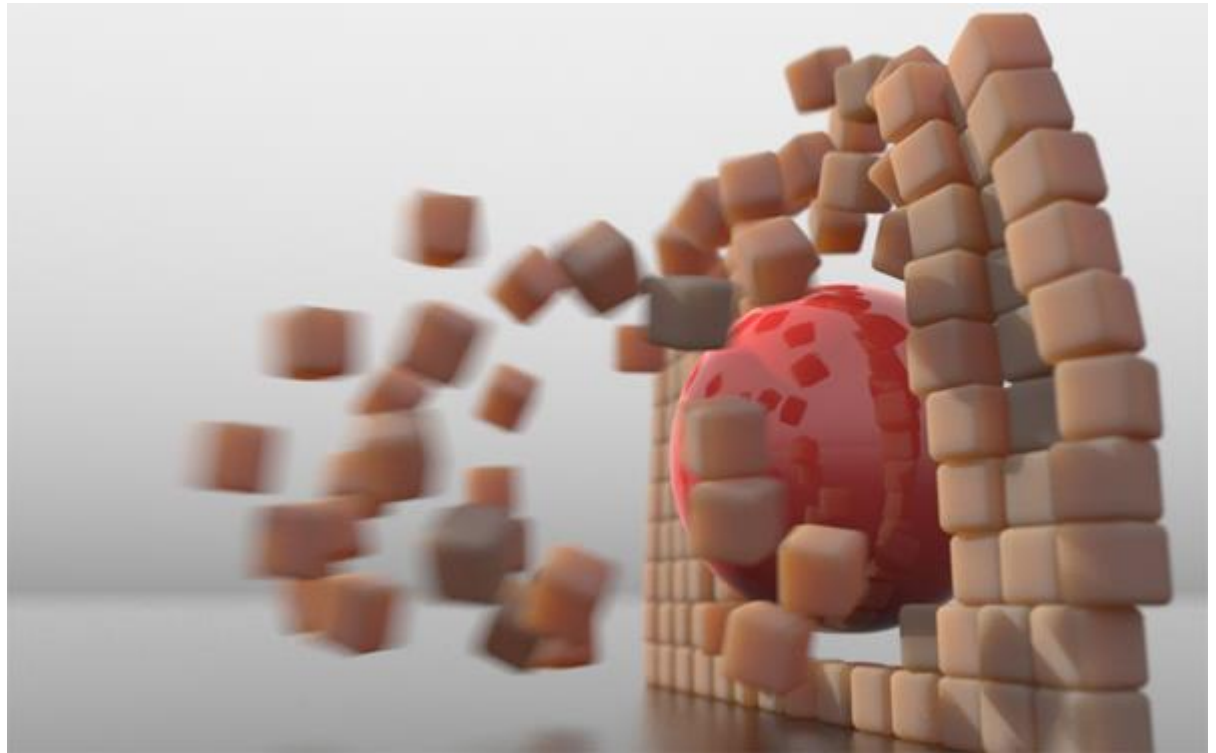


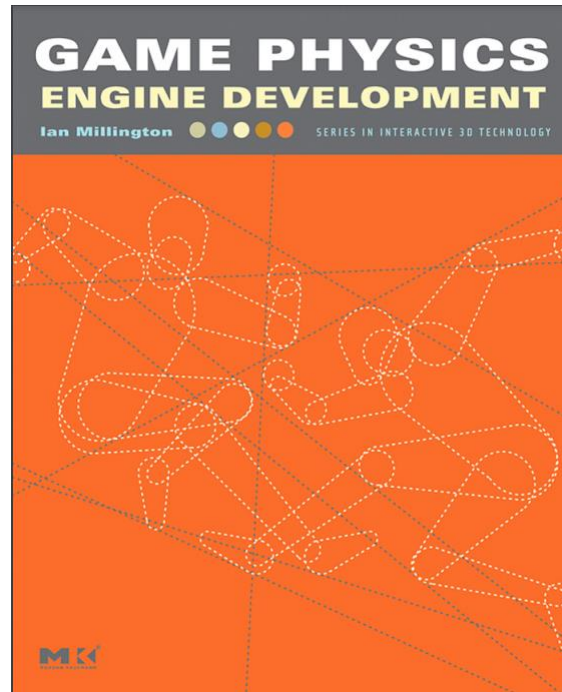
Physics Engines I

Fundamentals



Stefan Bornhofen

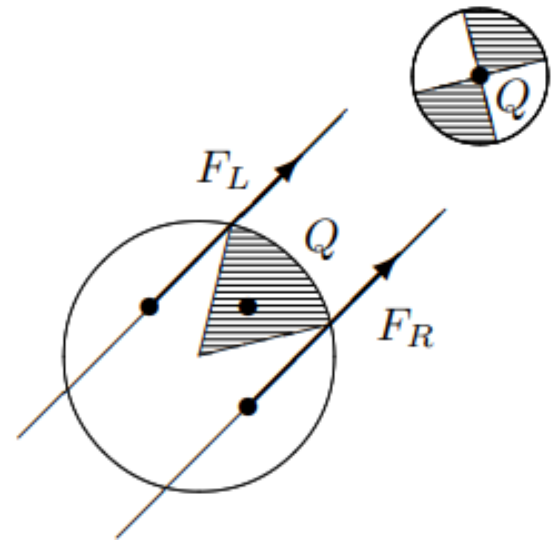
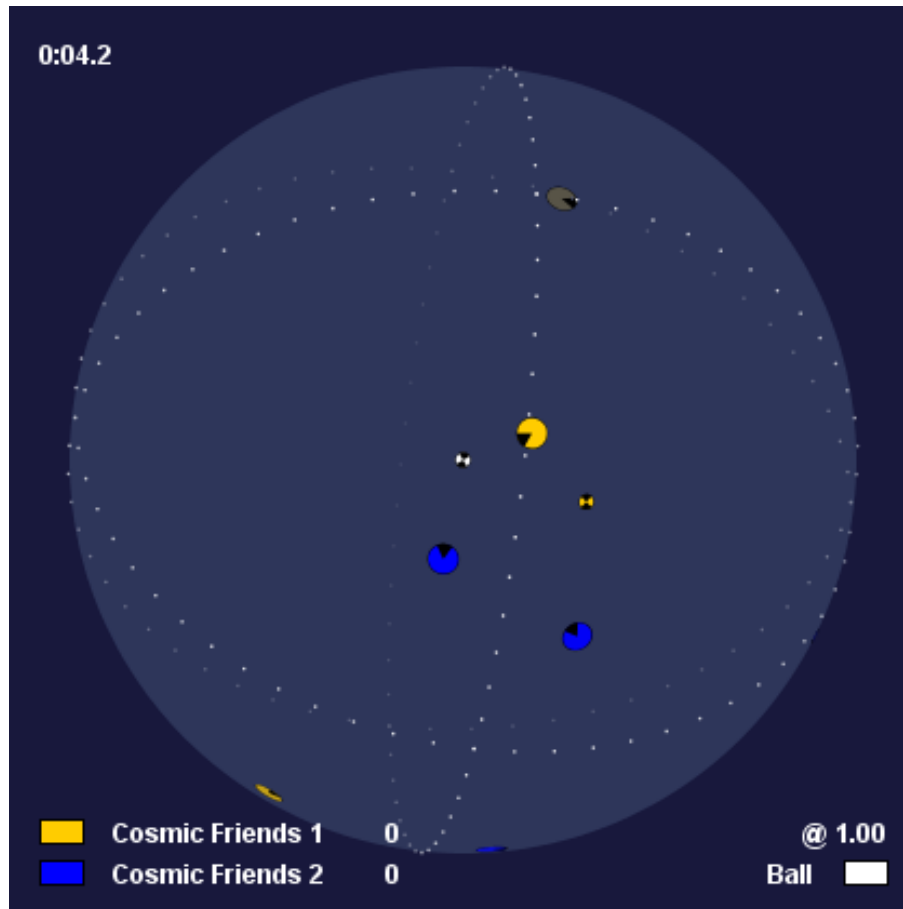
Our reference



Ian Millington: Game Physics Engine Development,
Morgan Kaufmann, 2007.

http://www.r-5.org/files/books/computers/algo-list/realtime-3d/Ian_Millington-Game_Physics_Engine_Development-EN.pdf

