CS130 : Computer Graphics

Lecture 25: Physics-Based Simulation

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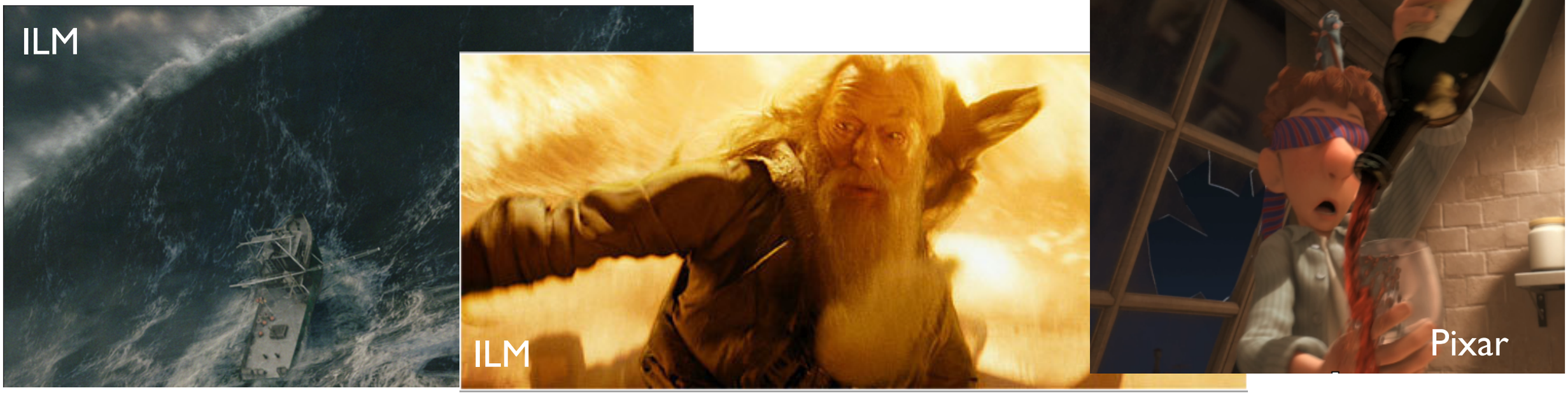
Physically-based simulation is widely used for movies, games,...



Some companies that work on special effects

- Industrial Light & Magic
- Weta Digital
- Digital Domain
- PDI/Dreamworks
- Rhythm & Hues
- Pixar
- Disney

Firestorm
Harry Potter and the Half Blood Prince
Industrial Light + Magic

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solid simulation in Pixar's *Ratatouille*

solid simulation in Pixar's *Ratatouille*

fluid simulation in Pixar's *Ratatouille*

fluid simulation in Pixar's *Ratatouille*

Similar techniques are used in 3D interactive games

- but here the constraint is real-time simulation
- detailed simulation for movies happens ‘off-line’

Some of the basic types of objects we're interested in simulating

- rigid bodies
- soft bodies
  - hair, cloth, deformable volumetric solids
- fluids
  - smoke, liquids, fire

