CS354P

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INTRODUCTION TO UNREAL

GETTING STARTED IN UE5...

- Can be a bit intimidating to bypass Blueprints!
  - Lots of code functionality
  - Large API with varying levels of documentation
    - Easy to do it wrong
- Good starting points for documentation:
  - https://docs.unrealengine.com/en-US/index.html
  - https://docs.unrealengine.com/en-US/API/index.html
- But in practice you're mostly going to rely on your search engine of choice...

SCENES AND ACTORS

- Game worlds and levels are similar to a movie: there is a scene, and actors within that scene
- Scene is composed of actors (all objects in the scene are a type of actor)

WORKING WITH ACTORS

- Base class of all gameplay objects that can be placed in the world
  - Can be spawned into the world
  - Can contain components which determine actor's behavior
- Handles memory management to spawn and destroy the actor object
- As an example, here are the virtual functions called on load:
  - `PostLoad -> OnComponentCreated -> PreRegisterAllComponents -> RegisterComponent -> PostRegisterAllComponents -> PostActorCreated -> UserConstructionScript -> OnConstruction -> PreInitializeComponents -> Activate -> InitializeComponent -> PostInitializeComponents -> BeginPlay`

ACTOR CLASSES

- Over 240 derived classes of AActor
- Many different types of functionality depending on the situation
  - You certainly won't need to use all of them but some may be useful!
- Some common ones:
  - APawn
    - Physical representation of actors that can **be possessed** by a player or AI
  - AController
    - Non-physical actors that can **possess** pawns and control actions
  - ATriggerBase
    - Actors that can generate collision events

ACTOR COMPONENTS

- Actors have components that implement much of their behavior and functionality
- **UActorComponent** is base class but do not have transforms (i.e. scale, rotate, translate)
- **USceneComponent** has transforms but not necessarily a geometric representation
- **UPrimitiveComponents** are Scene Components with a geometric representation
- **UActorComponents** can be registered to receive frame updates
  - Not very performant so only register when necessary and unregister when no longer necessary

UOBJECTS

- Base class of all objects in Unreal Engine
- Not required to use but provides useful functionality for runtime functionality (i.e. gameplay)
- Includes functionality for:
  - Garbage collection
  - Reflection
  - Serialization
  - Reference updating
  - etc...

UOBJECT AND GENERAL NAMING CONVENTION

- UE5 has quite a few code standards you should aim to follow
  - Extremely helpful on large, constantly changing teams
  - Still helpful on smaller, stable teams for readability
  - Full guide here: https://docs.unrealengine.com/en-US/Programming/Development/CodingStandard/index.html but we will discuss a lot of this later...
- Prefix U inherits from UObject; Prefix A inherits from AActor; Prefix S inherits from SWidget; Prefix I are abstract interfaces; Prefix E are Enums, Prefix F is for structs and most other classes

UOBJECT LIFE CYCLE

- All UObjects and sub-classes are **garbage collected**
  - Upon creation, UE5 adds object to its internal object list
  - Create using creation methods

- Caveat: **never use `new`!!**
- Create a **strong reference** using UPROPERTY macro or can manually flag
- Can call `Destroy` or `DestroyComponent` on actors and components
  - Will mark the object for destruction and null the UPROPERTY pointer upon destruction

MACROS

- What are macros?
  - Lines of code that are expanded by the preprocessor and substituted in during compilation
    - Can be “object-like” (no arguments) or “function-like” (with arguments)
- Used for abstracting frequently used code or definitions
- Used for creating **meta-object systems** in large, complex frameworks

MACROS AND SPECIFIERS IN UNREAL

- UE5 heavily uses macros to control engine and editor functionality
  - UPROPERTY creates strong references to objects, exposes property to the editor, and allows property to be recognized by reflection
  - UFUNCTION allows function to be recognized by reflection
- **Specifiers** inform how object or function should be used:

```
UPROPERTY(Replicated, EditAnywhere, BlueprintReadWrite,
Category = “Character”)

    float health;

UFUNCTION(BlueprintCallable, Category = “Character”)

    void takeDamage();
```