Hoverball



www.hoverball.org

Agenda

Physics Engines I

- Basic concepts

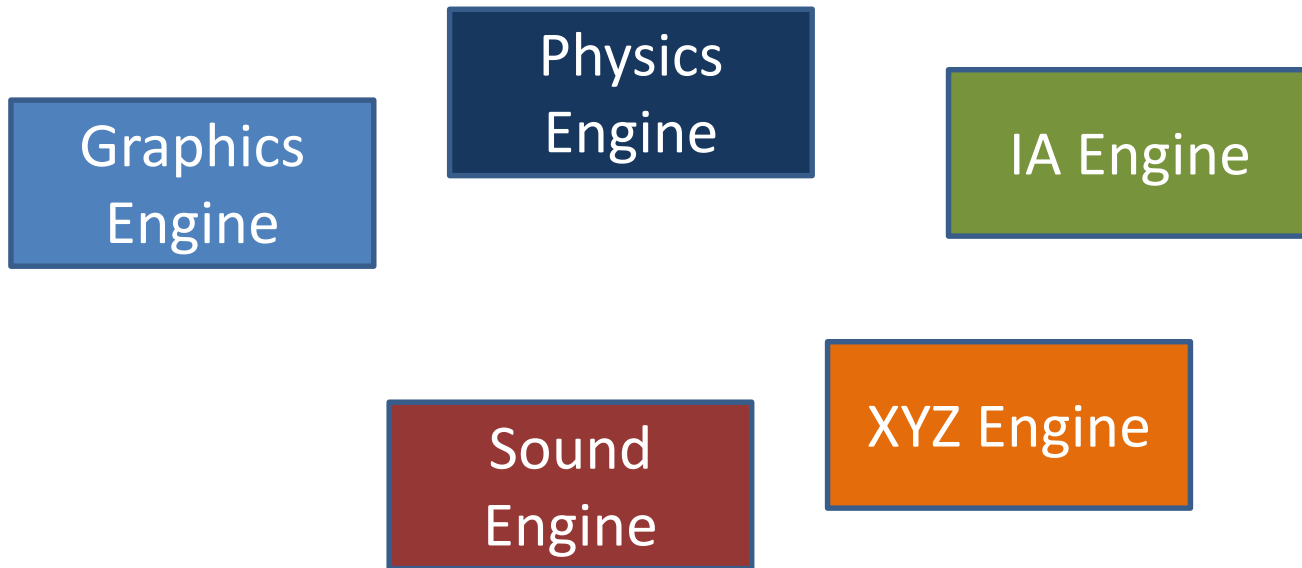
Physics Engines II

- Dynamics based on forces (2 days)