Particles

Particle: basic dynamic object

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mass

m

Particle: basic dynamic object

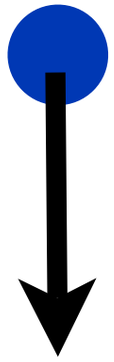
mass

m

3 dof

$$\vec{X} = (x, y, z)$$

Particle: basic dynamic object



mass

$$m$$

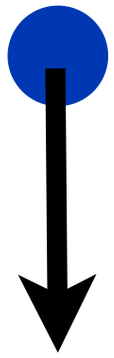
3 dof

$$\vec{X} = (x, y, z)$$

forces: e.g., gravity

$$\vec{F} = -m\vec{g}$$

Particle: basic dynamic object



Equations of motion:
Newton's 2nd Law

$$\vec{F} = m\vec{a}$$

Particle: basic dynamic object

Equations of motion:
Newton's 2nd Law

$$\vec{F} = m\vec{a}$$

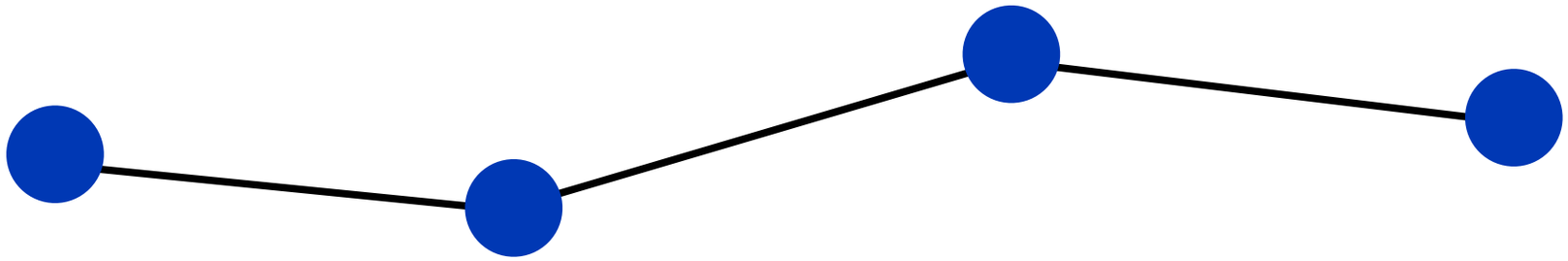
$$\frac{d\vec{x}}{dt} = \vec{v}$$

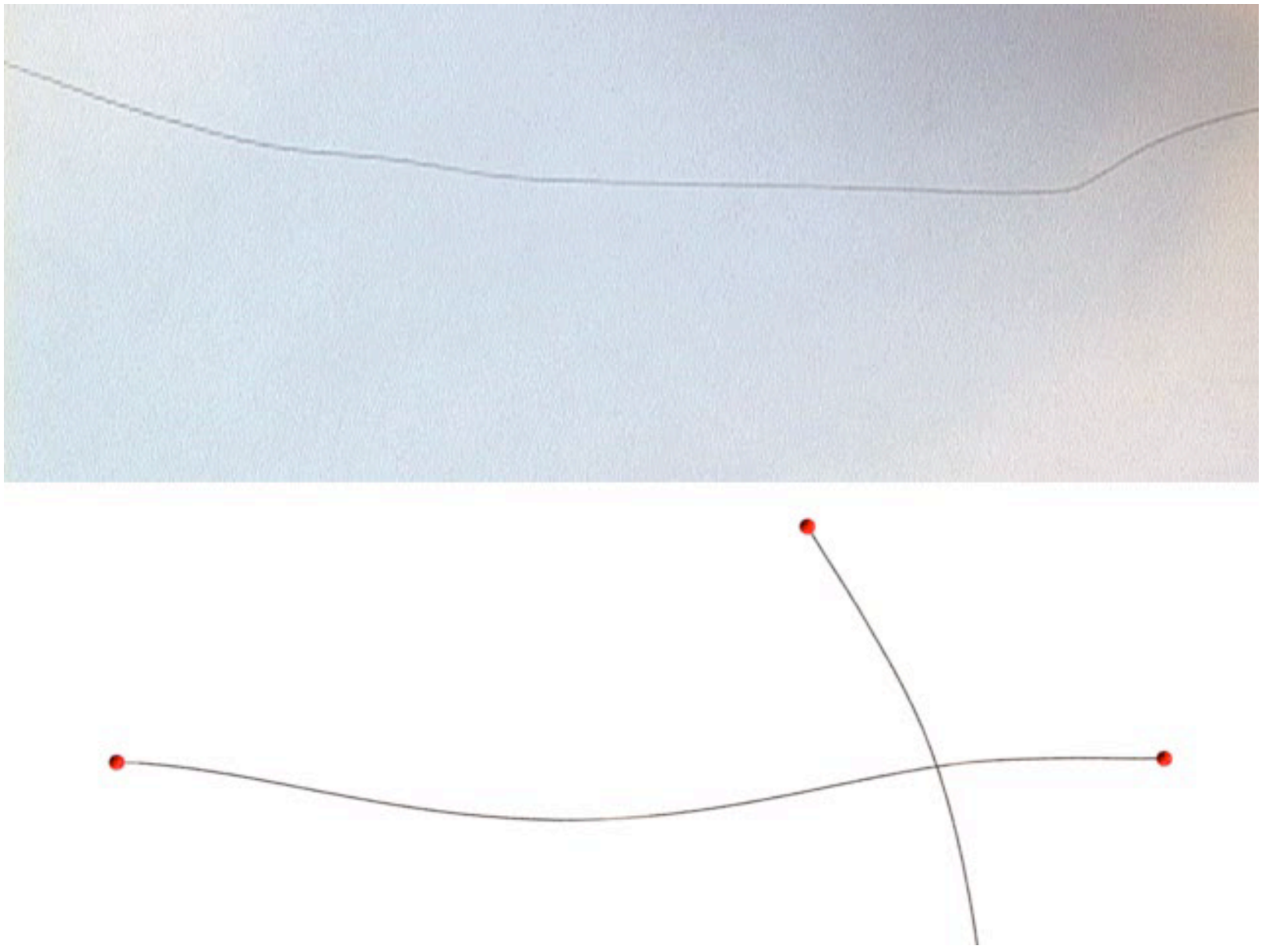
$$m\frac{d\vec{v}}{dt} = \vec{F}$$

System of ODEs

Deformable bodies

Connect a bunch of particles into a 1D line segment with springs

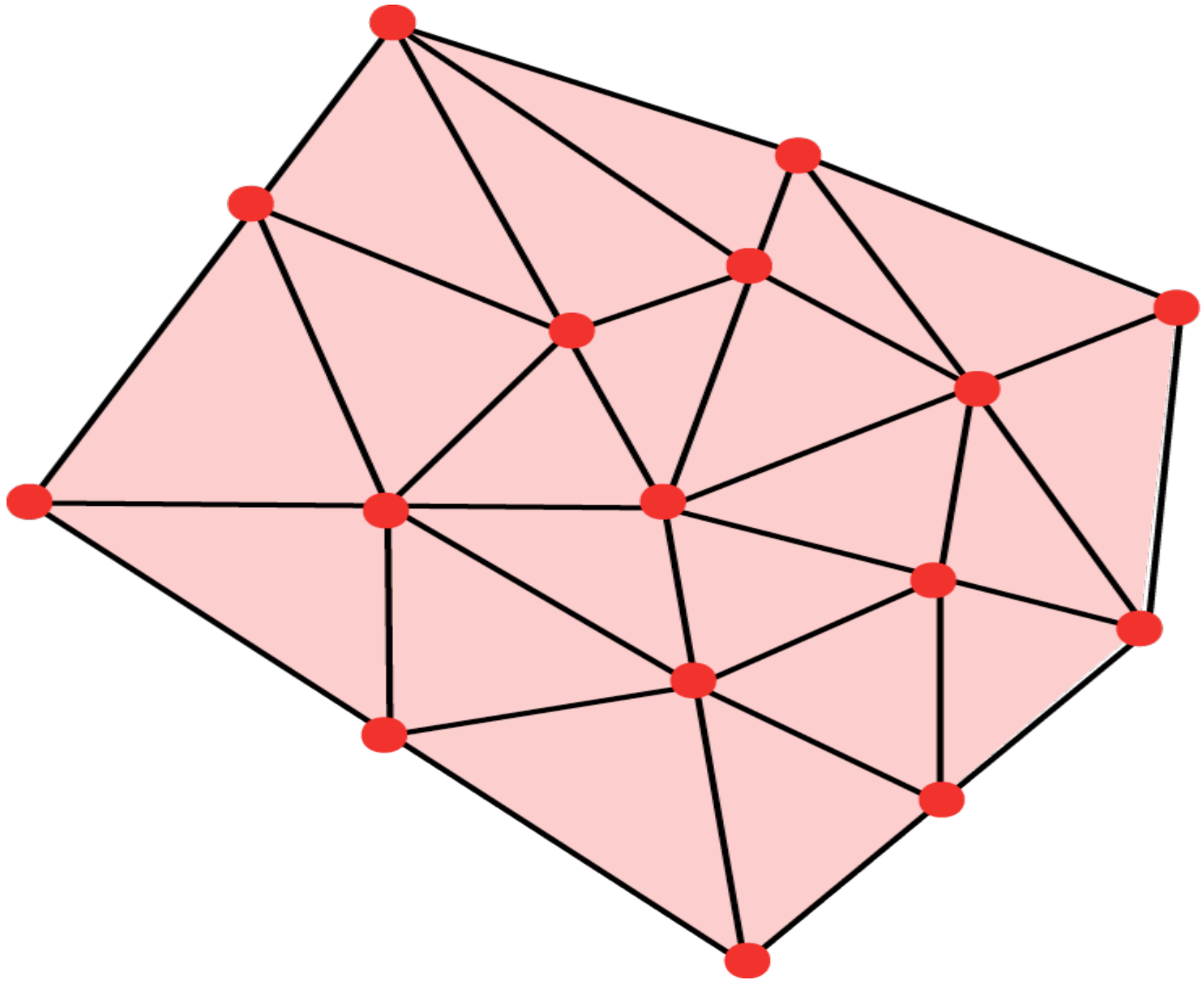




A Mass Spring Model for Hair Simulation

Selle, A., Lentine, M., G., and Fedkiw, R. ACM Transactions on Graphics SIGGRAPH 2008, ACM TOG 27, 64.1-64.11 (2008)

