CS130 : Computer Graphics
Lecture 17: Physics-Based Simulation

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

solid simulation in Pixar’s *Ratatouille*
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**fluid simulation** in Pixar’s *Ratatouille*
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**fluid simulation** in Pixar’s *Ratatouille*
Firestorm
Harry Potter and the Half Blood Prince
Industrial Light + Magic
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Harry Potter and the Half Blood Prince
Industrial Light + Magic
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
Particle: basic dynamic object

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

\[ \vec{F} = m\vec{a} \]

\[ \frac{d\vec{x}}{dt} = \vec{v} \]

\[ m\frac{d\vec{v}}{dt} = \vec{F} \]
Deformable bodies
Connect a bunch of particles into a **1D** line segment with springs
A Mass Spring Model for Hair Simulation

Connect a bunch of particles into a 2D mesh
Connect a bunch of particles into a 3D mesh
Deformable bodies: equations of motion

Equations of motion:
Newton’s 2nd Law

\[ \vec{F} = m\ddot{\vec{a}} \]

\[ \frac{d\vec{x}}{dt} = \vec{v} \]

\[ m\frac{d\vec{v}}{dt} = \vec{F} \]

System of PDEs
contains spatial derivatives