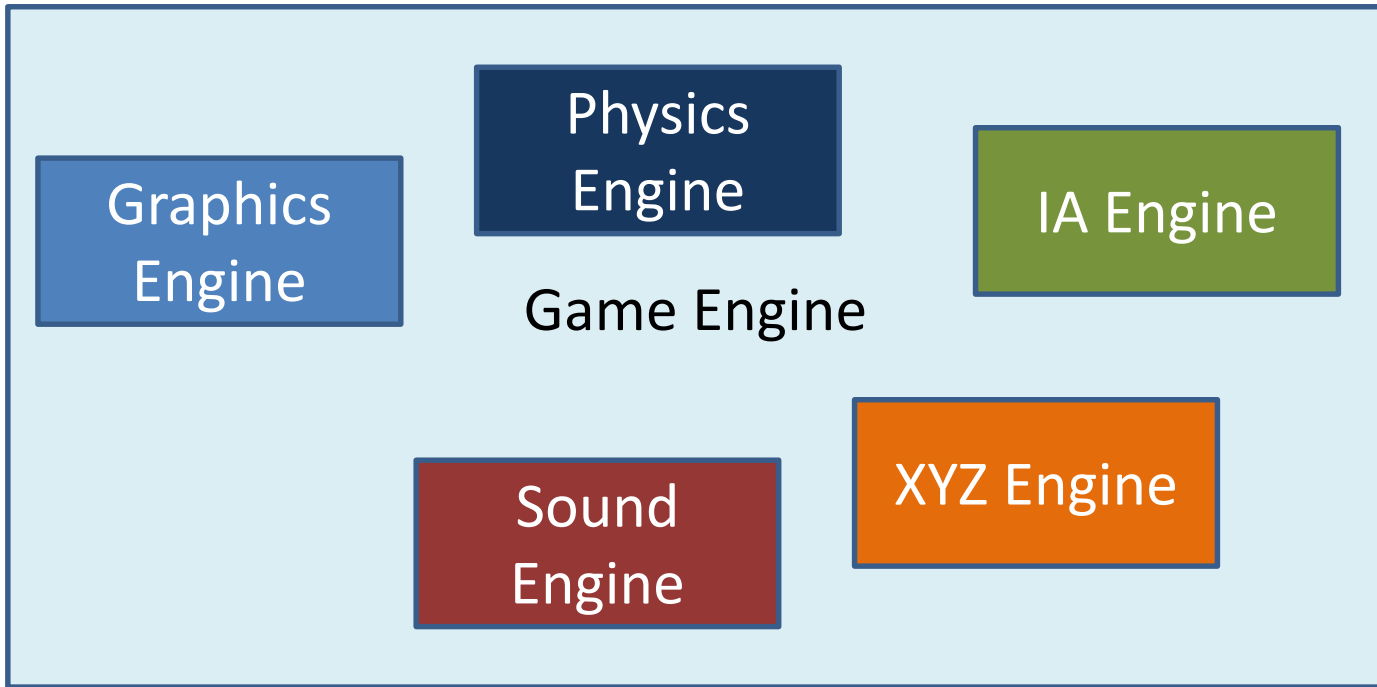
Physics Engines III

- Collision detection and resolution (2 days)

Engine



Engine




What is a Physics Engine?

- A physics engine is a library that models and simulates a physical system.
- It can simulate motion of objects in a virtual scene and predict effects under different conditions that would approximate what happens
 - in real life
 - or in a fantasy world (distorted dynamics).

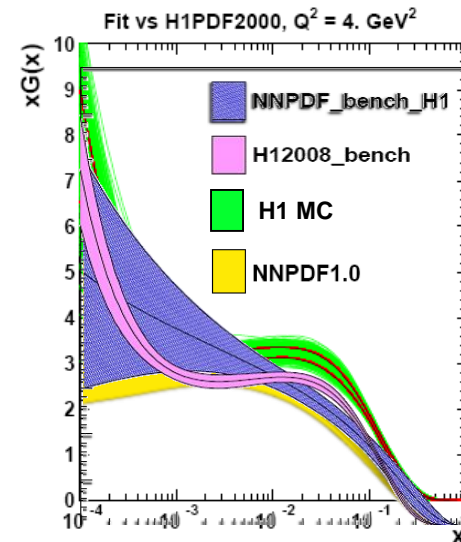
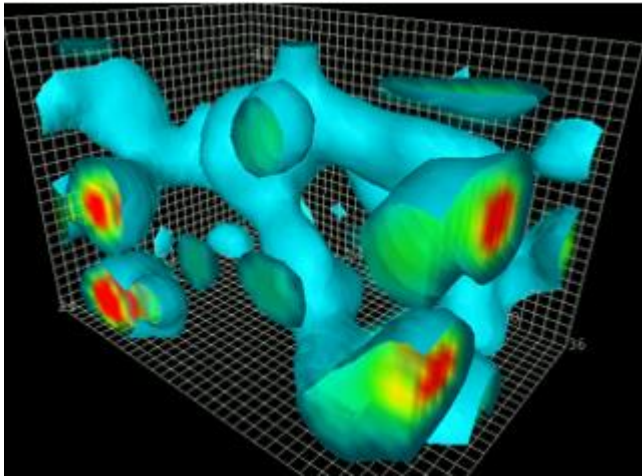
Classification

Physics engines can be classified into three main categories:

- Scientific
 - Industrial
 - Real-time
- 
- granularity

Scientific simulation

Employed by organizations like universities or NASA for various high-precision simulations.