Connect a bunch of particles into a 2D mesh



Selle, A., Su, J., Irving, G., and Fedkiw, R. IEEE Transactions on Visualization and Graphics (TVCG) 15(2) 339-350

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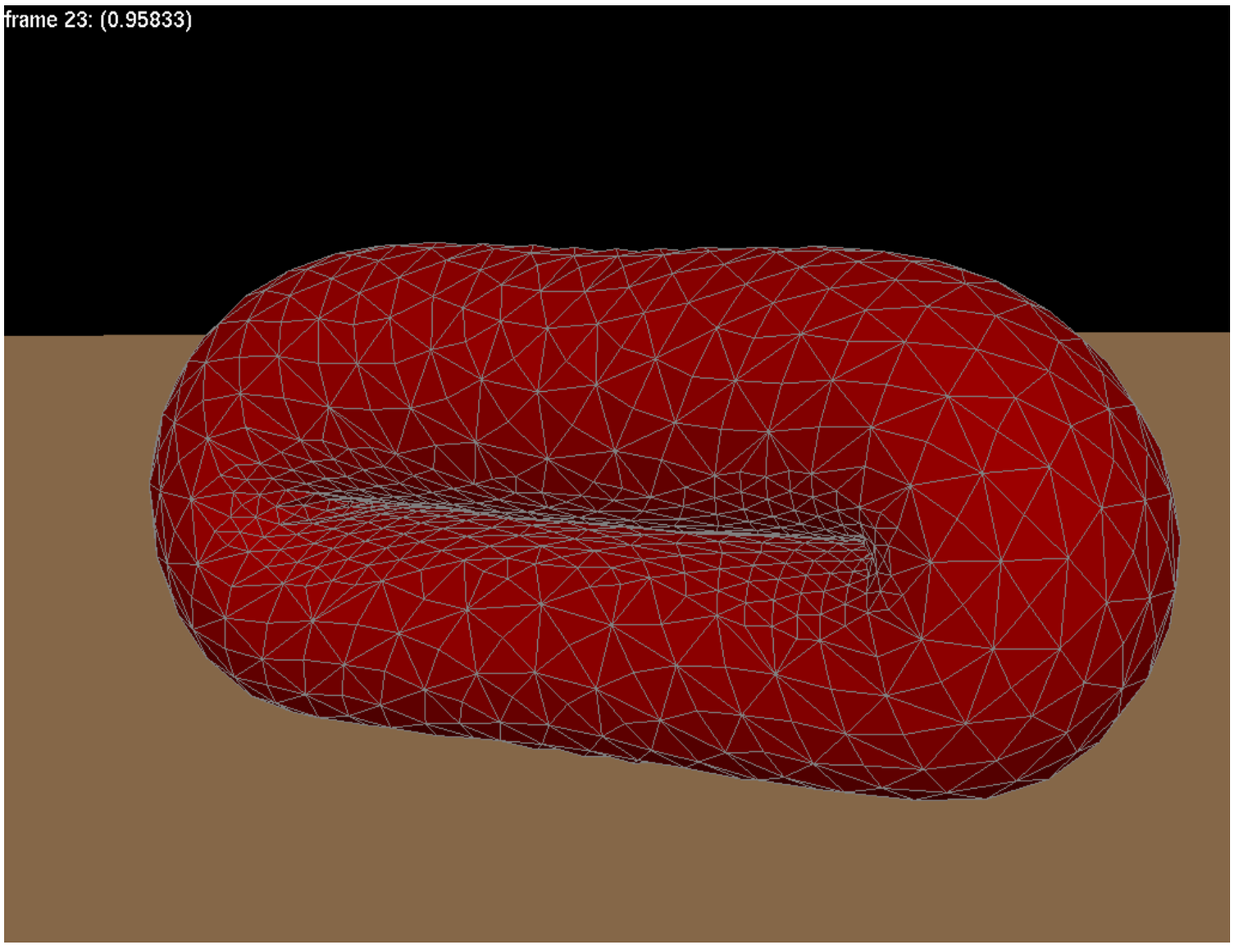
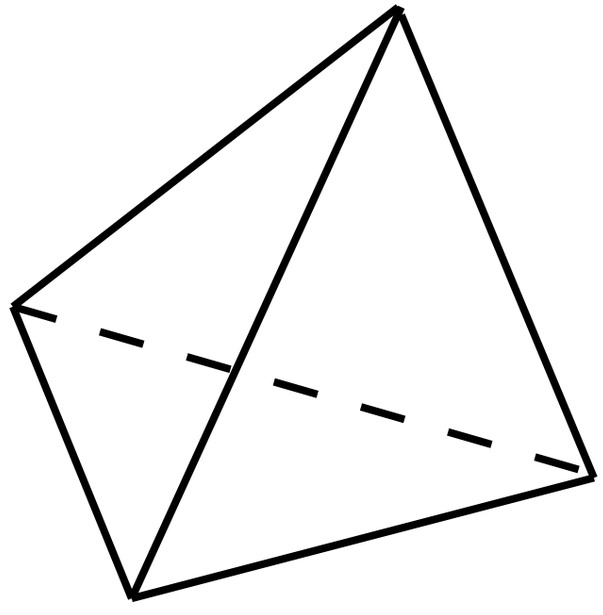
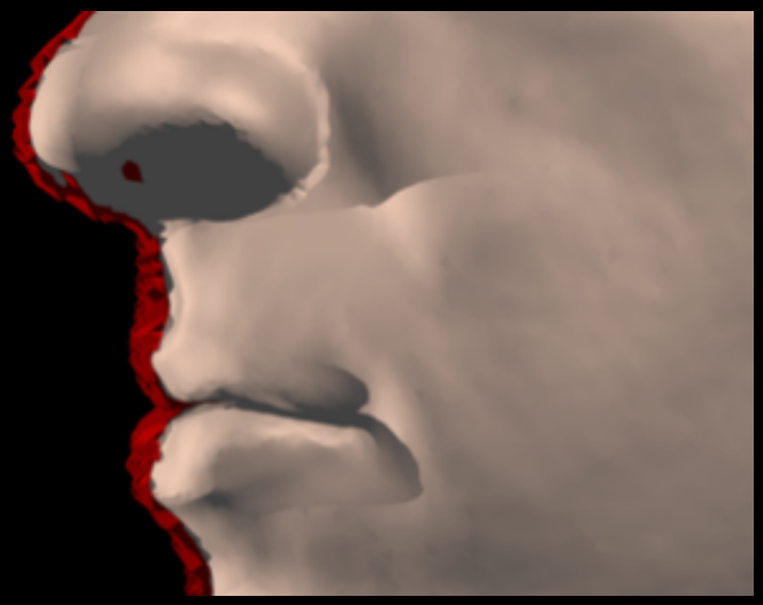
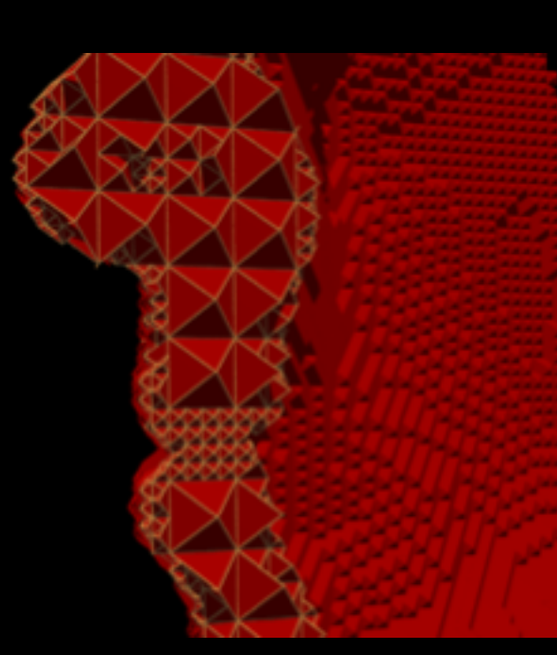
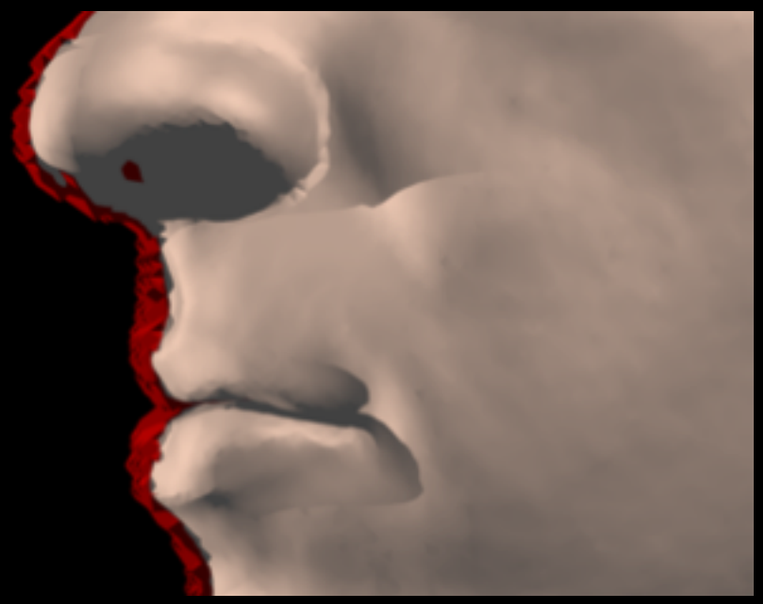


