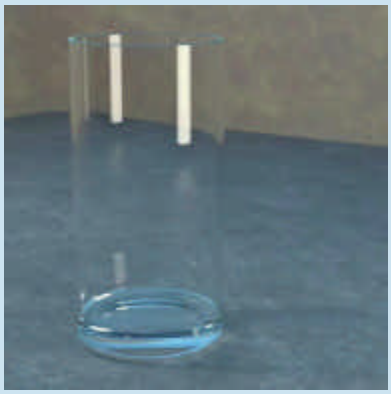


(J. Stam *et al*)

Water



(R. Fedkiw *et al*)



Particle Systems

- A basic particle systems consists of a collection of entities that have:
  - a position pi
  - a velocity vi
  - optionally, other attributes:
    - color
    - lifetime
    - mass
    - “shape”
- Can be used to simulate numerous behaviors

Newtonian Particle Movement

- Acceleration (f=ma):

$$\dot{\mathbf{v}}_i = \frac{1}{m_i}\mathbf{f}_i(t)$$

$$\dot{\mathbf{p}}_i = \mathbf{v}_i$$

- Euler’s method:

$$\mathbf{v}_i^{new} = \mathbf{v}_i^{old} + \frac{1}{m_i}\mathbf{f}_i(t)$$

$$\mathbf{p}_i^{new} = \mathbf{p}_i^{old} + \mathbf{v}_i^{old}\Delta t$$

Particle Forces

- Constant Force
  - use for gravity

$$\mathbf{f} = \begin{bmatrix} 0 \\ -g \\ 0 \end{bmatrix}$$

- Attraction/Replusion
  - gravitation between two objects or electrostatic repulsion

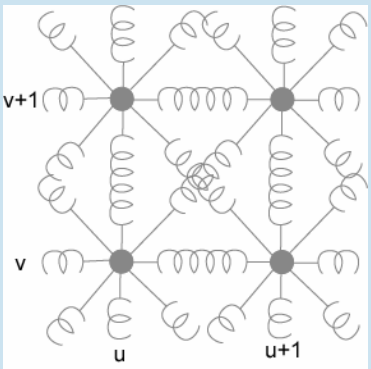
$$\mathbf{f} = -k_r \frac{\mathbf{d}}{|\mathbf{d}|^3} \qquad \mathbf{d} = (\mathbf{p}_b - \mathbf{p}_a)$$

- Drag
  - air resistance

$$\mathbf{f} = -k_d \mathbf{v}$$

Mass-Spring Systems

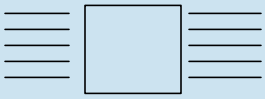
- A particle system connected by springs
- Simplest form of solid simulation
- Popular because of their simplicity



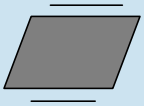
Mass-Spring Systems

•Resists 2 types of deformation:

- Stretch

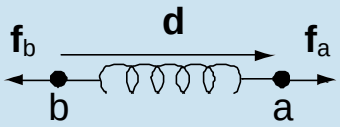


- Shear



Spring Formulation

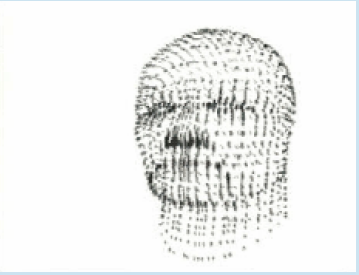
- Hooke's Law
  - defined between two particles a and b



$$\mathbf{f}_a = -\mathbf{f}_b = \frac{\mathbf{d}}{|\mathbf{d}|} k_s \left(|\mathbf{d}| - s_o \right)$$

Examples

(W. Reeves, 1983)



(K. Sims)

Examples