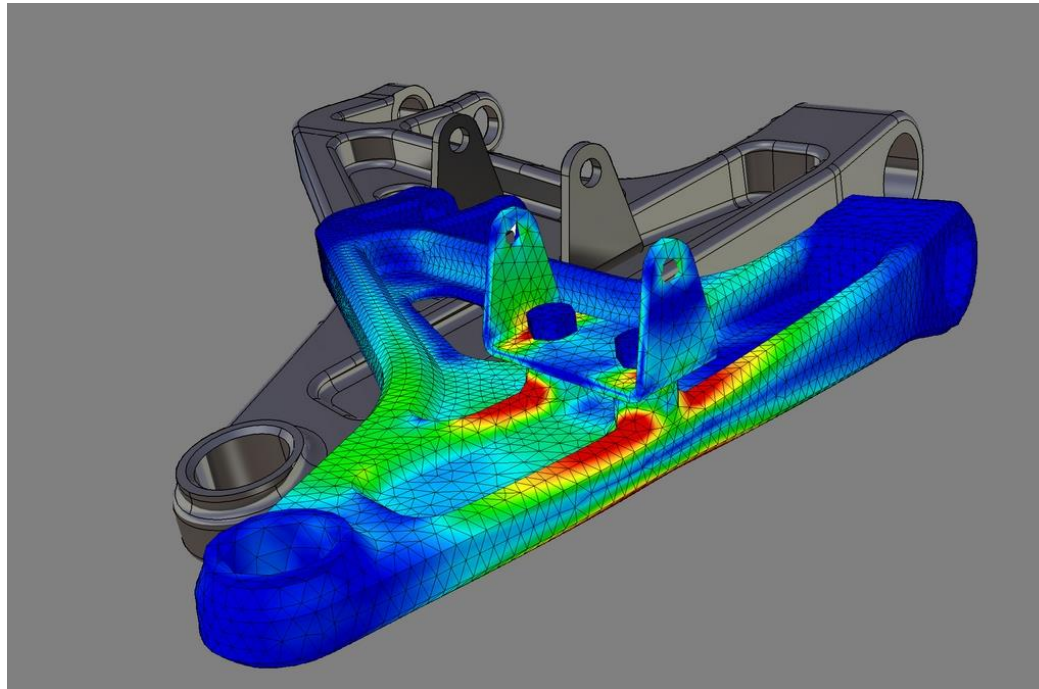


Summary of Hera-LHC Workshop: Parton Distributions
Ball et al; Feltesse, Glazov, Radescu; 0901.2504 [hep-ph]

Pythia: High-energy physics event simulator

Industrial simulation

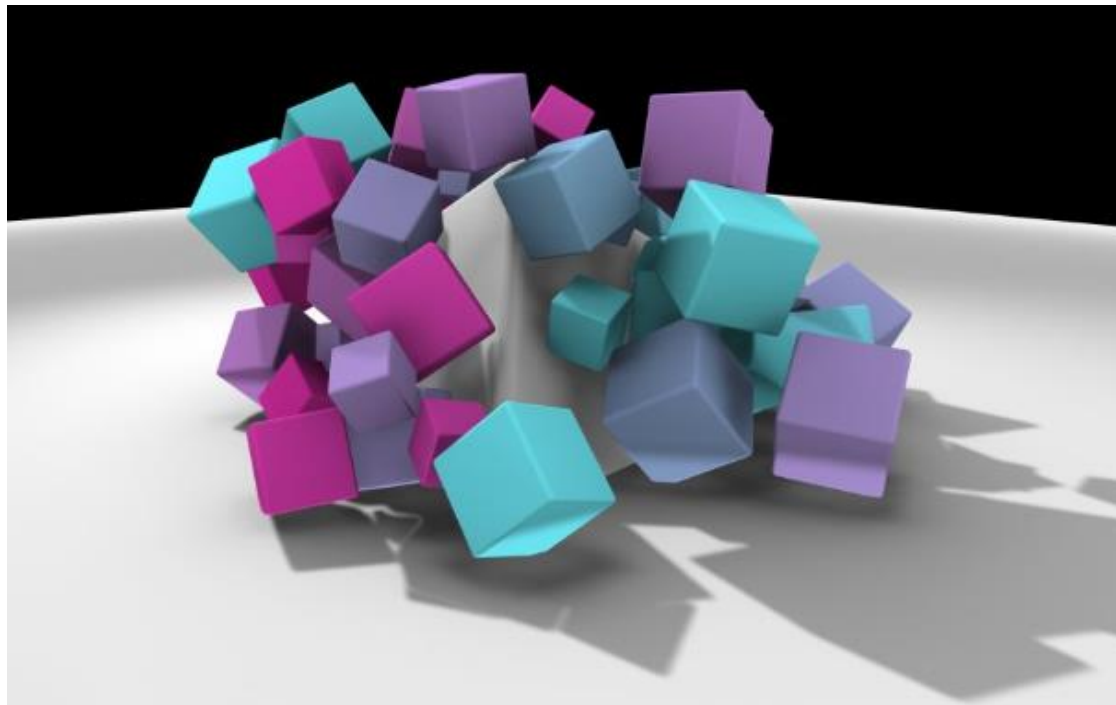
Heavily employed by automobile and aircraft industries.



