UNREAL ENGINE

HOUR 13

Working with Physics:
Introduction to UE4 Physics

INTRODUCTION

Physics in UE4 is a large topic, so establishing a basic framework to build off of is the main goal of this lecture.

The physics system in UE4 ranges from simply telling a Static Mesh to simulate physics, to creating Destructibles, to using the Physics Asset Tool (PhAT) Editor to control physics simulations on Skeletal Meshes.

LECTURE GOALS AND OUTCOMES

Goals

The goals of this lecture are to

- Learn how to make a Static Mesh Actor simulate physics
- Learn about Physical Materials
- Learn how to use Physics Constraint Actors
- Learn how to use Physics Thruster and Radial Force Actors
- Become familiar with the Destructible Actor pipeline
- Learn about Physics assets and the PhAT Editor

Outcomes

By the end of this lecture you will be able to

- Make a Static Mesh Actor simulate physics
- Create and assign Physical Materials
- Use Physics Constraint Actors
- Use Physics Thruster and Radial Force Actors

Basic Physics Terms

Before you start working with physics, it is a good idea to familiarize yourself with some basic terms:

- **Physics body**: A generic term used to describe any object that is set to simulate physics.

- **Rigid body**: A solid nondeformable object.

- **Soft body**: An object that conforms to the world around it when it collides with something.

- **Cloth**: A type of soft body.

Basic Physics Terms

- **Force**: Typically represented as a vector and is applied to a mass for a duration.

- **Impulse**: An instantaneous hit.

- **Linear**: Refers to directional force that changes the position of an Actor in a Level.

- **Angular**: Refers to rotational forces that change the orientation of an Actor.

Basic Physics Terms

- **Mass**: Refers to the amount of matter in a given body, regardless of the amount of gravity applied.

- **Density**: The amount of mass by volume in a given physics body.

- **Damping**: Refers to how quickly a physics body comes to rest after a force has been applied. It is the dissipation of energy over time. Two common types are linear damping and angular damping.

- **Friction**: The amount of resistance applied to a sliding or rolling body.

- **Restitution**: Refers to the amount of bounce a physics body has and how quickly the body comes to rest.

PHYSICS SYSTEM

There are a set of Actors, assets, and file types that are associated with the physics system in UE4.

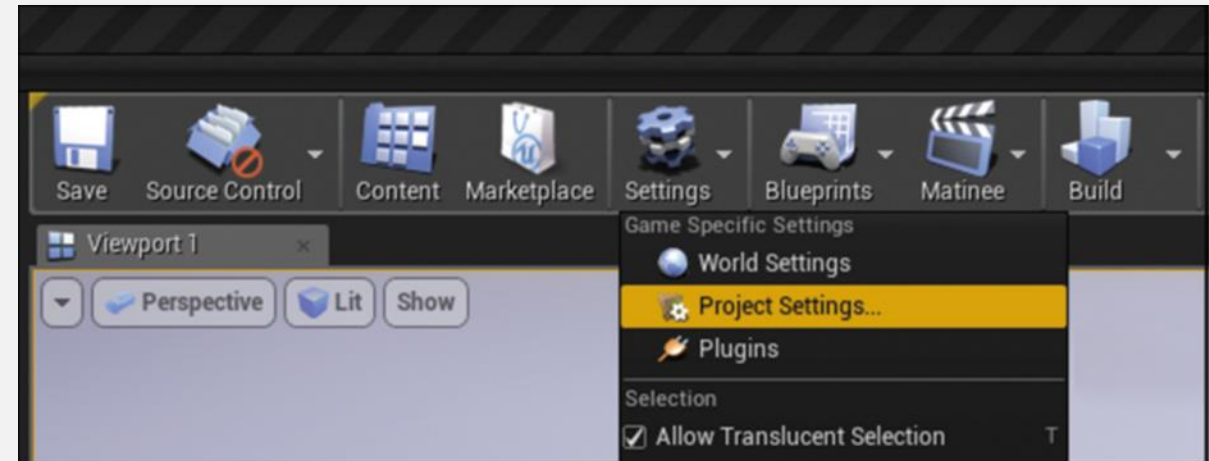| Actors	Assets	File Types
• Static Mesh • Physics Constraint • Physics Thruster • Radial Force • Destructible • Skeletal Mesh	• Destructible Mesh • Physical Material • Physics	• .fbx • .apx • .apb

PROJECT PHYSICS SETTINGS

You can control general physics settings on a project-wide or per-Level basis.

To access the project-wide physics settings, select Settings > Project Settings.

PROJECT PHYSICS SETTINGS

The Physics section of the Project Settings panel allows you to set many attributes related to physics for a project.

You can set Default Gravity Z. By default this is –980 cm on the *z* axis, which is roughly the rate of acceleration per second squared on a body as it falls due to the force of gravity.

You can also set Default Terminal Velocity to cap the top speed of a physics body.

These settings apply to all the Actors simulating physics in the project.
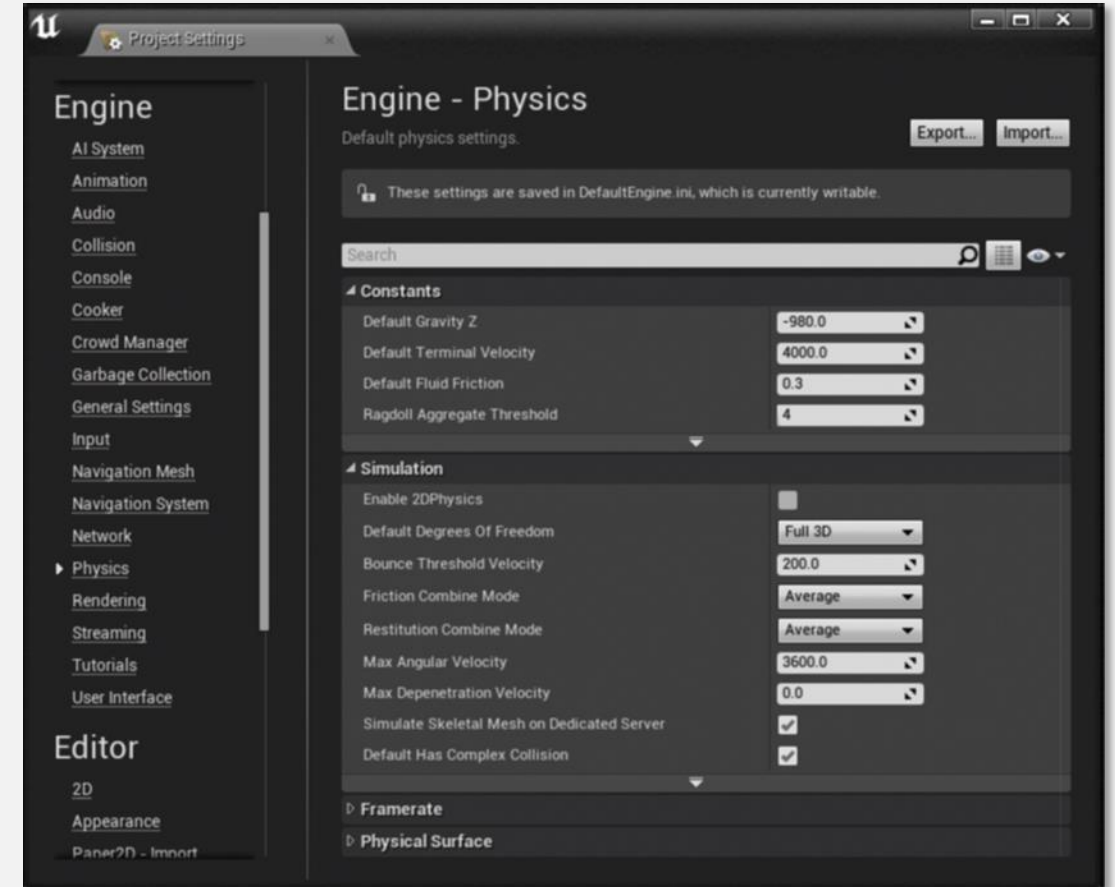
PER-LEVEL PHYSICS SETTINGS

There are also default physics attributes for individual Levels. You can override the project's default gravity settings for just the current Level.

With a Level open, select the World Settings tab and look for the Physics section, which shows the default settings.
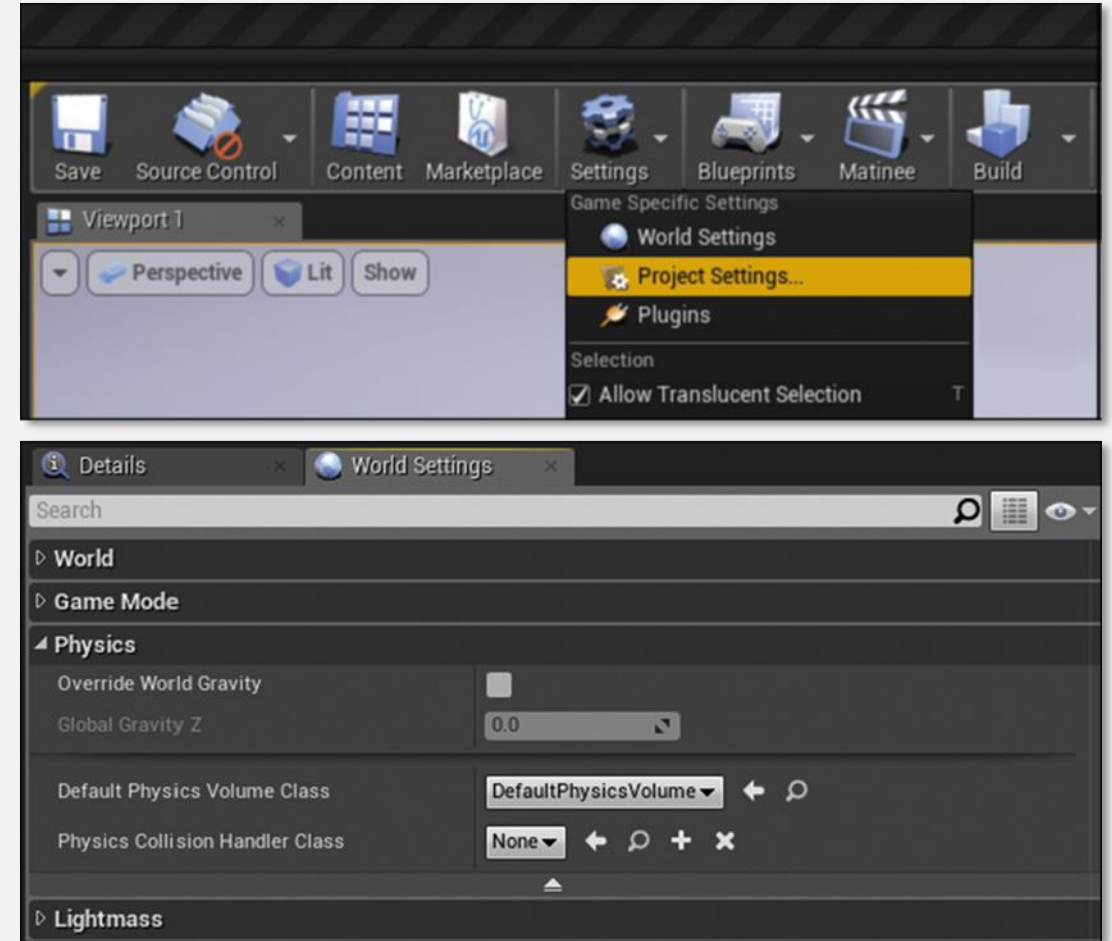
SIMULATING PHYSICS ON A STATIC MESH ACTOR

Making a rigid body in UE4 is as simple as setting a Static Mesh Actor's Simulate Physics property to True.

This can be done by selecting a placed Static Mesh in the Level Viewport, navigating to the Level Details panel, and toggling on Simulate Physics under the Physics tab.

