Game Physics
Game Programming

● Rendering
● Looping and control
● Math
● Animation
● Physics
● Behaviour and navigation (AI)
● Effects
● Networking
Game Programming

- Rendering
- Looping and control
- Math
- Animation
- **Physics**
- Behaviour and navigation (AI)
- Effects
- Networking
Physics

● Simulation
  ○ Rigidbody dynamics
  ■ Forces
    ● Mass
    ● Gravity
    ● Friction
Physics

- Simulation
  - Rigidbody dynamics
  - Collision detection
Unity physics engines

- Built-in 2D physics engine
- Built-in 3D physics engine
- DOTS physics engine
Unity physics engines

- Built-in 2D physics engine
  - Box2D: [https://github.com/erincatto/box2d](https://github.com/erincatto/box2d)

- Built-in 3D physics engine
  - Nvidia PhysX

- DOTS physics engine
  - Unity Physics / Havok Physics for Unity
Rigidbody

- Mass: 1
- Drag: 0
- Angular Drag: 0.05
- Use Gravity: unchecked
- Is Kinematic: checked
- Interpolate: Interpolate
- Collision Detection: Discrete
- Constraints
- Info
Rigidbody

- Mass: 1
- Drag: 0
- Angular Drag: 0.05
- Use Gravity: Unchecked
- Is Kinematic: Checked
- Interpolate: Interpolate
- Collision Detection: Discrete
Rigidbody

- Mass: 1
- Drag: 0
- Angular Drag: 0.05
- Use Gravity: unchecked
- Is Kinematic: checked
- Interpolate: Interpolate
- Collision Detection: Discrete

Character controller?
Rigidbody

Character controller ?

Non-player : Rigidbody
Project settings: Physics

- Gravity: X 0, Y -9.81, Z 0
- Default Material: None (Physic Material)
- Bounce Threshold: 2
- Sleep Threshold: 0.005
- Default Contact Offset: 0.01
- Default Solver Iterations: 6
- Default Solver Velocity Iterations: 1
- Queries Hit Backfaces: [off]
- Queries Hit Triggers: [on]
- Enable Adaptive Force: [on]
- Contacts Generation: [off]
- Auto Simulation: [on]
- Auto Sync Transforms: [on]
- Reuse Collision Callbacks: [on]
- Cloth Gravity: X 0, Y -9.81, Z 0
- Contact Pairs Mode: Default Contact Pairs
Demo : 3D Game Kit

- Create a new **Scene**
- Add an **Cube** with RigidBody component
  - isKinematic
  - useGravity
Project settings: Time

Time

Fixed Timestep: 0.02
Maximum Allowed Timestep: 0.333333
Time Scale: 1
Maximum Particle Timestep: 0.03
Demo : 3D Game Kit

- Create a new **Scene**
- Change **FixedUpdateTimestep**
- Add a **Cube** and let it fall
Rigidbody
Demo : 3D Game Kit

- Create a new `Scene`
- Change `FixedUpdateTimestep`
- Add a `Cube` and let it fall
Collision detection

- Performance
  - Discrete collision detection
  - Continuous collision detection
Discrete collision detection

- Intersection test
  - Point-circle
  - Point-rectangle
  - Circle-circle
  - Circle-rectangle
  - Point-stadium
  - ...

Discrete collision detection

- Intersection test
- Temporal search
  - FixedUpdate() ?
Discrete collision detection

- Intersection test
- Temporal search
  - Accurate result?
Discrete collision detection

- Intersection test
- Temporal search
  - Accurate result?
    - Linear / binary search?
Discrete collision detection

- Intersection test
- Temporal search
  - Accurate result?
    - Linear / binary search?
    - Final result?
Discrete collision detection

- Intersection test
- Temporal search
  - Accurate result?
    - Linear / binary search?
    - Final result?
Colliders

* The shape of a GameObject for the purposes of physical collisions:
  * box collider, sphere collider, capsule collider, …
Colliders

- The shape of a GameObject for the purposes of physical collisions:
  - box collider, sphere collider, capsule collider, …
  - compound, or mesh collider?
Colliders

- The shape of a GameObject for the purposes of physical collisions:
  - box collider, sphere collider, capsule collider, …
  - compound, or mesh collider?
    - convex
Colliders

- The shape of a GameObject for the purposes of physical collisions:
  - box collider, sphere collider, capsule collider, …
  - compound, or mesh collider?
    - convex
  - Trigger
    - without real collisions
Collider interactions

- Static Collider
  - .... static
- Rigidbody Collider
  - collide with each other
- Kinematic Rigidbody Collider
  - ... static ?
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<th>RigidBody Collider</th>
<th>Kinematic RigidBody Collider</th>
<th>Static Trigger Collider</th>
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Project settings: Physics
Demo : 3D Game Kit

- Create a new **Scene**
- Add two **Cube** and make them collide
Discrete collision detection

- Intersection test
- Temporal search
  - Fast objects?
- Multiple collisions may happen
Continuous collision detection

- Intersection test
- Temporal search
- Multiple collisions may happen
Continuous collision detection

- Intersection test
- Temporal search
- Multiple collisions may happen
Continuous collision detection

- Intersection test
- Temporal search
- **Multiple collisions may happen**
Sweep-based CCD
Speculative CCD [1]
Speculative CCD [2]
Speculative CCD [3]
Speculative CCD [4]
Speculative CCD [5]
Demo : 3D Game Kit

- Create a new **Scene**
- Add two **Cube** and make them collide
Physics material

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<td>Bounciness</td>
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<td>Friction Combine</td>
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<tr>
<td>Bounce Combine</td>
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Physics material

Inspector

Grenade

- Dynamic Friction: 20
- Static Friction: 20
- Bounciness: 0.6
- Friction Combine: Maximum
- Bounce Combine: Maximum
Demo : 3D Game Kit

● Create a new Scene
● Add an enemy using Grenadier prefab
● Play with Physics material: Grenade
Physics debug visualization
Data-oriented design
Data-Oriented Technology Stack

- Entity Component System (ECS)
- C# Job System
- Burst compiler
Q & A