Principles of Computer Game Design and Implementation

Lecture 18

We already learned

- Collision detection
- Collision response

Outline for today

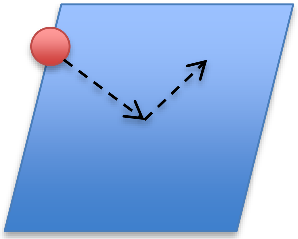
- Physics engines
- The usage of physics engine in jMonkey

Classes of Physics Engines

- High-precision physics engines:
  - usually used by scientists and computer animated movies.
  - more processing power to calculate very precise physics
- Real-time physics engines
  - used in video games and other forms of interactive computing
  - use simplified calculations and decreased accuracy to compute in time for the game to respond at an appropriate rate for gameplay.

Real-Time Game Physics

- We had a look at just some aspects of the use of physics in computer games
  - Particle motion
    - Newtonian physics
  - Simple collision
    - Ball-Plain
    - Ball-Ball
- Rigid-body physics, soft-body physics, fluid mechanics, etc



Physics Engine

- A prebuild solution
  - Typically provides above mentioned functions
  - Supports collision detection
    - Part of physics?
    - Part of graphics?
    - All-in-one solutions exist
      - jME v3.0

Physics Engine vs Home Tools

- Advantages of game engines
  - Complete solution from day 1
  - Proven, robust code base (in theory)
  - Lower costs
- Advantages of home-grown solutions
  - Choose only the features you need
  - Opportunity for more game-specific optimizations
  - Greater opportunity to innovate

Hardware support

- Hardware acceleration for physics processing is now usually provided by graphics processing units that support more general computation, a concept known as General Purpose processing on Graphics Processing Unit.
- AMD and NVIDIA provide support for rigid body dynamics computations on their latest graphics cards.
- Migrating data into graphical form and then using the GPU to scan and analyze it can create a large speedup.

Some Physics Engines

This is an incomplete list of physics engines available on the market.

- Open Source
  - Bullet
    - jBullet – a Java port
  - Box2D
  - Newton Game Dynamics
  - Open Dynamics Engine (ODE)

Commercial Projects

- Havoc
- PhysX
- Euphoria
- …

Bullet

- Features: Multiplatform support, various shapes for collision detection, rigid and soft-body dynamics, discrete and continuous collision detection, constraints and motors, plugins.
- improved support for robotics, reinforcement learning and VR.
- Showcase:
  - Movies:
    - How to train your dragon, Megamind, Shrek, Sherlock Holmes, Bolt …
  - Games:
    - Toy story 3
    - HotWeels: Battle Force 5
    - …

Newton Dynamics

- Scene management, collision detection, dynamic behaviour
- Showcase: A number of games including *Penumbra*, *Mount&Blade*

ODE

- Features:
  - Rigid body dynamics
  - Collision detection engine
- Showcase:
  - Call of Juarez
  - World of Goo
  - …

Havoc

- Features: rigid body dynamics, collision detection
- Lots (over 150) of games, including
  - Halo (2, 3, Wars, Reach)
  - Bioshock (1, 2)
  - Fable (2, 3)
  - Battlefield: Bad Company (1, 2)
  - …

PhysX

- Fully-fledged physics engine with hardware acceleration
- Showcase:
  - Metro 2033
  - Mafia II
  - …