NO COLLISION HULL

If a Static Mesh Actor does not allow you to set Simulate Physics, it is most likely because the Static Mesh asset does not have a collision hull.

In this case, locate the Static Mesh asset in the Content Browser, open it in the Static Mesh Editor, and assign a collision hull before resaving it.

MASS

When a Static Mesh Actor has been set to simulate physics, its initial mass is determined by the volume of the Static Mesh.

This setting can be overridden by clicking on the Override toggle and setting the Mass in Kg property to your desired value or by scaling the Actor.

PHYSICS PROPERTIES

The table on the right lists some of the properties that can be set for a Static Mesh Actor under the Physics tab in the Details panel.

Property	Description
Simulate Physics	Toggles physics simulation on and off for the Actor.
Mass in KG	Mass of the body, in kilograms, based on the Actor's volume in the world. This property can be set manually by turning on Override.
Linear Damping	Drag force added to reduce linear movement.
Angular Damping	Drag force added to reduce angular rotation.
Enable Gravity	Whether the object should have the force of gravity applied. If false, the Actor will float.
Constraints	Controls which axis the Actor can move and rotate on when simulating physics.
Modes	Presets for constraint assignments.
Start Awake	Whether the object should start awake or initially be sleeping.
Center of Mass Offset	Specifies the offset for the center of the mass of this object from the calculated location.
Mass Scale	Per-instance scaling of mass.
Max Angular Velocity	Limits the amount of angular velocity that can be applied.

PHYSICAL MATERIAL ASSETS

Physical Material assets allow you to control more properties for physics simulations.

For example, they can be used to make a Static Mesh Actor simulating physics behave like a beach ball or a block of ice that slides across the floor.
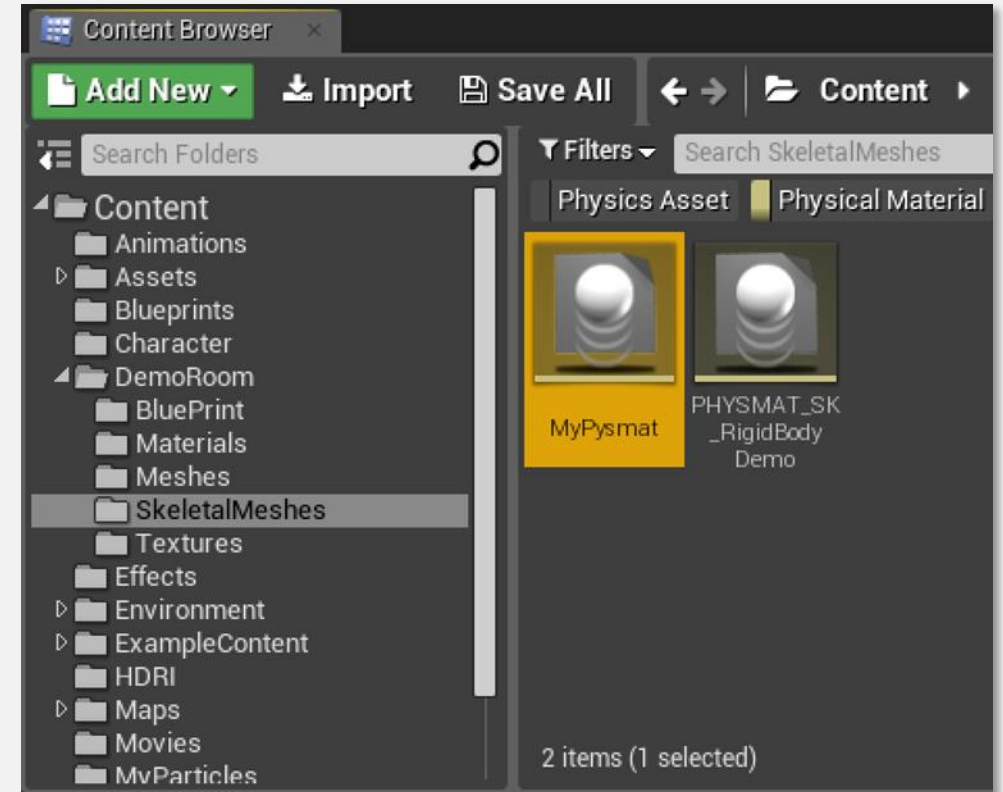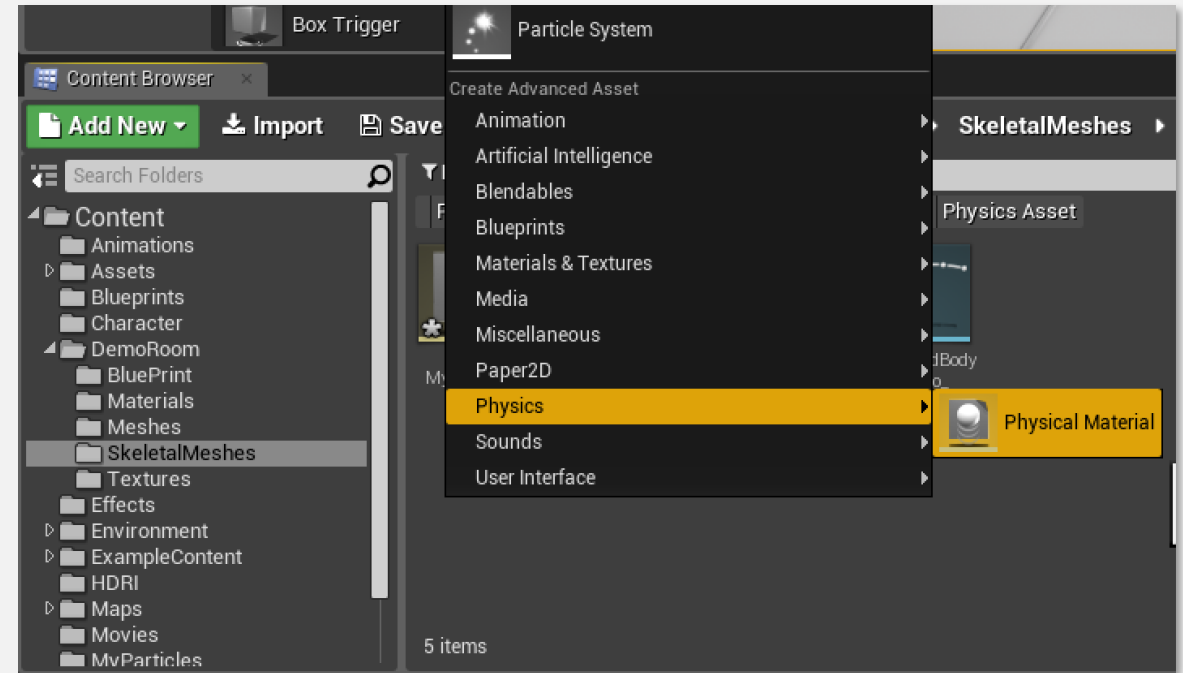
PHYSICAL MATERIAL ASSETS

To create a Physical Material asset:

- Right-click in the Content Browser and go to Physics > Physical Material.

- In the Pick Physical Material Class window, select the PhysicalMaterial class and click Select to add the Physical Material asset to the Content Browser.

- Give the asset a name and save it to write it to disk.

PHYSICAL MATERIAL ASSETS

Double-clicking on the Physical Material asset in the Content Browser opens the Generic Asset Editor and displays the asset's properties.

The Physical Material asset allows you to set properties such as Friction, Restitution, and Density.
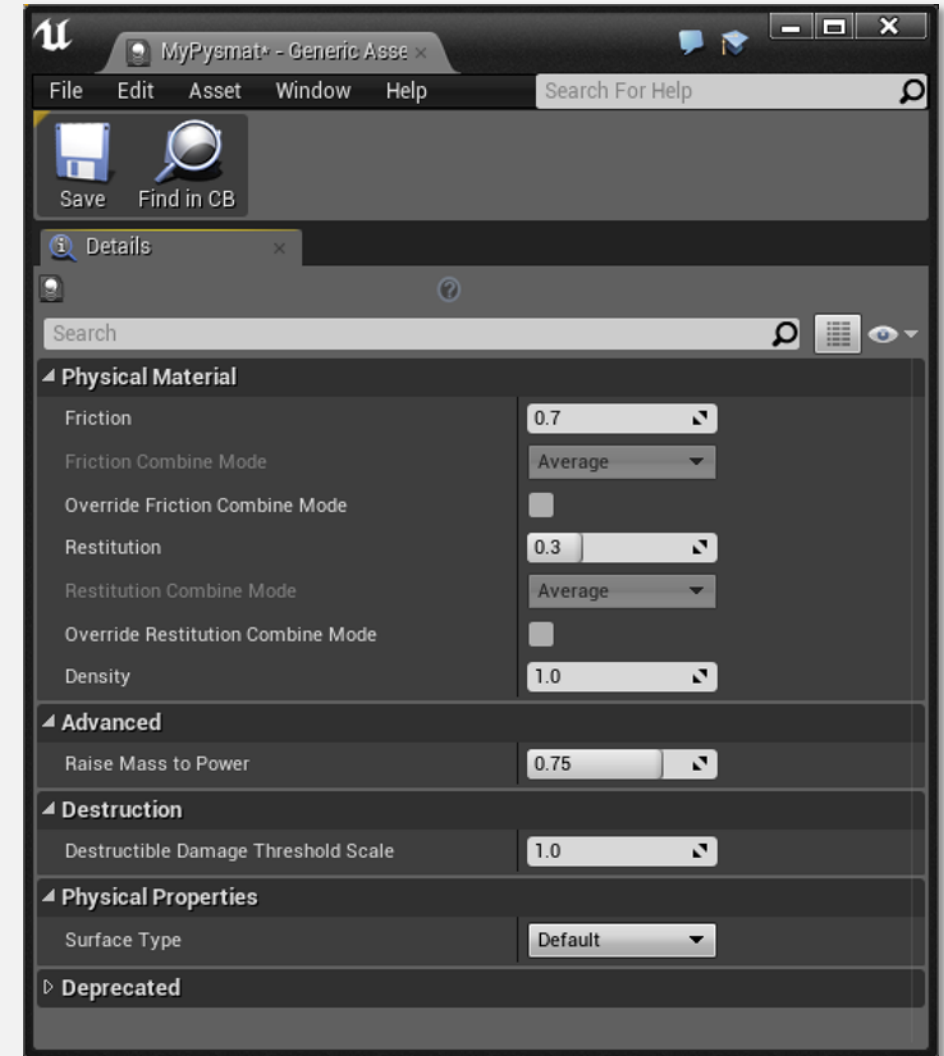
ASSIGNING PHYSICAL MATERIAL ASSETS

A Physical Material asset can be assigned to Static Mesh assets and Actors.

- To set the Physical Material on the Static Mesh asset, double-click on the asset in the Content Browser, and in the Details panel search for the Physical Material and assign it to the asset.