Simulia: Physics simulator by Dassault Systèmes

Real-time simulation

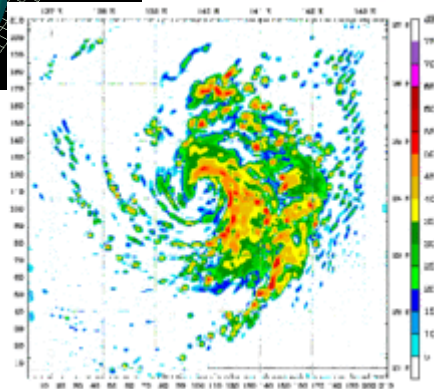
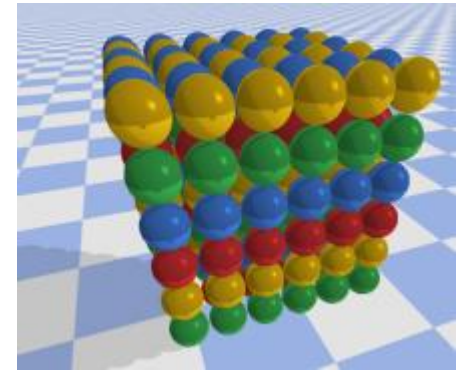
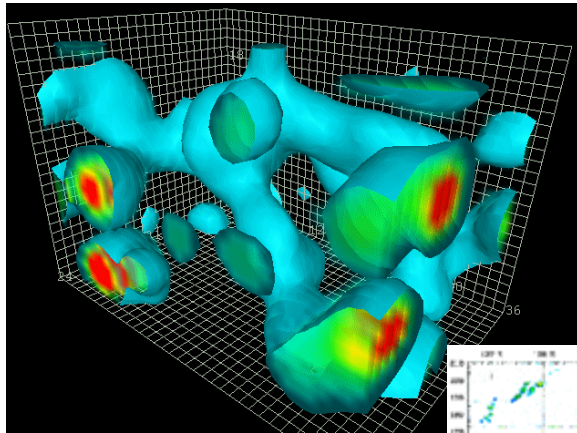
Approximate physics modelling to balance computational accuracy with the speed.



Speed vs. Accuracy

« you get what you pay for »

speed



accuracy

Simplification

- Real-time simulations, in particular computer games, do not implement physical systems down to the letter.
- They outline the physics needed and simulate the required effects as close to real life as possible, using a lot of **optimizations** and **assumptions** to simplify the original laws.

Physics Cheat

- Typically most 3D objects in a game are represented by two separate meshes or shapes.
 - **Visual geometry.** One of these meshes is a highly complex and detailed shape which the player sees in the game, for example a vase with elegant curved and looping handles.