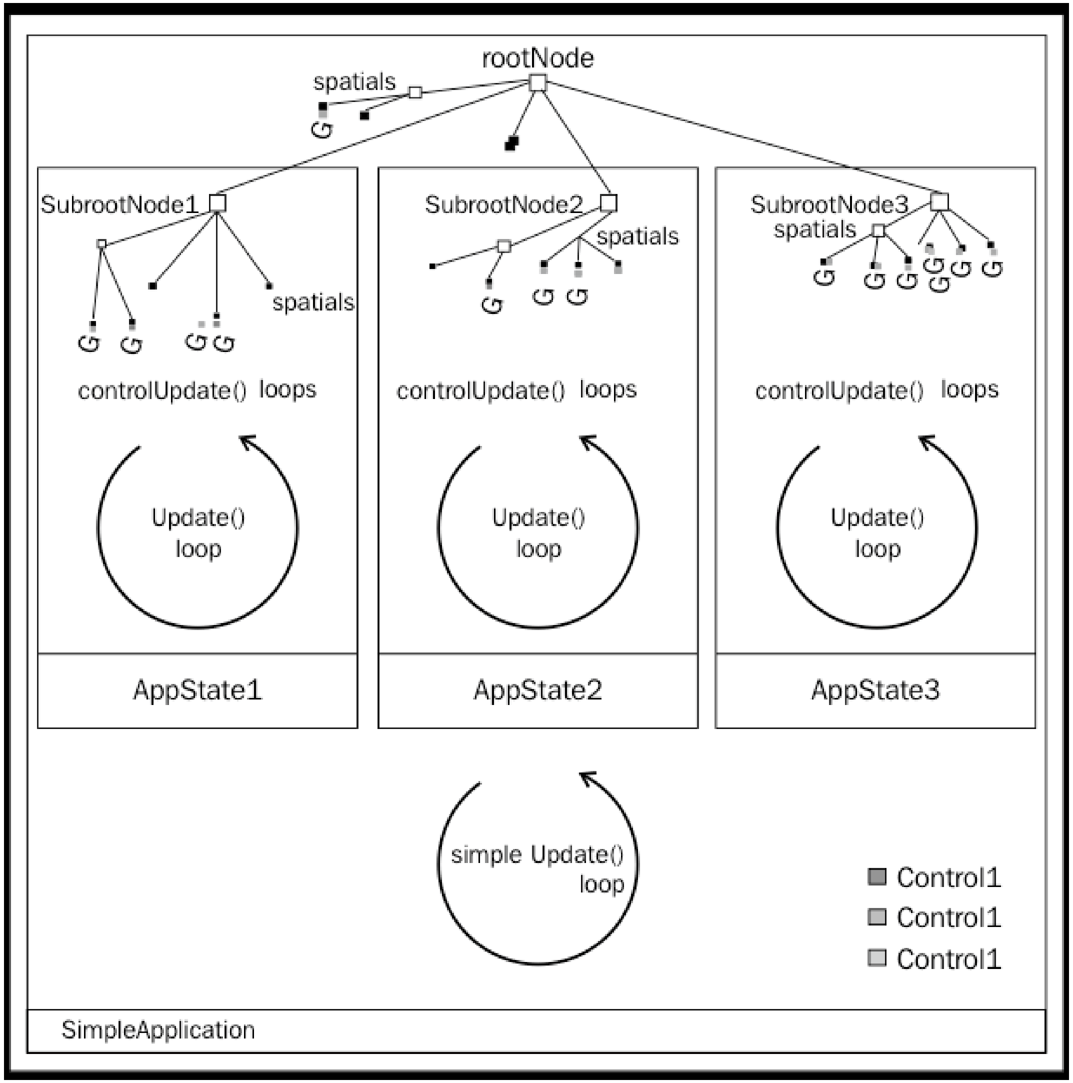
Euphoria

- Features: on the fly 3D character animation.
- Showcase:
  - GTA IV
  - Red Dead Redemption
  - Star Wars: The Force Unleashed

jBullet

- A re-implementation of the Bullet physics engine
  - `most of Bullet 2.72 base features’
  - Bullet is now at version 2.83
- jMonkeyEngine integration
- jMonkey also supports native Bullet
  - Functionality purposely limited to that of jBullet

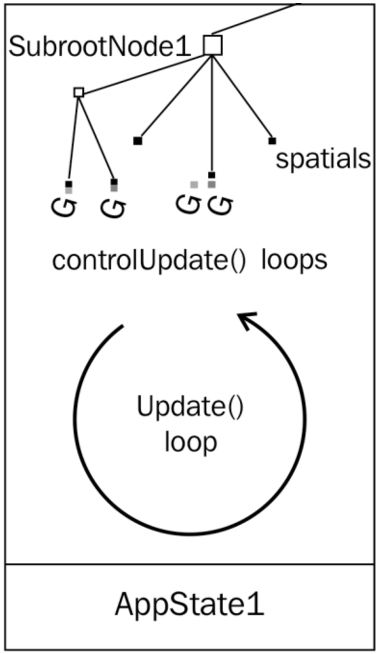
jME3 AppState



- jME is natively a multithreaded application
- A separate control loop associated with an AppState