- To override the Physical Material setting on a per-Actor basis, select a Static Mesh Actor so its properties are displayed in the Details panel. Then click and drag the Physical Material asset from the Content Browser to the Collision tab's Phys Material Override property.
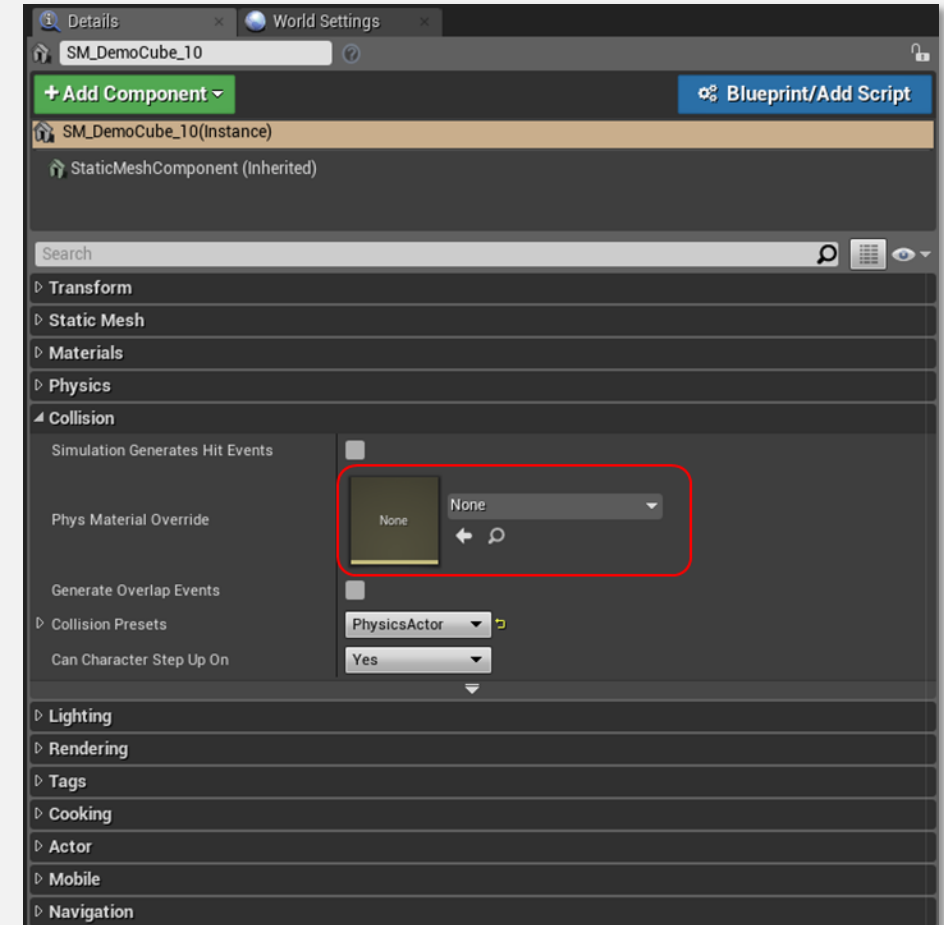
ASSIGNING PHYSICAL MATERIAL ASSETS

A Physical Material asset can also be assigned to regular Materials.

- Open a Material in the Material Editor and select the base Material node.
- In the Material Editor's Details panel, under Physical Material, assign the Physical Material.
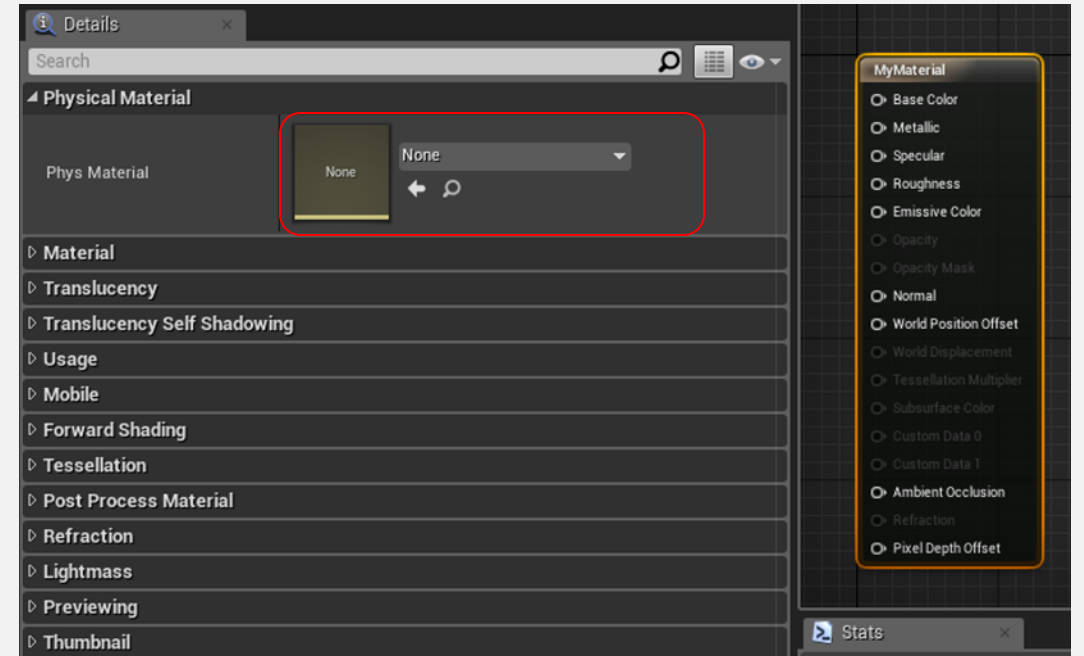
WORKING WITH CONSTRAINTS

If you attach one Static Mesh Actor simulating physics to another in the World Outliner, it will create a parent-child relationship.

However, if both Actors are simulating physics, they will ignore one another during runtime.

To attach two Physics Actors together and have the movement of each affect the other, you need to use a Physics Constraint Actor.

WORKING WITH CONSTRAINTS

The table on the right shows attachment (parent-child) relationships between Static Mesh Actors with different Mobility and Simulate Physics settings and the various outcomes.

Parent	Child	Result
Mobility: Static Simulate Physics: No	Mobility: Static Simulate Physics: No	The attachment is allowed, but neither Actor moves, so it does not matter.
Mobility: Movable Simulate Physics: No	Mobility: Static Simulate Physics: No	The attachment does not work because the child cannot move.
Mobility: Movable Simulate Physics: No	Mobility: Movable Simulate Physics: No	The attachment works, and the child will follow the parent, but the parent will have to be animated with Sequencer or the Timeline.
Mobility: Movable Simulate Physics: Yes	Mobility: Movable Simulate Physics: No	The attachment works, and the child will follow the parent.
Mobility: Movable Simulate Physics: No	Mobility: Movable Simulate Physics: Yes	The attachment is allowed, but since the child is simulating physics, it ignores the parent except when they collide with one another.
Mobility: Movable Simulate Physics: Yes	Mobility: Movable Simulate Physics: Yes	The attachment is allowed, but since both Actors are simulating physics, they ignore one another except when they collide.

CONSTRAINT ACTORS

A constraint is basically a type of joint. It allows you to connect two Actors together (presumably one physically simulating) and also apply limits or forces.

Unreal Engine 4 has a very flexible and data-driven constraint system that allows designers to make many different types of joints simply by changing some options.

The engine has a few default joint types (ball-and-socket, hinge, prismatic), but they only differ in their settings.
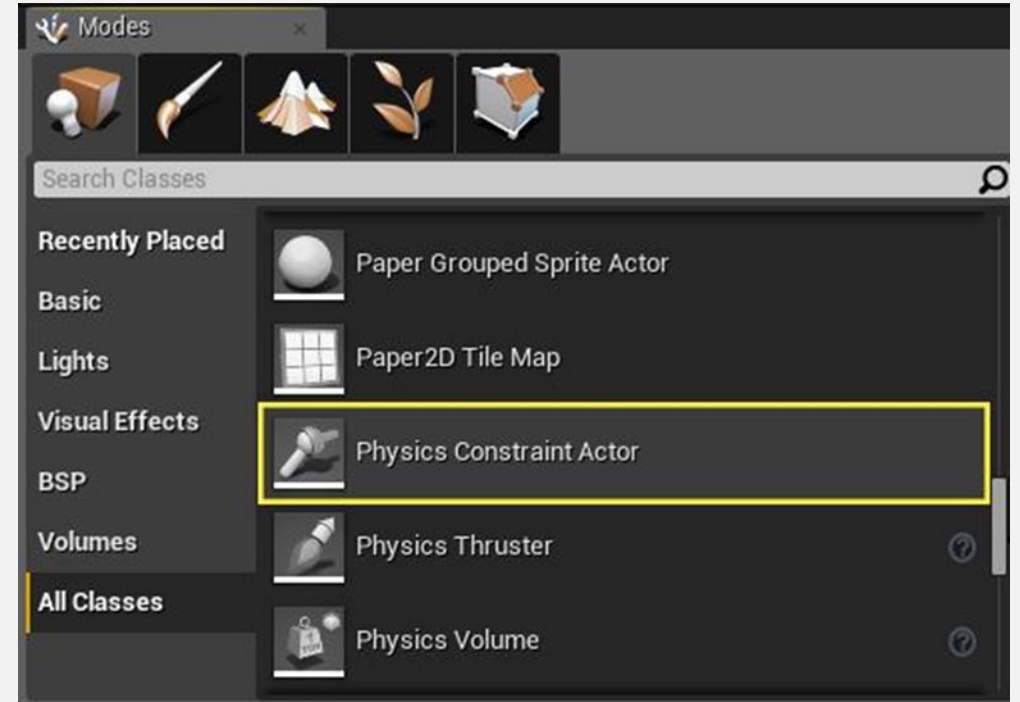
CONSTRAINT ACTORS

A Physics Constraint Actor allows you to attach Physics Actors to any other Actor. Constraint Actors create a joint, or a hinge, between two physics bodies.

Physics Constraint Actors are located in the Modes panel, in the Place mode's All Classes section.
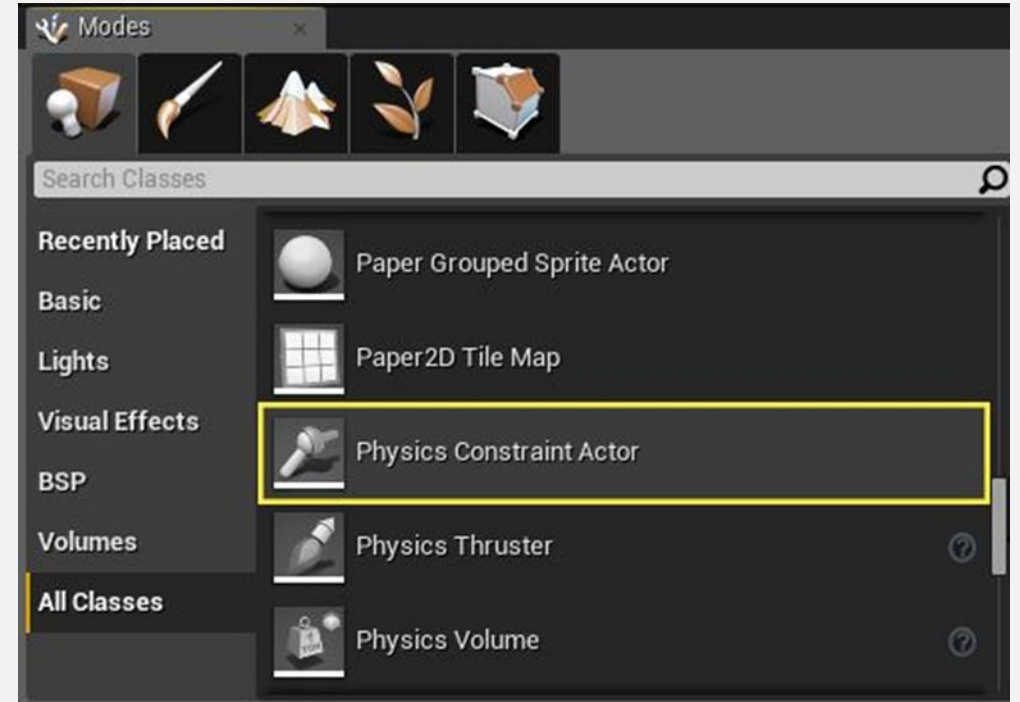
CONSTRAINT ACTORS

