Building a physics engine - part 1: architecture

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Physics engine basics

Main goals

- Apply Newton's law of motion $F = ma$ to linear and rotational movement (easy)
- Ensure no interpenetration of moving objects (absolutely **not easy**)

Physics engine basics

Interpenetration avoidance

- Find pairs of touching objects
- Find time of contact
- Find points of contact
- Apply forces to ensure no interpenetration/stacking/etc.

Physics engine basics

Finding colliding pairs

- Broad-phase collision detection with AABBs
- Medium-phase collision detection with bounding volumes (BS, OBB)
- Narrow-phase collision detection to find exact time and points of contact

Physics engine basics

Collision response

- Between pairs of objects: easy, just apply the laws of conservation of momentum
- How about between multiple objects, maybe even stacked?
- Solving in pairs does not work!
- We need to solve all of these constraints at the same time

Physics engine basics

Collision response and constraints

- Collision response balances external forces and velocities; it applies to multiple kinds of constraints:
  - Contact constraints (the obvious ones)
  - Distance constraints
  - Friction constraints
  - ...

General layout of a physics engine

```
physics.Initialize:
  setup AABB, BV (BS and others), BSP/Gauss maps,
      other support data structures

physics.Tick:
  update AABBs
  find AABBs intersections
  refine AABBs intersections with BV tests (optional)
  separating axes collision detection
  resolve physics constraints
    contacts
    friction
    distance
    ...
  apply kinematics
```

Assignment

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- Before the end of next week
- Group-work archive/video on Natschool or uploaded somewhere else and linked in your report
- Individual report by each of you on Natschool
- Build a kinematics simulator with movement and rotation, with RK2 or RK4

That's it

Thank you!