- Physics engine is one such control loop

Setting Up the Engine



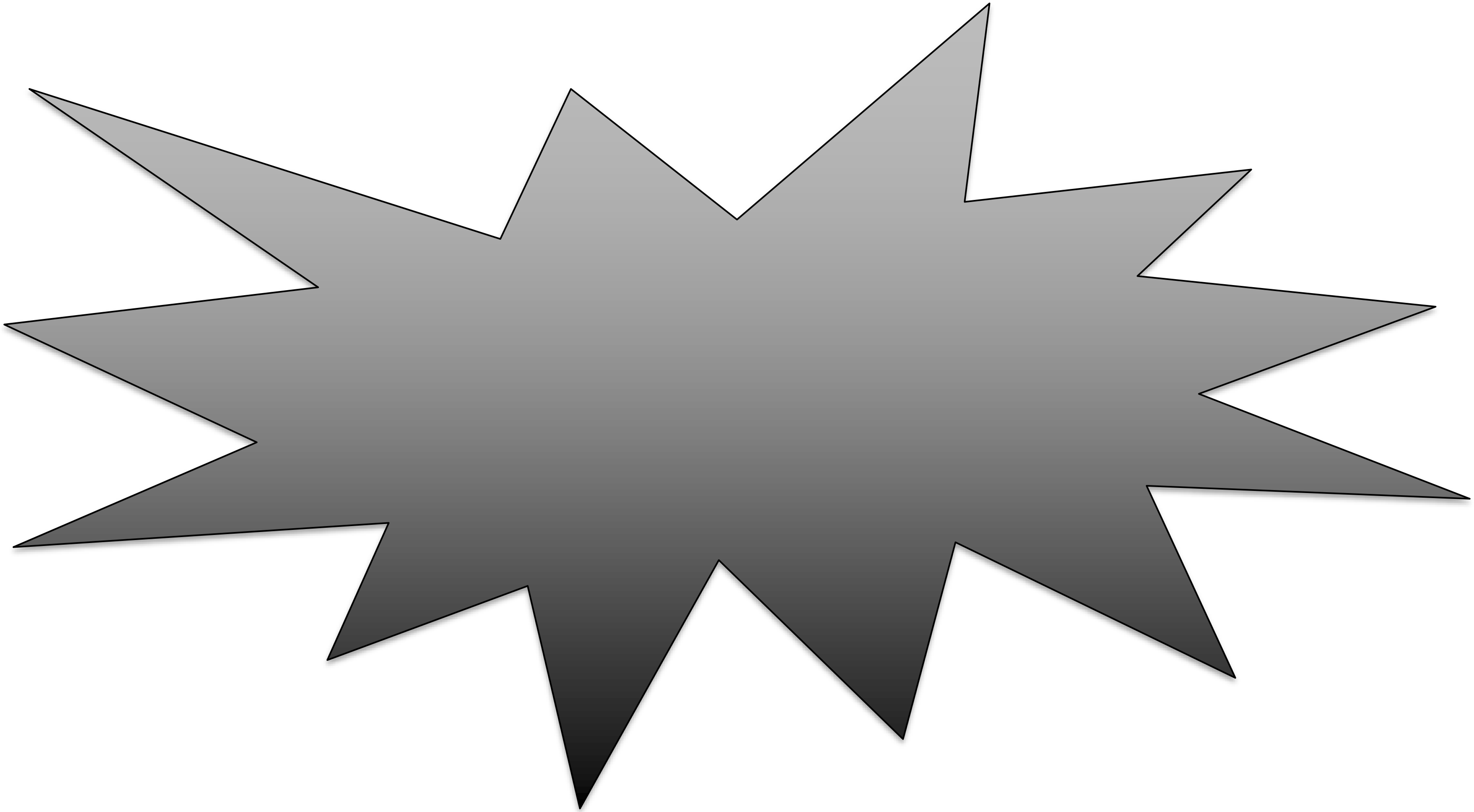
```
public void simpleInitApp() {
  bulletAppState = new
                BulletAppState();

stateManager.attach(bulletAppState);
```