Attachment using a Physics Constraint Actor differs from a standard attachment method in that the movement of the parent (Constraint Actor 1) and the child (Constraint Actor 2) each has an effect on the other's movement and rotation.
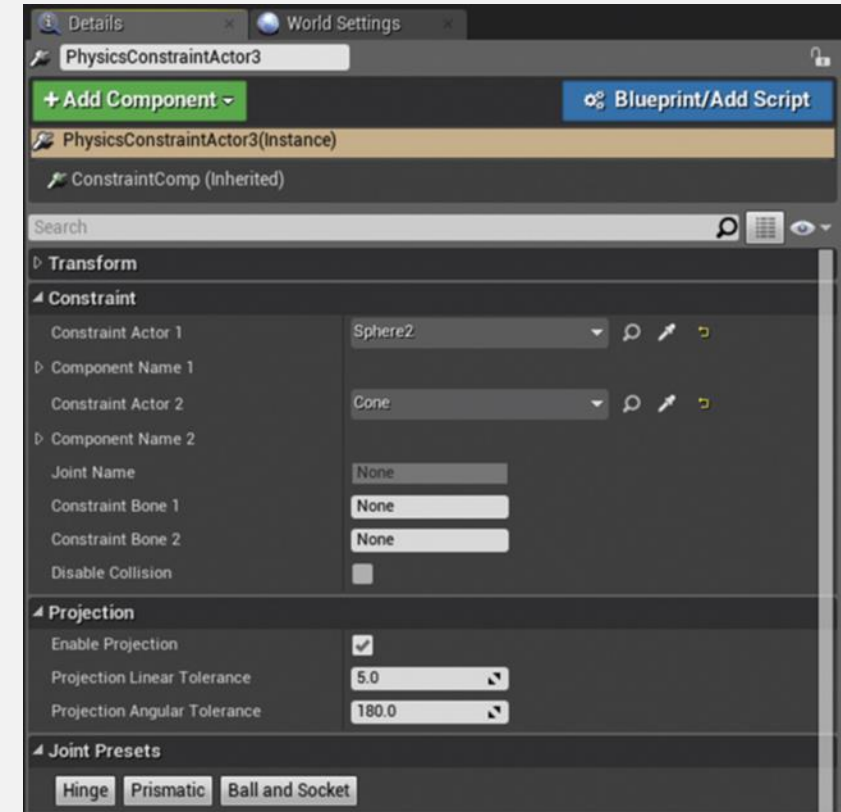
CONSTRAINT ACTORS

To attach two Actors together using a Constraint Actor:

- Place the Physics Constraint Actor between the two Actors that you want to attach in the Level.

- With the Physics Constraint Actor selected, click on the eye dropper icon for the Constraint Actor 1 property under the Constraint tab in the Details panel. Then click on the first Actor you want to attach in the Level Editor Viewport to assign it.

- Repeat the process for the Constraint Actor 2 property and the second Actor.
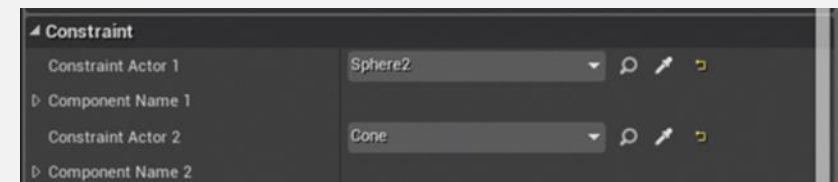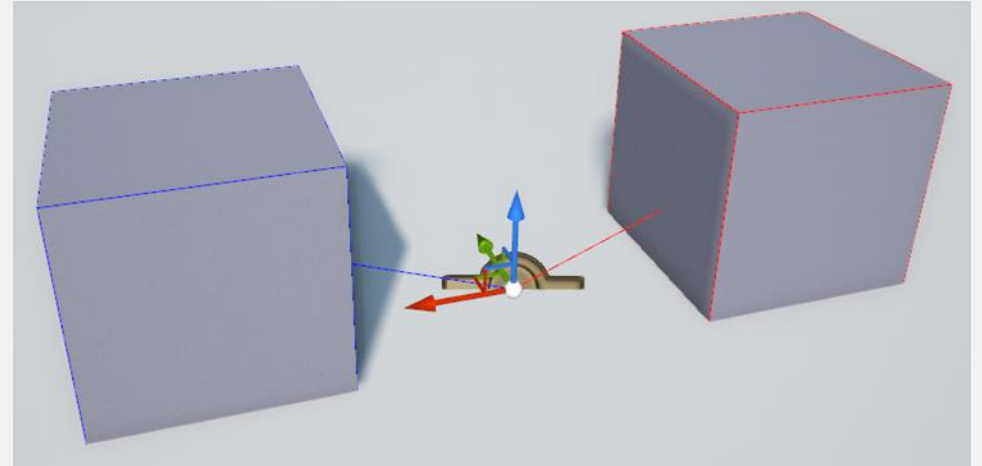
THRUSTER ACTORS

A Physics Thruster is a special Physics Actor you can attach to another Actor simulating physics to apply force in a specified direction.

Physics Thrusters can be found in the Modes panel, in the Place mode's All Classes section.
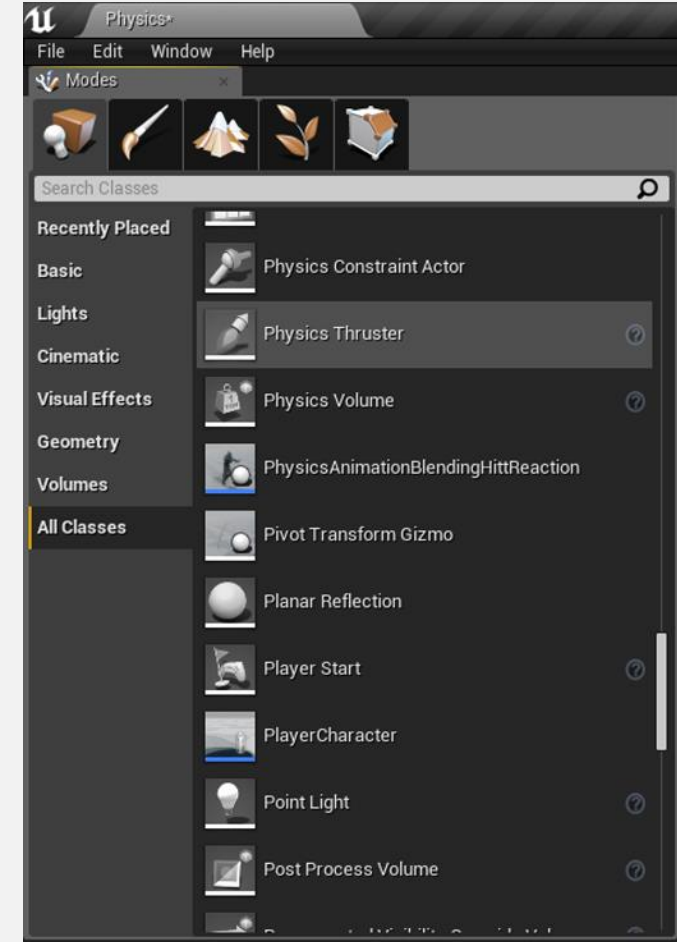
THRUSTER ACTORS

- The force propels the Physics Thruster in its negative *x* direction.

- The positive *x* axis of the Thruster is the "exhaust of a jet engine."
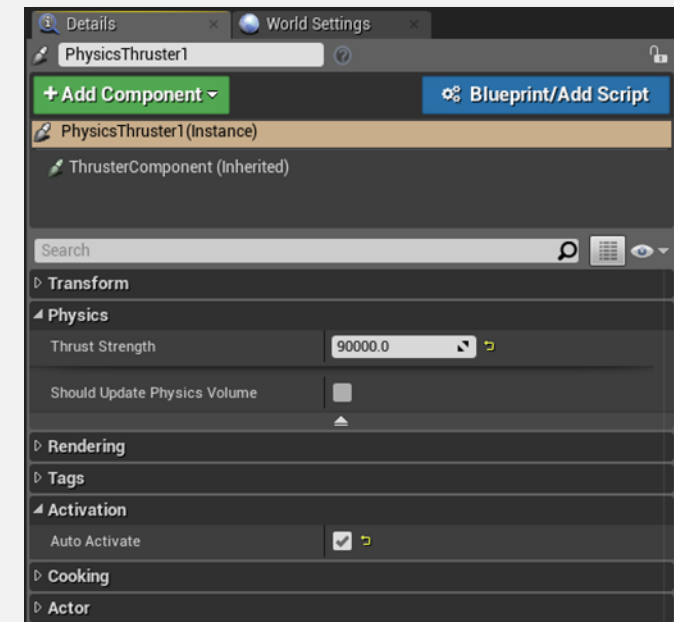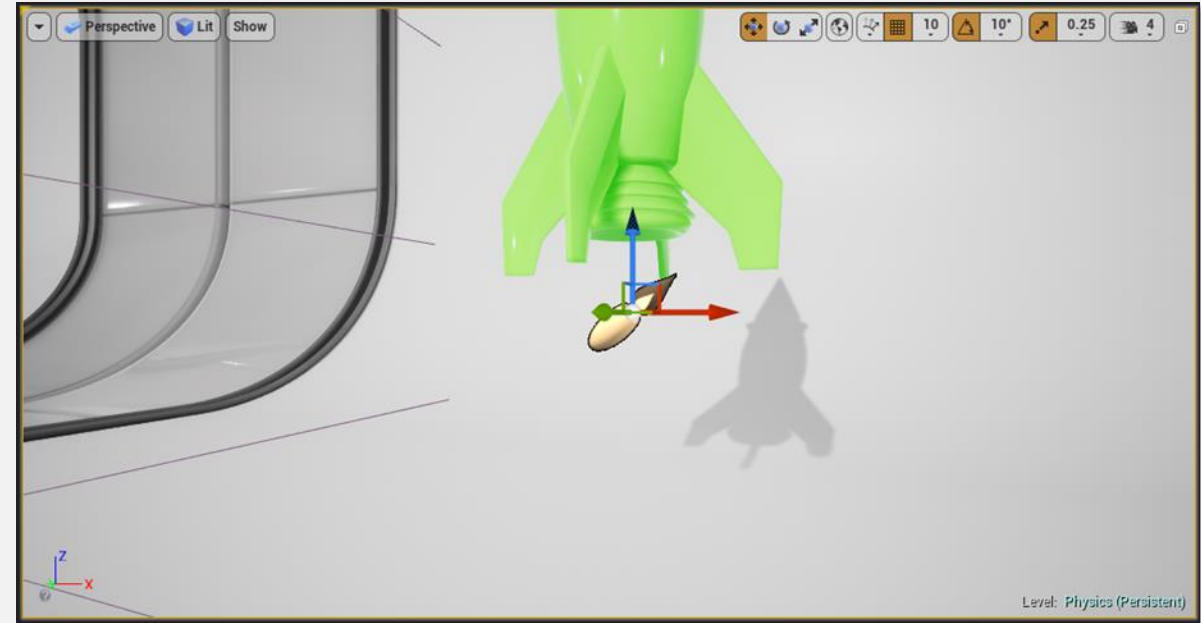
RADIAL FORCE ACTORS

A Radial Force Actor applies force in a defined volume in all directions from a single point.