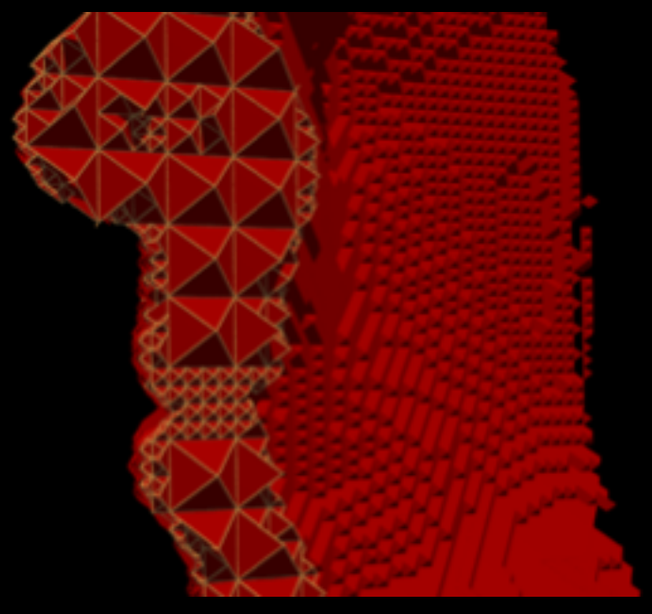
tetrahedron



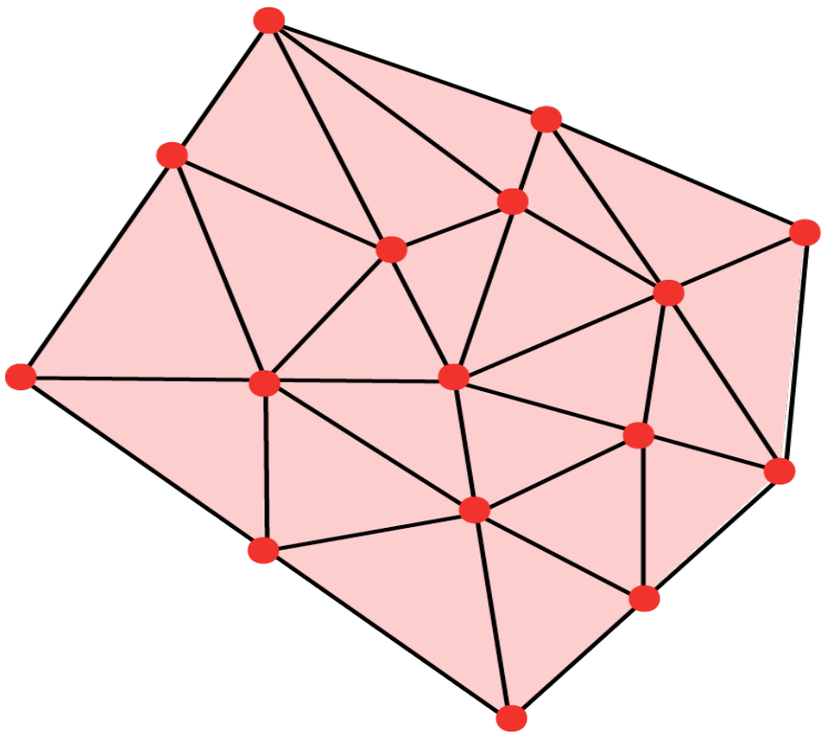








Deformable bodies: equations of motion



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Newton's 2nd Law

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$$\frac{d\vec{x}}{dt} = \vec{v}$$

$$m\frac{d\vec{v}}{dt} = \vec{F}$$

System of PDEs

contains spatial derivatives