Rigid Body Mechanics

```
Sphere s = new Sphere(60, 60, 1.5f);
Geometry ball = new Geometry("Sphere", s);
ball.setMaterial(mat);
ball.move(15, 30, 0);

RigidBodyControl myControl = new
                      RigidBodyControl(1f);
ball.addControl(myControl);

bulletAppState.getPhysicsSpace().add(myControl)
;

rootNode.attachChild(ball);
```

Body mass

Demo



Tuning the Behaviour

```
RigidBodyControl myControl =
    new RigidBodyControl(1f);
ball.addControl(myControl);
```

Make it bounce

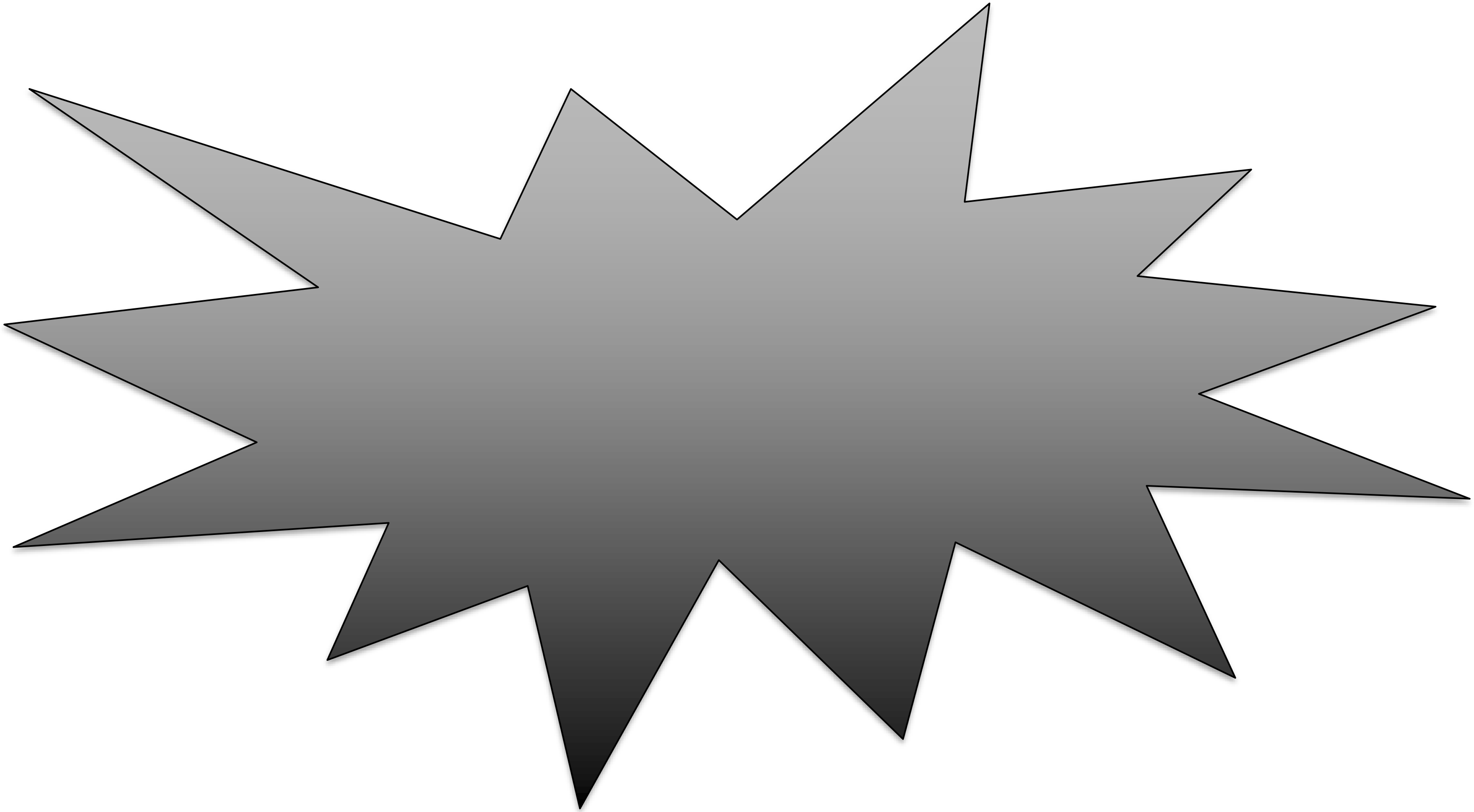
```
myControl.setRestitution(.8f);

myControl.setFriction(2);
```