Radial Force Actors can be found in the Modes panel, in the Place mode's All Classes section.
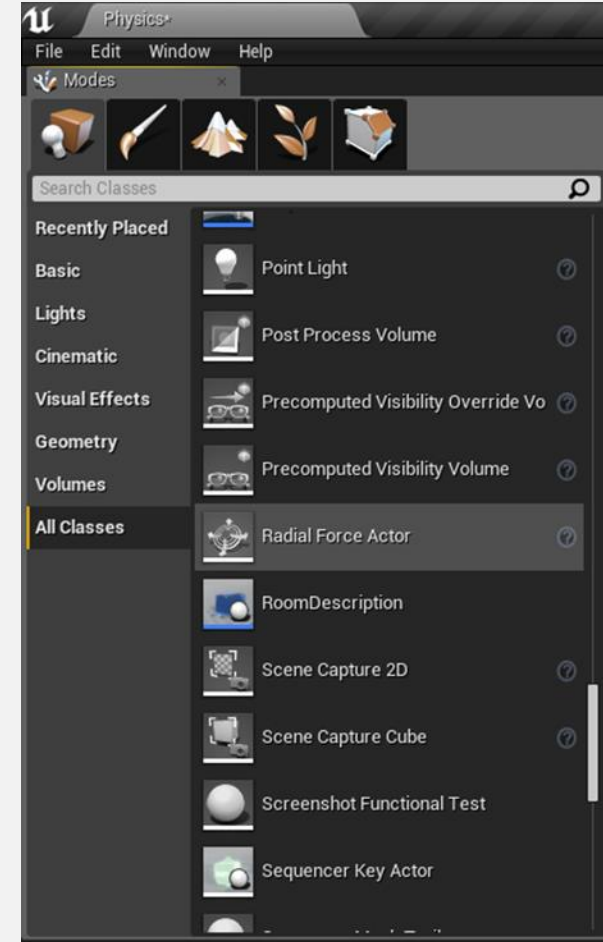
RADIAL FORCE ACTORS

A Radial Force Actor applies a constant force (listed as Force Strength in the Editor) or an impulse.

- The orientation of the Radial Force Actor does not matter.

- The Radial Force Actor only affects Physics Actors that fall within its area of influence.

- The area of influence can be adjusted by scaling the Actor.

- The influence has a falloff value, so the applied force on a physics body is greater the closer it is to the center of the Radial Force Actor.
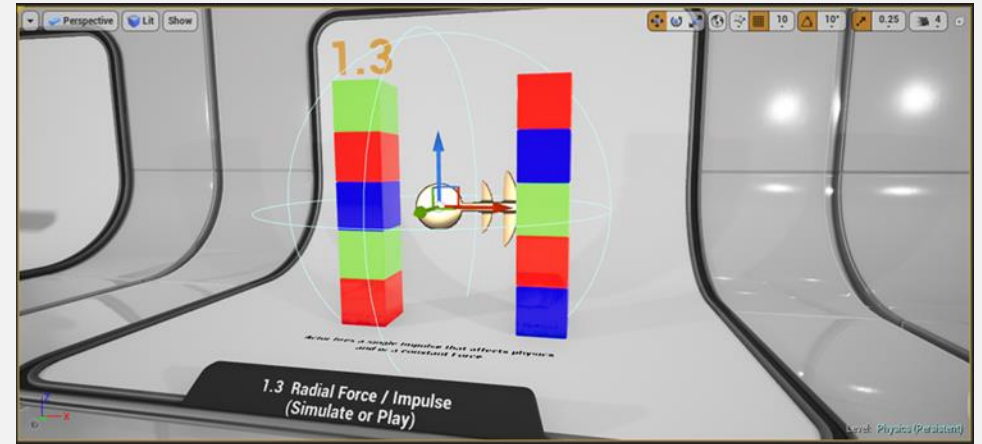
RADIAL FORCE ACTORS

A Radial Force Actor can apply a constant force or impulses, but impulses need to be activated from a Blueprint.
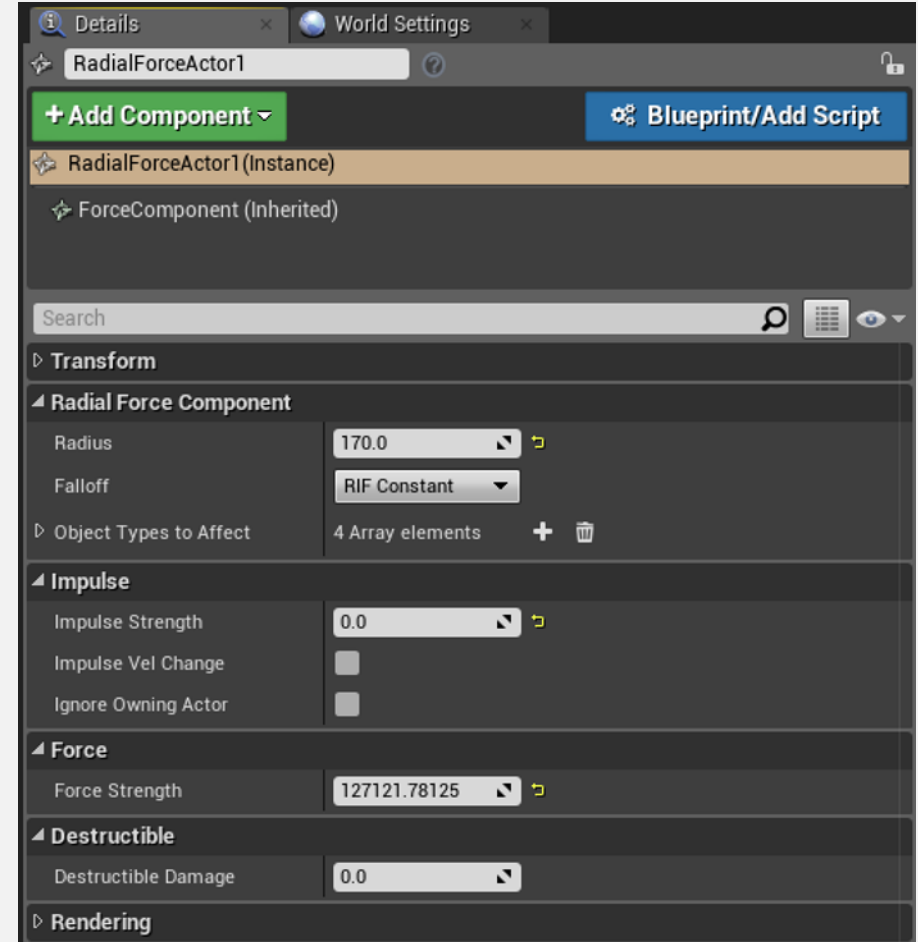
DESTRUCTIBLES

DESTRUCTIBLES

Destructibles are rigid bodies that fracture and crumble when enough force or damage has been applied. They can be used to create cinematic effects or great gameplay experiences.

Destructible Actors can be generated within UE4 using Voronoi with a single depth level.
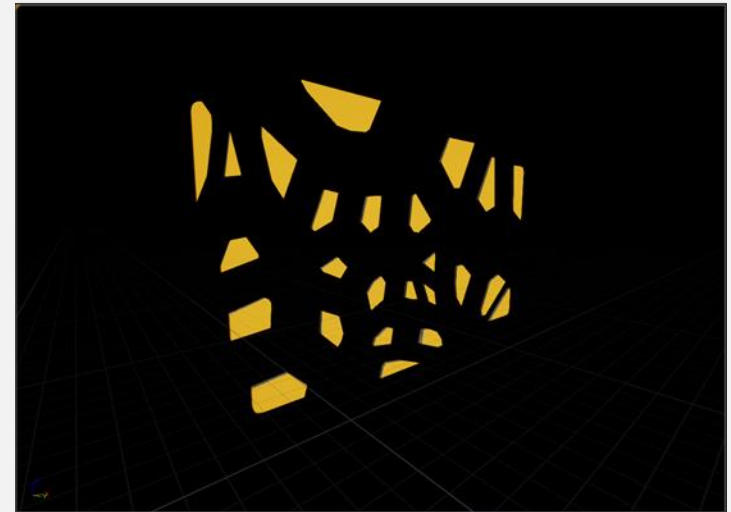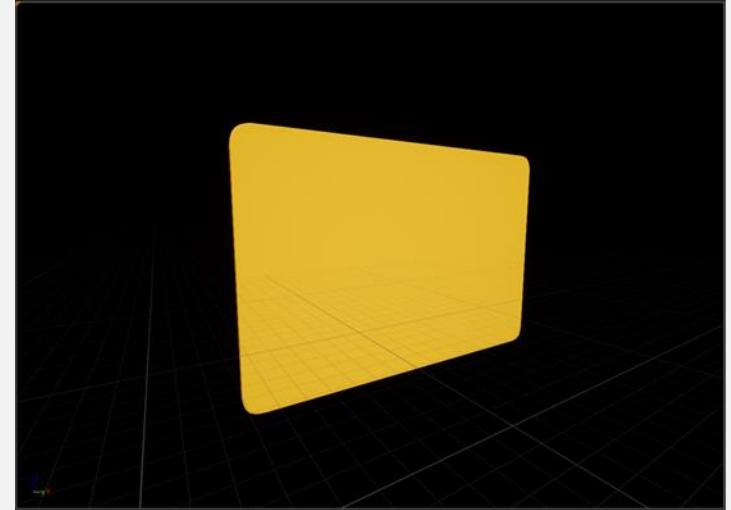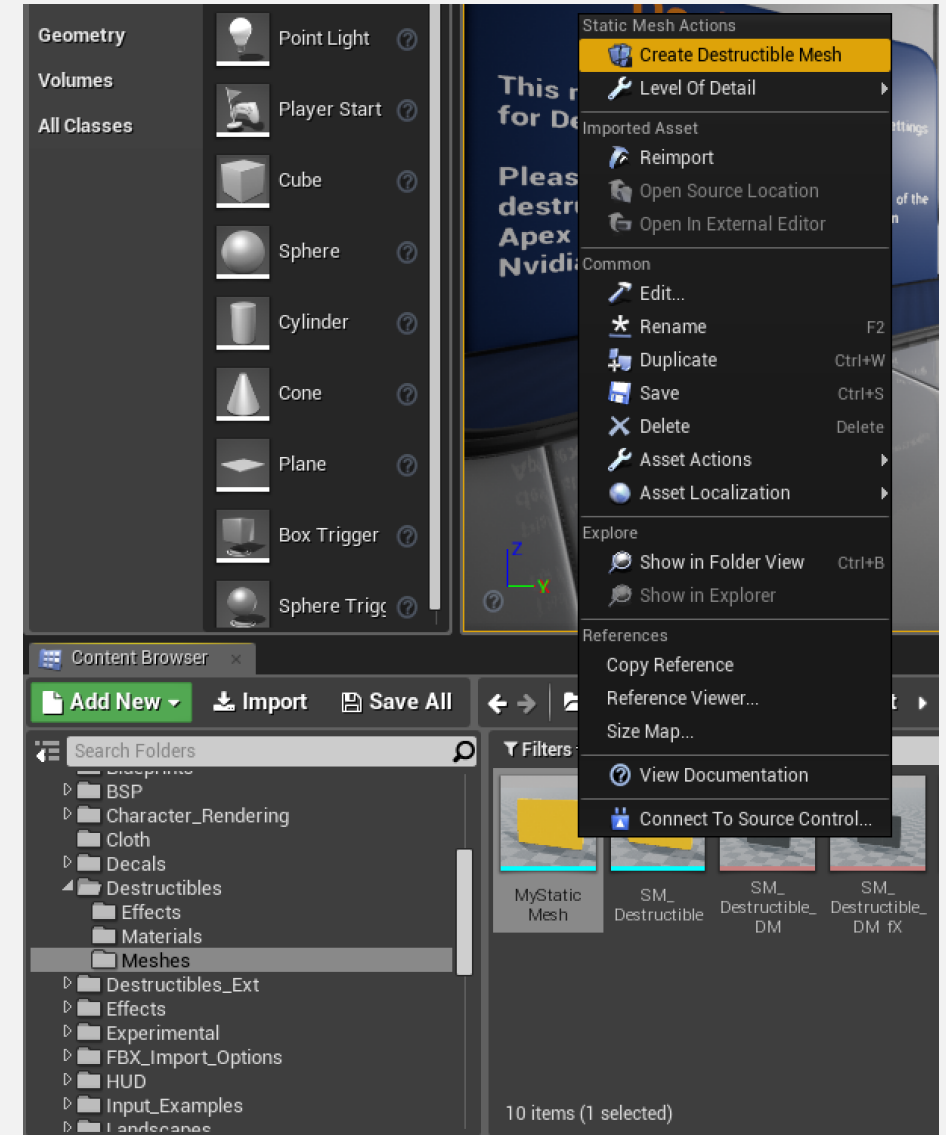
DESTRUCTIBLES

A Destructible Mesh asset is created simply by right-clicking on a Static Mesh asset in the Content Browser and selecting Create Destructible Mesh.