CONSTRUCTORS

- Several different ways to create objects in UE5 -- none of which involve calling `new`!
- All UObjects (whether actors or components) should use their default creation methods:
  - `FooObject* f1 = NewObject<FooObject>();`
  - `World->SpawnActor<FooActor>(FVector::ZeroVector, FRotator::ZeroRotator);`
  - `UComponent* FooComponent = CreateDefaultSubobject<FooComponent>(TEXT("ComponentName")); //Only use in object constructor`

GENERATED CODE

- Because of this compilation process, you must be cognizant of the macros and includes associated with generated code
  - i.e. do no randomly start deleting pre-generated code!
- `#include “MyObject.generated.h”`
  - Must be **last include** in header of MyObject
- UCLASS specifies class is a UObject and should have reflection data
- `GENERATED_BODY()` placed at start of the class declaration
  - UE4 will populate this with all necessary boilerplate code for this type

ULEVEL

- Level object that contains list of actors (lights, volumes, mesh instances, etc), geometry (BSP) information, and a “World” it is associated with
- Multiple levels can be loaded and unloaded in a World to stream assets
- An `ALevelScriptActor` exists within a level and executes level-wide logic on actor instances
  - Access that via code or Blueprint to deal with level-wide behaviors

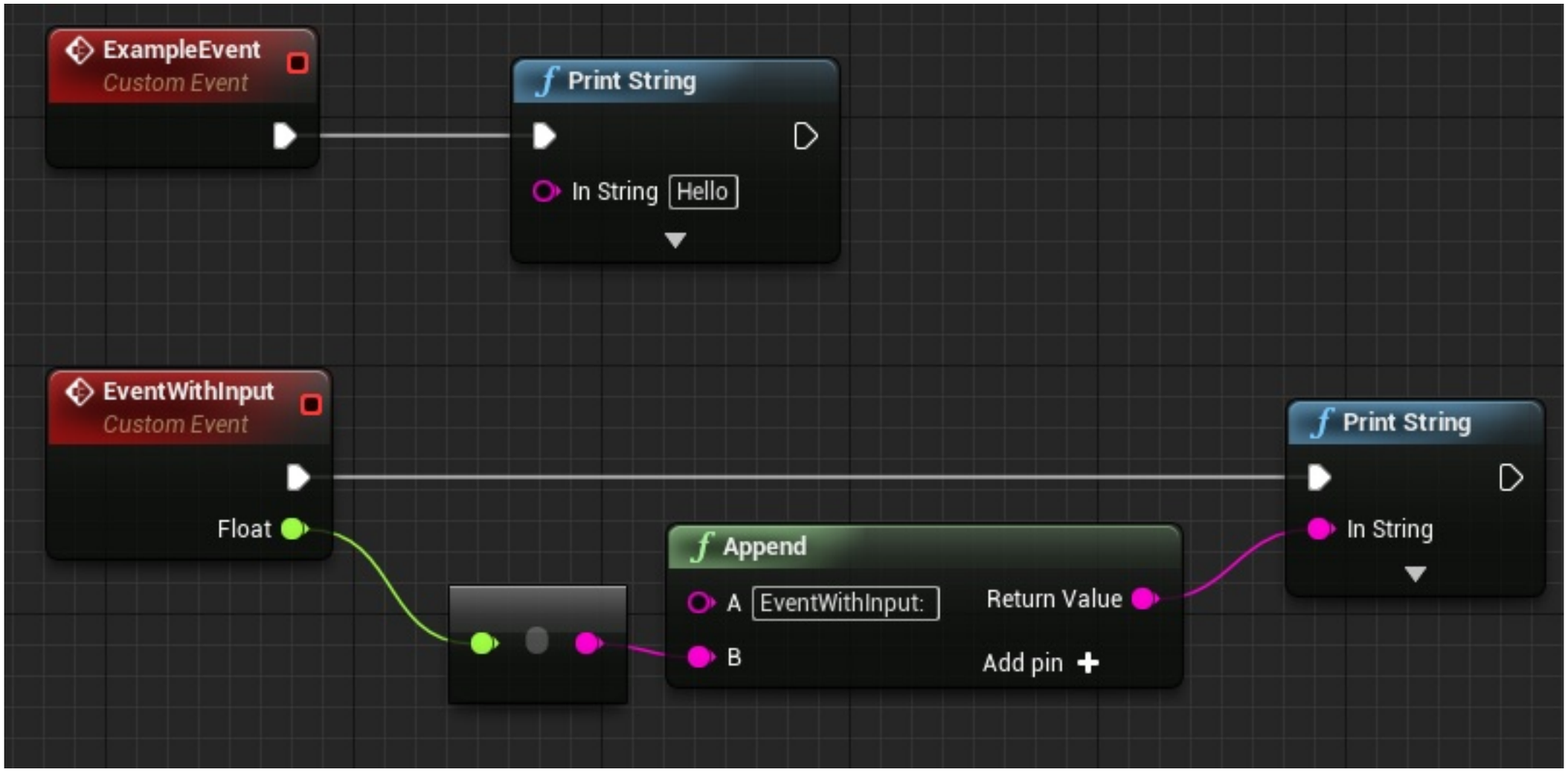
ACTORS' GAMEPLAY LOOP

- `OnConstruction(const FTransform & Transform)` called when actor is placed in editor or spawned at runtime
- `BeginPlay()` called when play begins for this actor
- `Destroy(bool bNetForce, bool bShouldModifyLevel)` called to initiate destruction of the instance
- `Tick(float DeltaSeconds)` called every frame on this actor
  - Avoid this at all costs!
  - How?