Linear

Roll

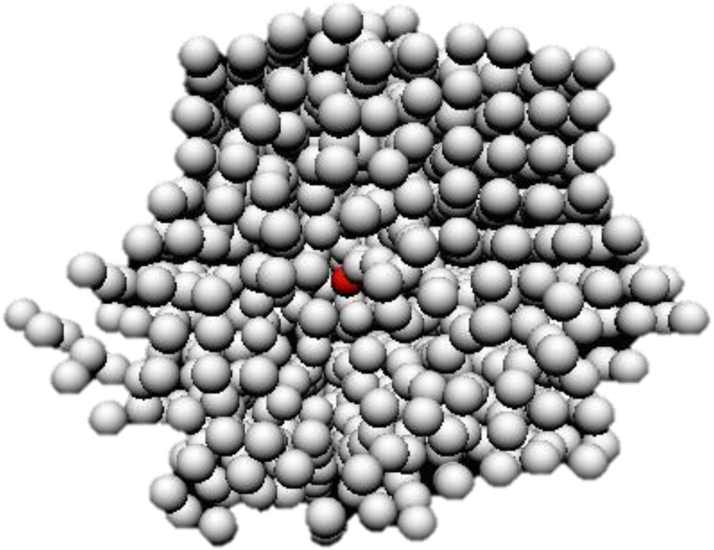
```
myControl.setDamping(0, 0.1f);
```

Demo

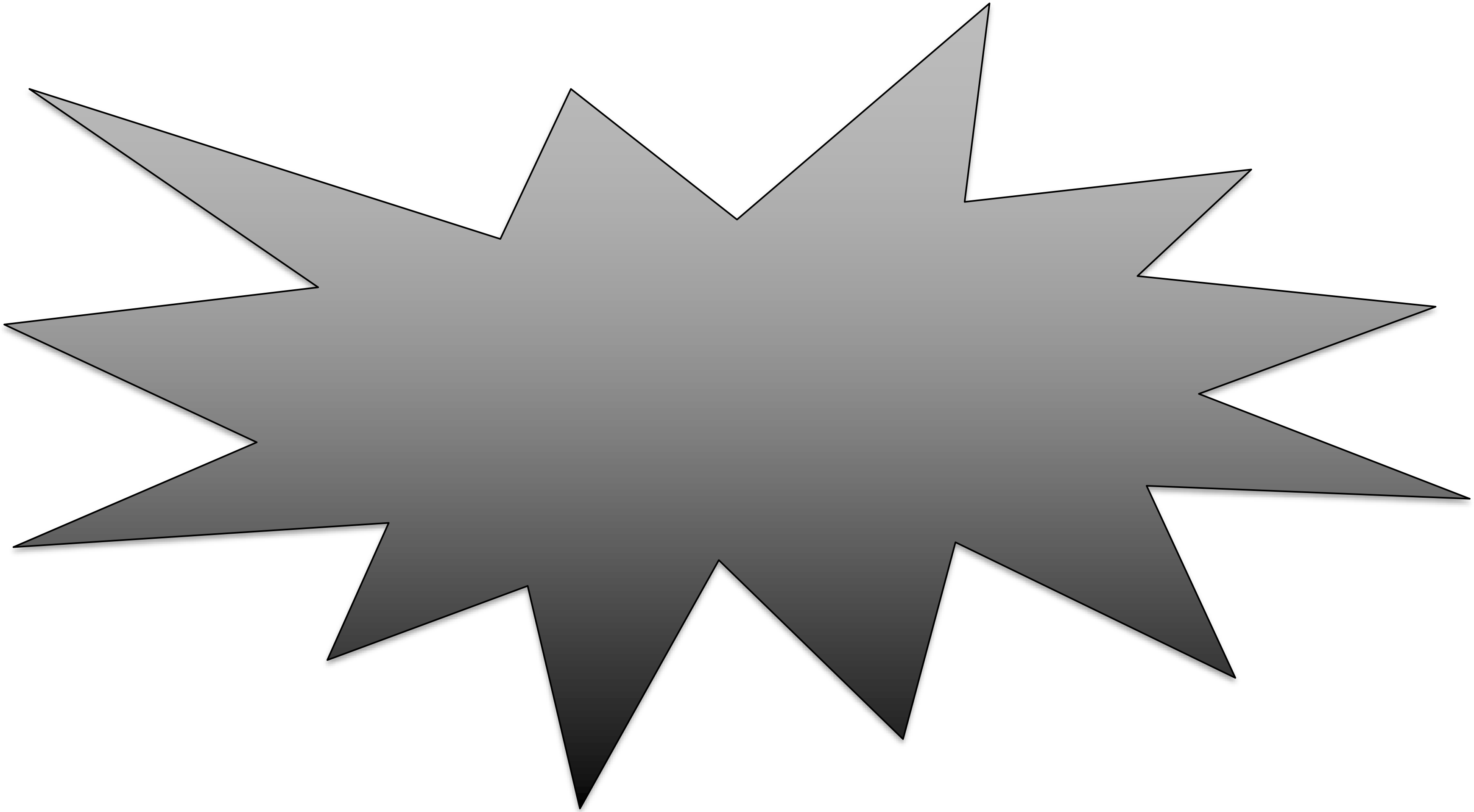


Global Properties

```
bulletAppState =
        new BulletAppState();
stateManager.attach(bulletAppState);
bulletAppState.getPhysicsSpace().
                      setGravity(Vector3f.ZERO);
```



Demo



Static, Dynamic and Kinematic Objects

- An object of zero mass is static

```
RigidBodyControl scenePhy =
             new RigidBodyControl(0f);
```

- Dynamic and Kinematic objects have non-zero mass

```
RigidBodyControl paddleControl =
        new RigidBodyControl(100f);
paddleControl.setKinematic(true);
```

Controlling Static or Kinematic Entities

- setLocalTranslation
- setLocalRotation
- move
- rotate
- …

The difference:

Kinematic objects update their physical state as they move

Controlling a Dynamic Entity (1)

`setAngularVelocity(v)`	This sets the current rotational speed of the object. The x, y, and z components of the vector are the speed of rotation around the respective axis. (Rotation)
`setLinearVelocity(v)`	This sets the current linear speed of this object. (Translation)
`applyCentralForce(v)`	This pushes an object over time with an additional moment `v`, expressed as `Vector3f`, applied to the center. (Translation)
`applyForce(v,p)`	This pushes an object over time with additional force `v`, applied to a non-central point `p`. (Translation)
`applyTorque(v)`	This twists an object over time additionally around its axes. The x, y, and z components of the `Vector3f` `v` specify the torque around the respective axis. (Rotation)

R. Kusterer: jMonkeyEngine 3.0 Beginner's Guide

Controlling a Dynamic Entity (2)

`applyTorqueImpulse(v)`	This applies an instantaneous torque `v` to the object. The x, y, and z components of the `Vector3f v` specify the torque around the respective axis. (Rotation)
`applyImpulse(v,p)`	This applies an instantaneous impulse `v`, expressed as `Vector3f`, to the object at a point `p` relative to the object. (Translation)
`clearForces()`	This cancels all forces and stops all current motion.