This adds the new Destructible Mesh asset to the Content Browser and opens the Destructible Mesh Editor.

DESTRUCTIBLE MESH EDITOR

The Destructible Mesh Editor is used to set the properties for a Destructible Mesh asset.

It has a toolbar, a Viewport, a Destructible Settings panel, a Chunk Parameters panel, and a Fracture Settings panel.
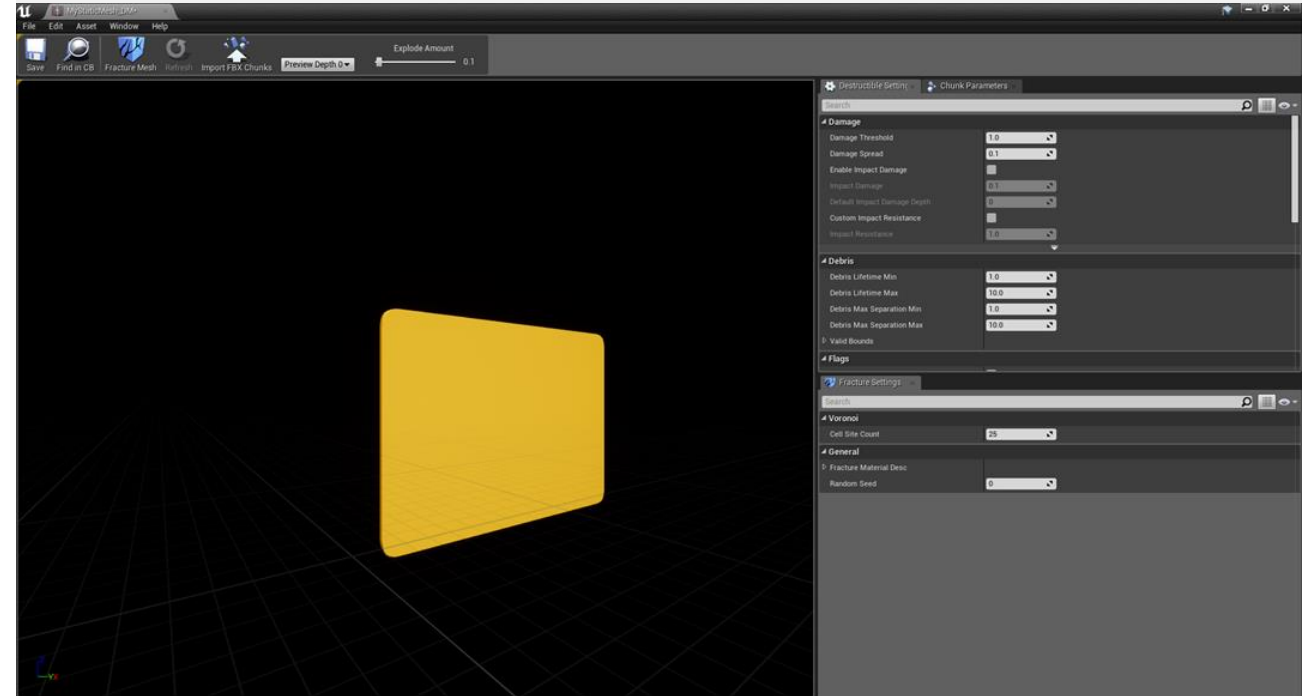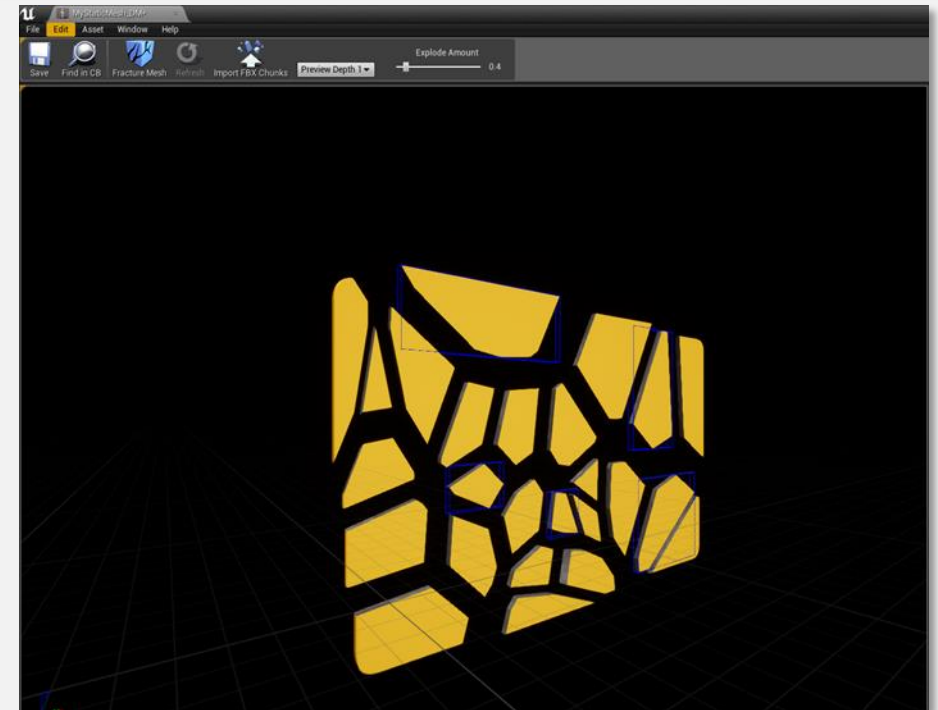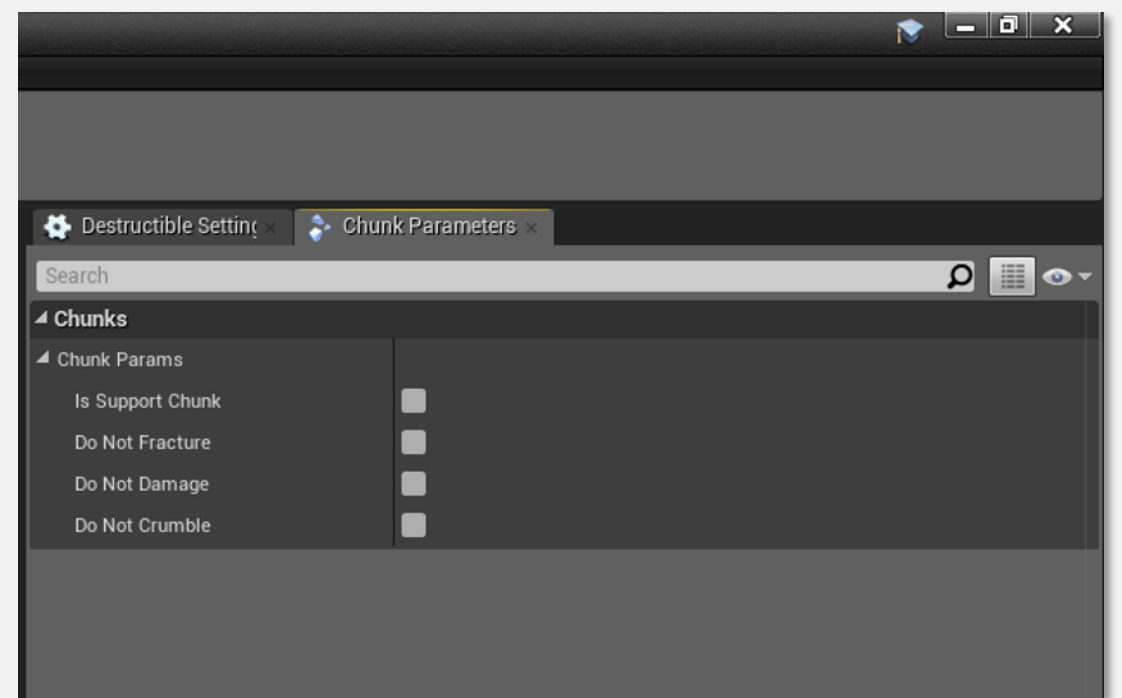
DESTRUCTIBLE SETTINGS PANEL

The Destructible Settings panel is where you set properties such as how much damage or force needs to be applied before the mesh fractures.
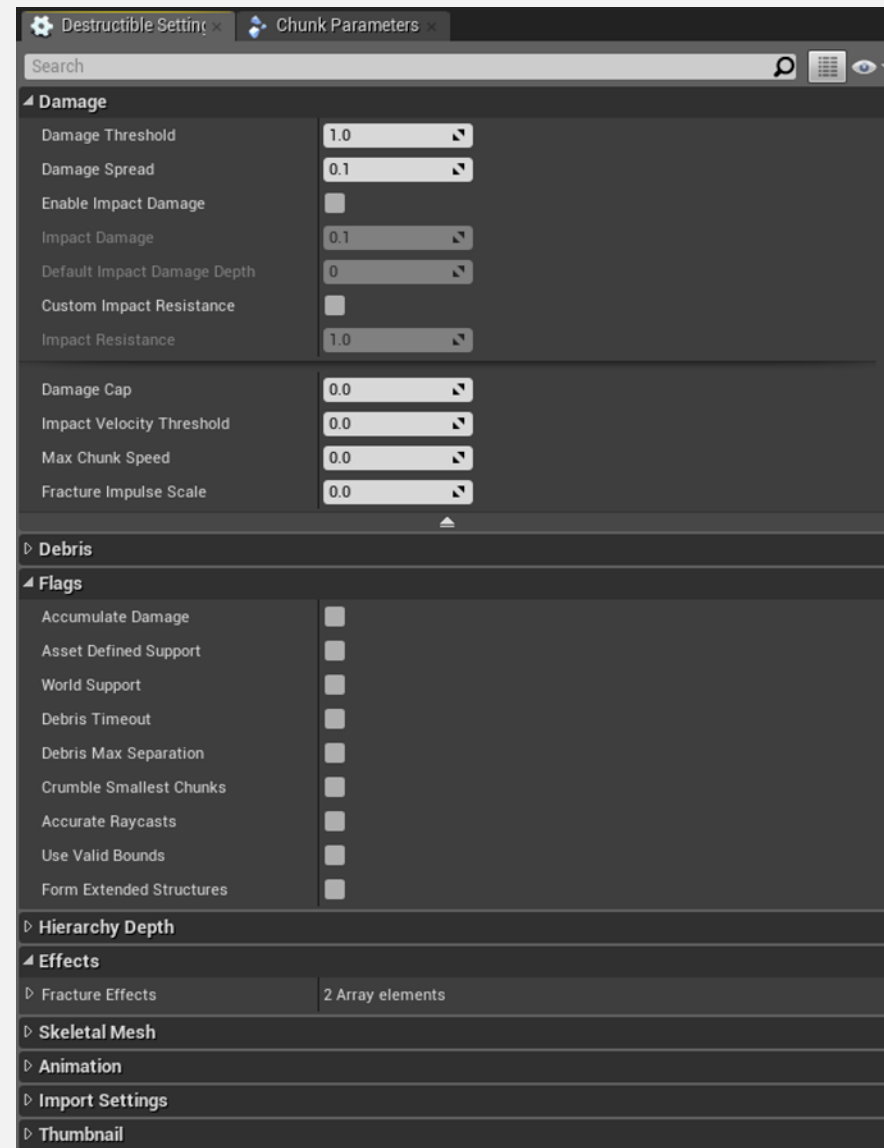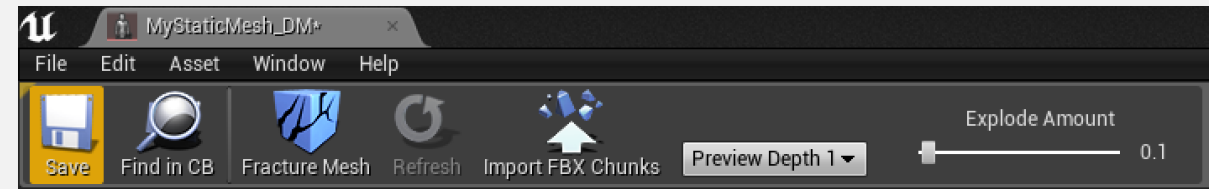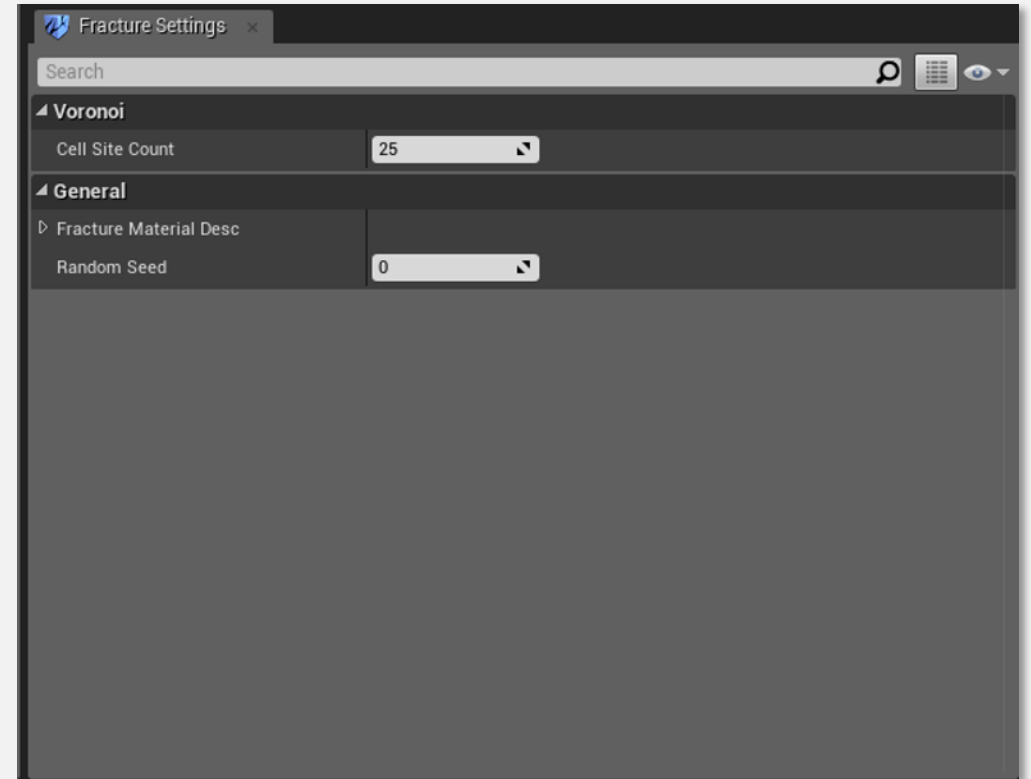
CHUNK PARAMETERS PANEL