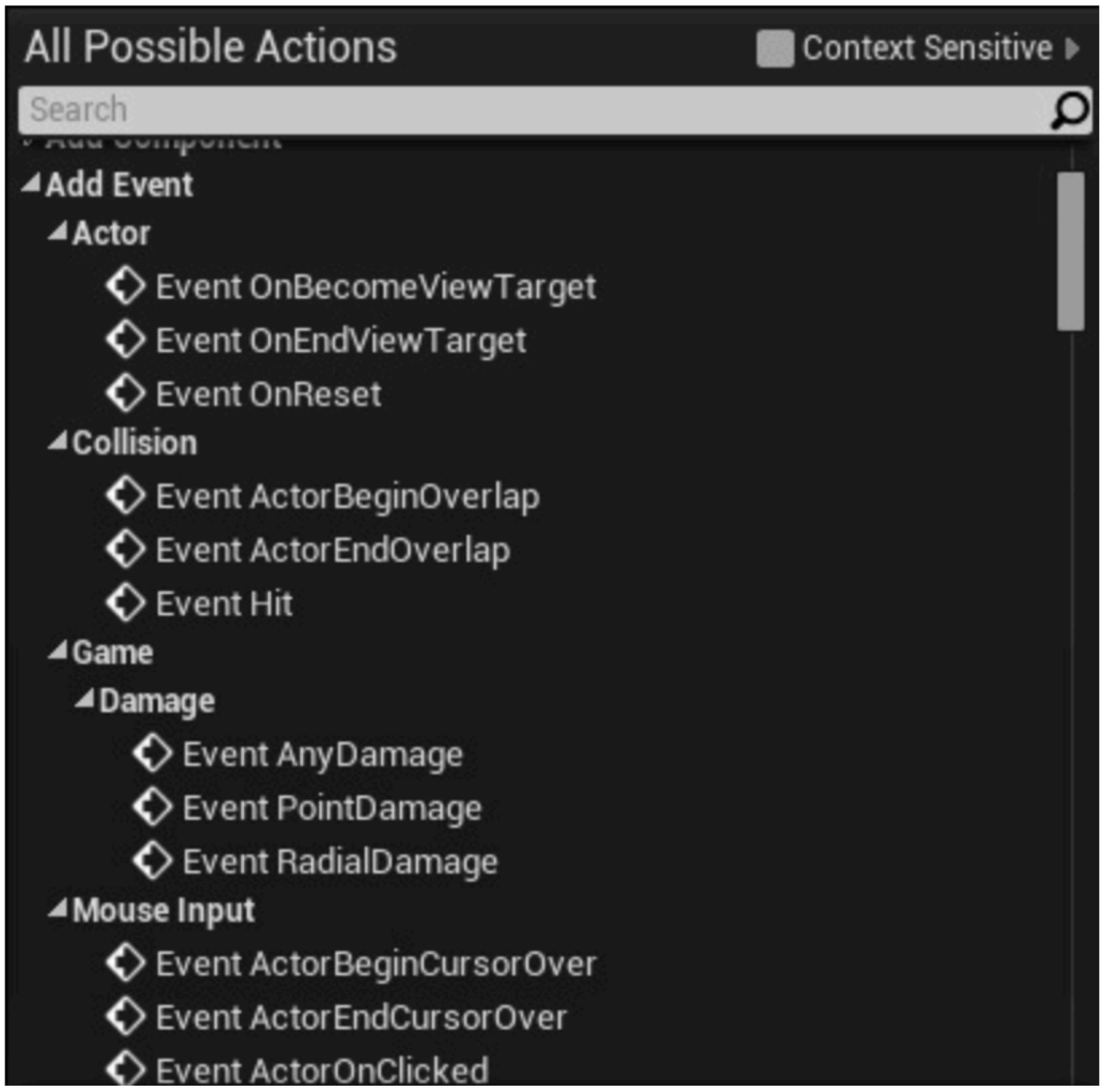
EVENTS AND DELEGATES

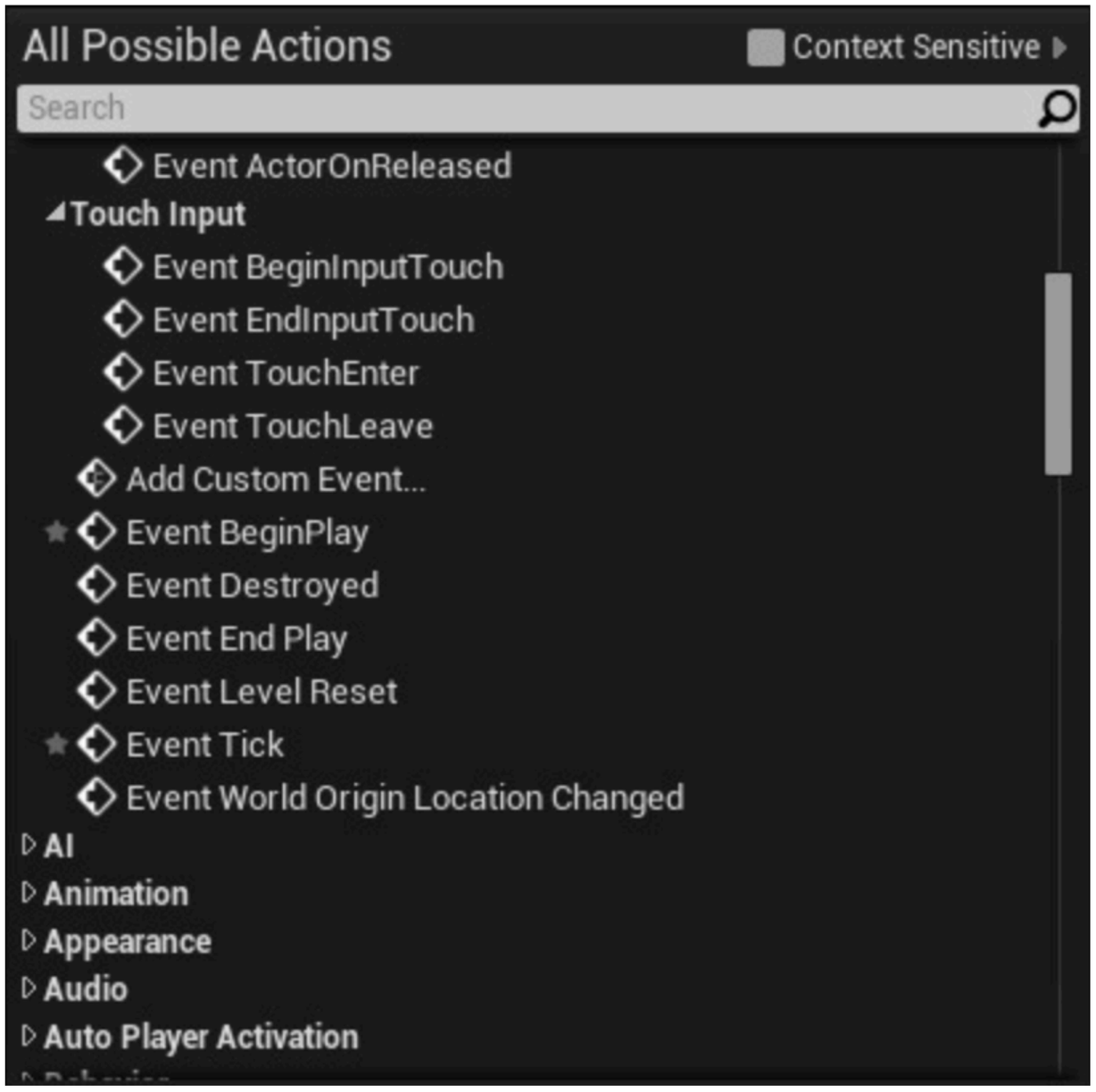
- Events (or timers/delegates) should be used over tick whenever possible
  - ...It should pretty much always be possible...
- Many Blueprint events provided for common use-cases
- Can implement/call events in either C++ or Blueprints
  - Must use function specifiers to override in C++
- Can use delegates for native C++ code (will cover those later)