R. Kusterer: jMonkeyEngine 3.0 Beginner’s Guide

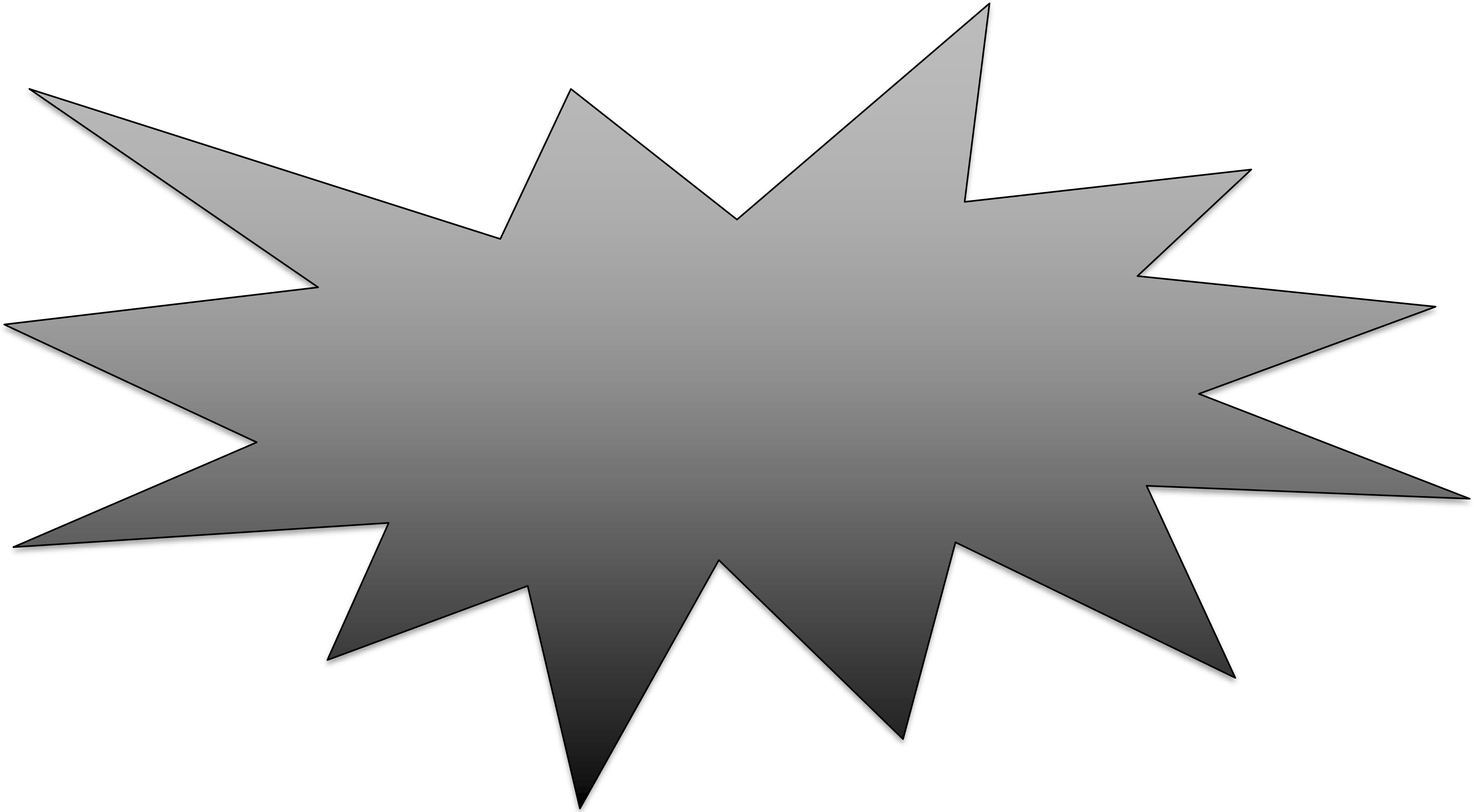
Physics-Based Collision Detection in jME3

```
public class Example06 extends
SimpleApplication implements
PhysicsCollisionListener {
…
}
public void collision(PhysicsCollisionEvent event) {
      …
   }
```

Reacting to Collision Events

```
public void collision(PhysicsCollisionEvent event) {
  if((event.getNodeA().getName().equals("Sphere") &&
     event.getNodeB().getName().equals("paddle"))||
    (event.getNodeB().getName().equals("Sphere") &&
      event.getNodeA().getName().equals("paddle"))){
       Material mat = new Material(assetManager,
         "Common/MatDefs/Light/Lighting.j3md");
       mat.setBoolean("UseMaterialColors", true);
       mat.setColor("Ambient”,
            ColorRGBA.randomColor());
       paddle.setMaterial(mat);
   }
}
```

Demo



Many Other Features

- E.g Hinges

```
HingeJoint joint =
  new HingeJoint(
        hC, // A
        bC, // B
         // pivot point local to A
        new Vector3f(0f, 0f, 0f),
         // pivot point local to B
        new Vector3f(0f, 10f, 0f),
         Vector3f.UNIT_Z,   // DoF Axis of A (Z axis)
        Vector3f.UNIT_Z  );// DoF Axis of B (Z axis)

bulletAppState.getPhysicsSpace().add(joint);
```

Game Physics

- Getting a physics engine (and even free of charge) for your project is not a big deal
  - Integrating a physics engine into your system is a different matter

Repeated:
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