The Chunk Parameters panel allows you to set properties for individually selected chunks.

VORONOI FRACTURE SETTINGS PANEL

Once a Destructible Mesh asset has been created, you need to fracture the mesh. This is done in the Fracture Settings panel by setting the Cell Site Count and then clicking the Fracture Mesh button on the toolbar.
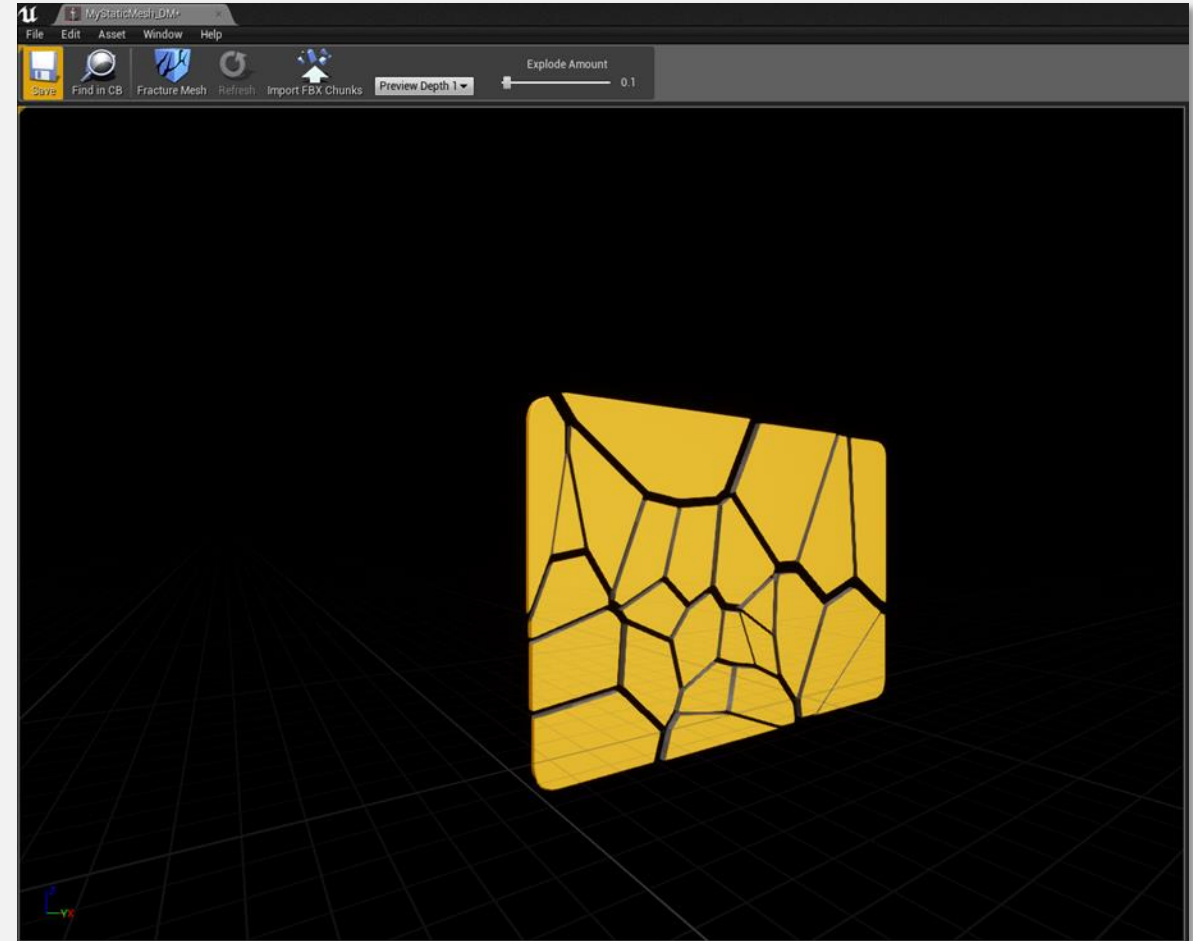
VORONOI FRACTURE SETTINGS PANEL

Fracturing the mesh creates a new fracture depth.

Destructibles can have multiple fracture depths.

- **Preview Depth 0** is the original mesh without being fractured.
- **Preview Depth 1** is the first level of fracture, where the number of chunks is determined by the Cell Site Count setting.

APEX PHYSX LAB

While Destructible Actors with one depth level can be generated within UE4 using Voronoi, creating Destructible Mesh assets with more than one depth level, or using a function other than Voronoi to shatter the mesh, must currently be done in the APEX PhysX Lab.

Importing an APEX object is the same as importing an .fbx file. All APEX assets are exported as an .apb or .apx file. The Unreal Editor will determine the type of APEX object being imported.
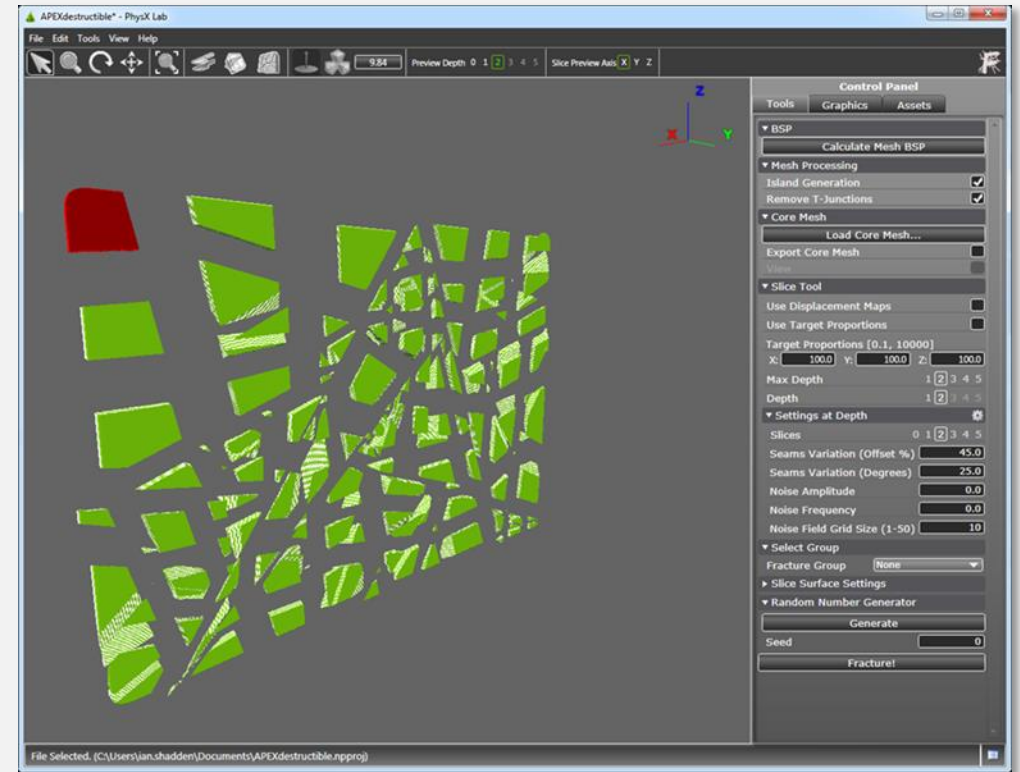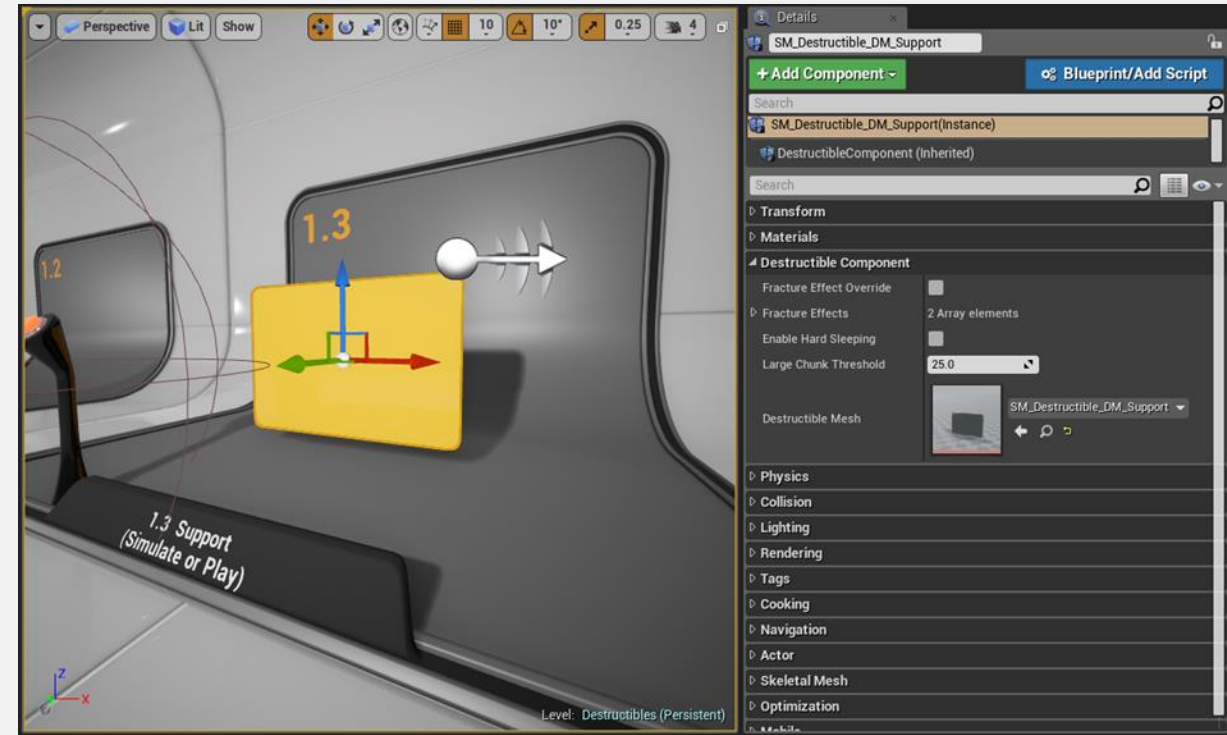
DESTRUCTIBLE MESH ACTOR

Once a Destructible Mesh asset has been created and its properties set, you can place it in a Level.