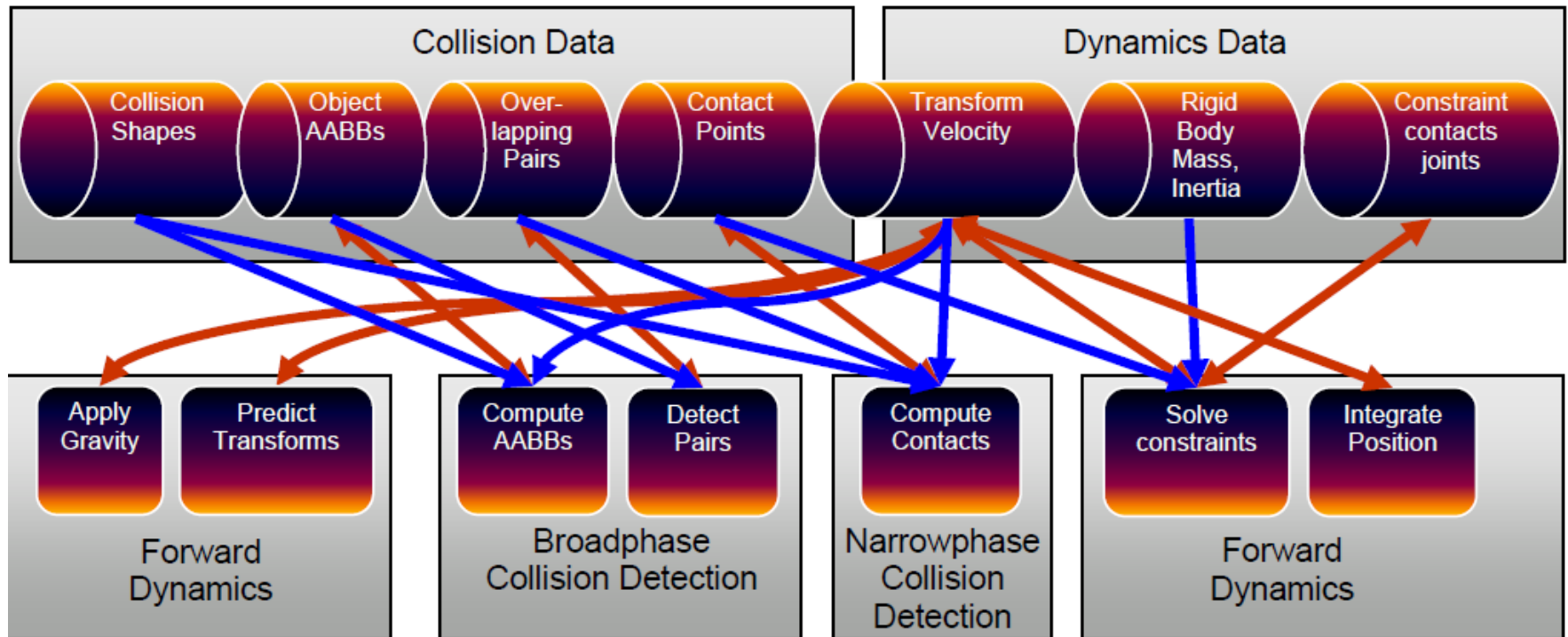
Physics Cheat

- Typically most 3D objects in a game are represented by two separate meshes or shapes.
 - **Visual geometry.** One of these meshes is a highly complex and detailed shape which the player sees in the game, for example a vase with elegant curved and looping handles.
 - **Physical geometry.** For purposes of speed, a second highly simplified invisible form is used to represent the object to the physics engine (“hitbox”)



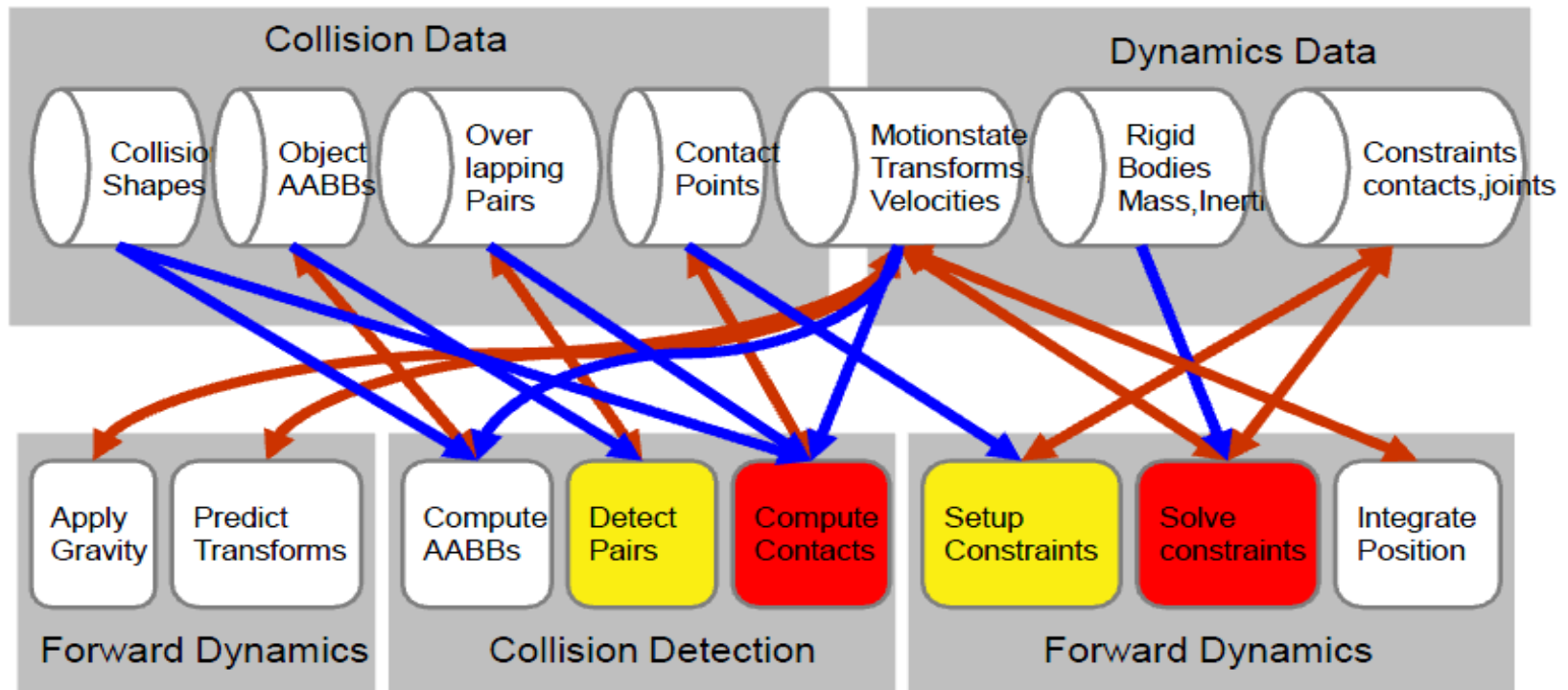
Physics Pipeline

- Physics engines have two core components:
 - a **collision detection** system
 - the **dynamics simulation** responsible for resolving the forces affecting the simulated objects.



Physics Pipeline

- Physics engines have two core components,
 - a **collision detection** system
 - the **dynamics simulation** responsible for resolving the forces affecting the simulated objects.



PPU

Dedicated Physics Processing Units

(*2006 †2008)



FIGURE 14-2 Asus-based AGEIA's PhysX PPU card



NVIDIA soon abandoned the idea of a PPU and replaced it by general GPU acceleration.

Current Real-time Solutions

Engine	Proprietary	OpenSource	Performance
Havok	Microsoft	n	Excellent
PhysX	NVIDIA	n	Excellent
Bullet	free, open	y	Good
Newton	free, open	y	Good
ODE	free, open	y	Moderate
...



The built-in physics in Unity and Unreal are subsets of the PhysX engine.

Object Types

Particles

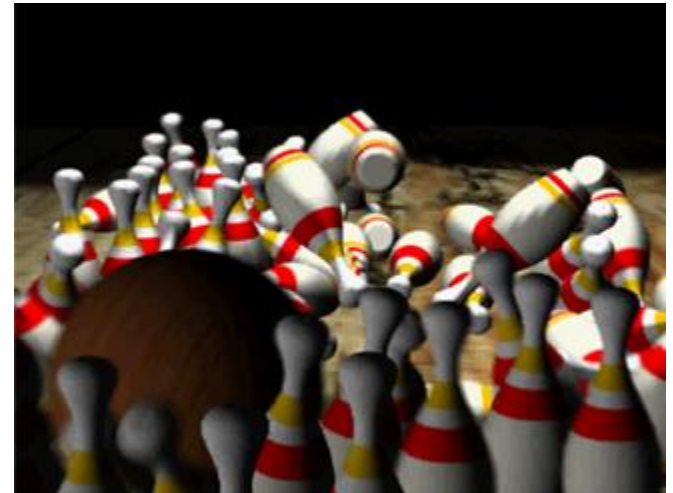
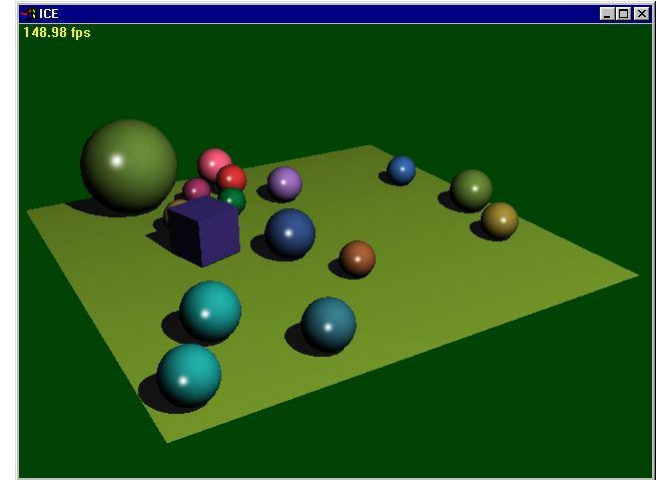
- A sphere of finite radius with a perfectly smooth, frictionless surface
- Mass, position, velocity
- Apply forces
- Experiences no rotational motion
- Move in 3 DOF
- Fast, good for game FXs.



Object Types

Rigid bodies

- occupy space and have geometrical properties, experience rotational motion
- Their shape does not change
- Mass, position, linear velocity, inertia tensor, orientation, angular velocity
- Move in 6 DOF
- Apply forces and torques



Object Types

Soft Bodies & Fluids

- The shape of soft bodies is deformable, meaning that the relative distance of two points on the object is not fixed
- Very time consuming
- The applications are mostly in video games and films.
- Modern games are starting to use soft body physics.