To place a Destructible Actor, click on the asset in the Content Browser and drag it into the Level.

Notes

- Destructible Meshes are easy to create, but they are hard to master because of the large number of properties that require tweaking.

- You have to use NVIDIA tools to create multiple destruction depths. Typically, a single depth level is all that is needed for many effects.

PHAT EDITOR

The Physics Asset Tool Editor, or PhAT Editor for short, is used to set up anything from ragdoll effects on characters to dynamic hoses or chains that react with the world around them.

The PhAT Editor is used to edit Physics assets created from Skeletal Mesh assets.
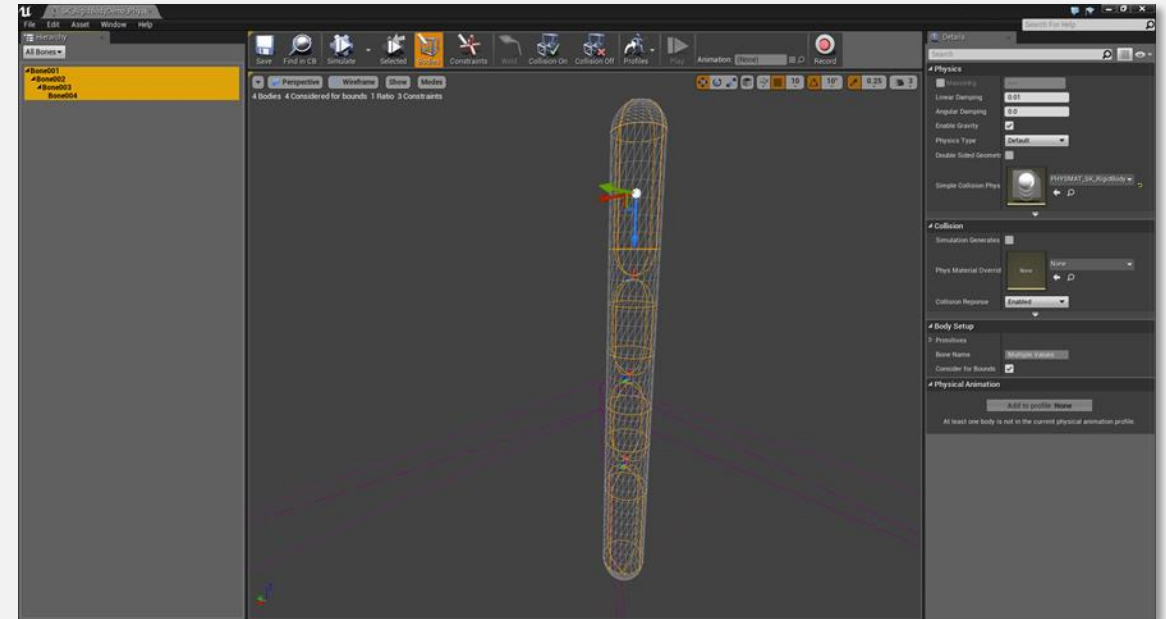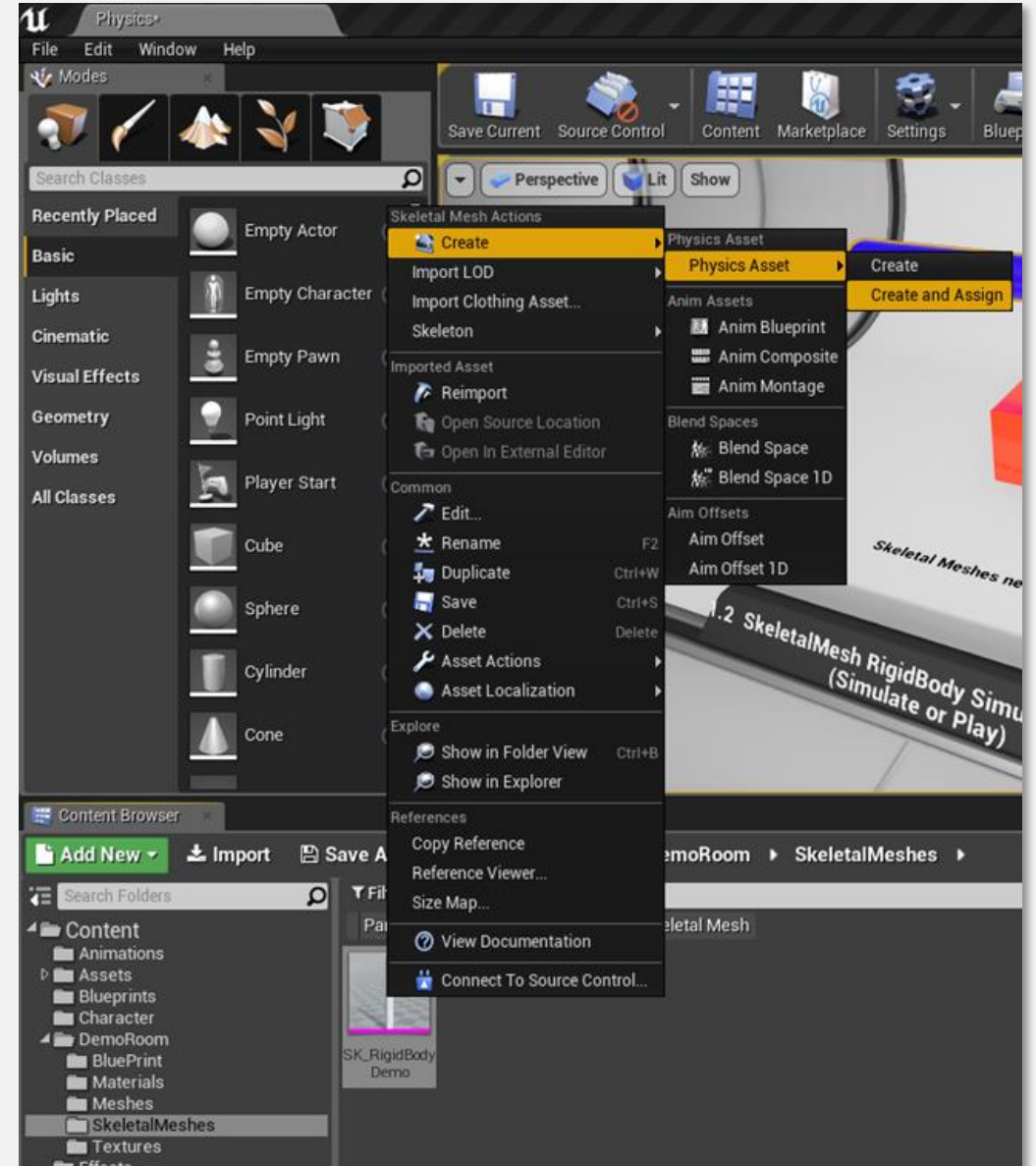
PHYSICS ASSETS

A Physics asset is derived from a Skeletal Mesh asset.

To create a Physics asset from a Skeletal Mesh, right-click on a Skeletal Mesh asset in the Content Browser and select Create > Physics Asset > Create and Assign.
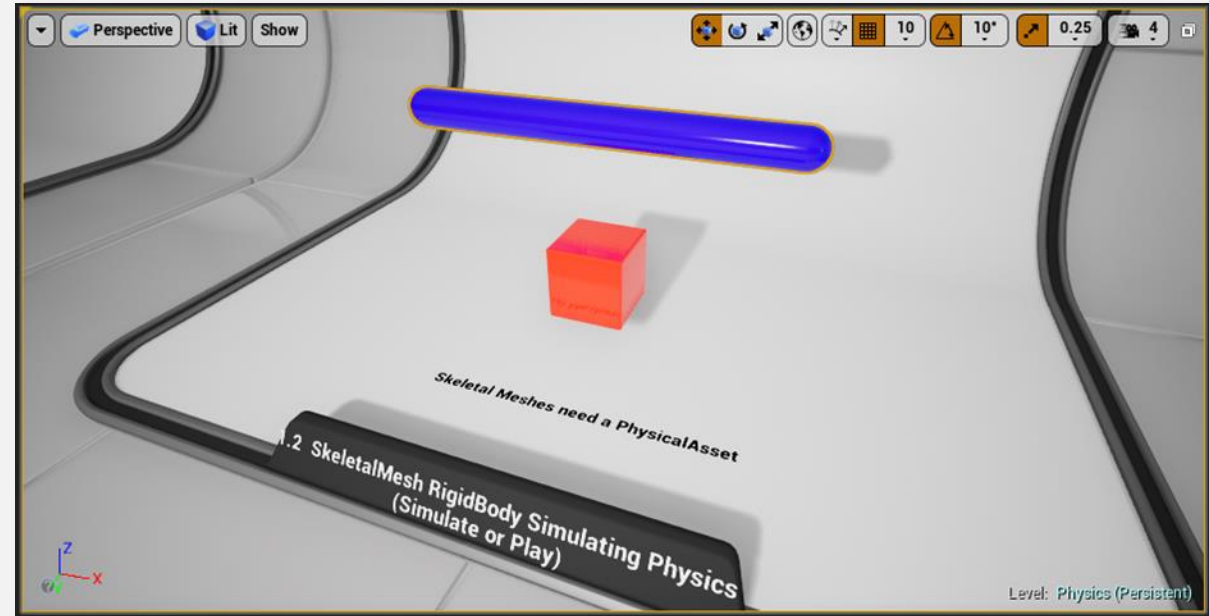
PHYSICS ASSETS

This will create a new Physics asset from the Skeletal Mesh and open the PhAT Editor.

You can assign primitive collision hulls to bones in the skeletal hierarchy and set up joint constraints.

Basic Physics System Assets and Actors

- NVIDIA produces a tool called the APEX PhysX Lab, which can be used to create Destructible Meshes.

- Information on its usage can be found in the NVIDIA documentation over the APEX PhysX Lab tools.

- It should be noted that currently Unreal Engine 4 only supports APEX Destructibles and APEX Cloth.

- To create APEX Cloth assets, you must use the PhysX plug-in for 3ds Max/Maya DCC, or the standalone tool is included in the APEX SDK.

Basic Physics System Assets and Actors

- NVIDIA PhysX APEX has two file types that UE4 can import: .apx and .apb.
- Both Cloth assets and Destructible Meshes can be exported as these file types, but only Destructible Meshes can be imported via the Content Browser.
- Cloth assets will need to be imported via Persona.