USING BLUEPRINT EVENTS



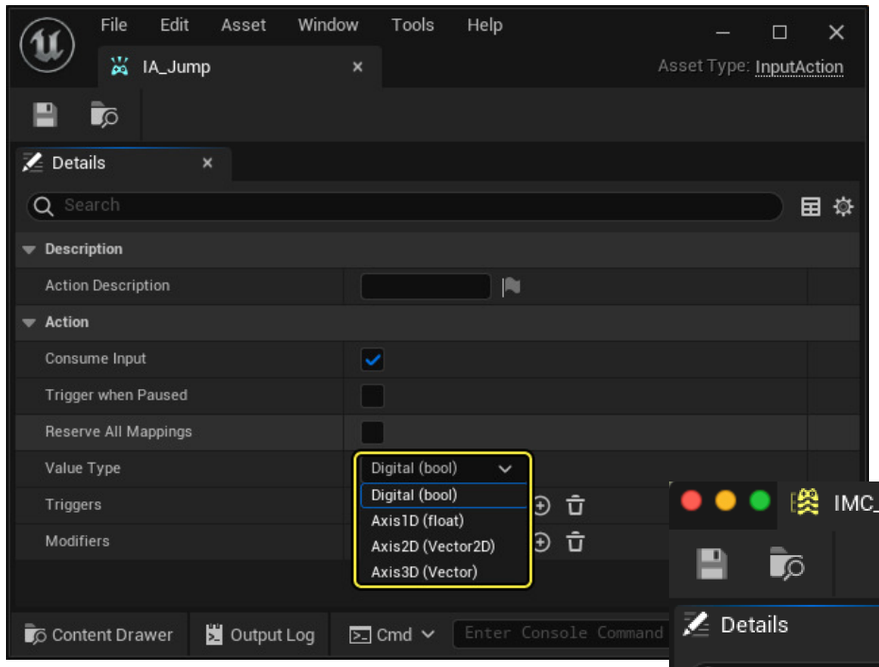
SOME BLUEPRINT EVENTS...

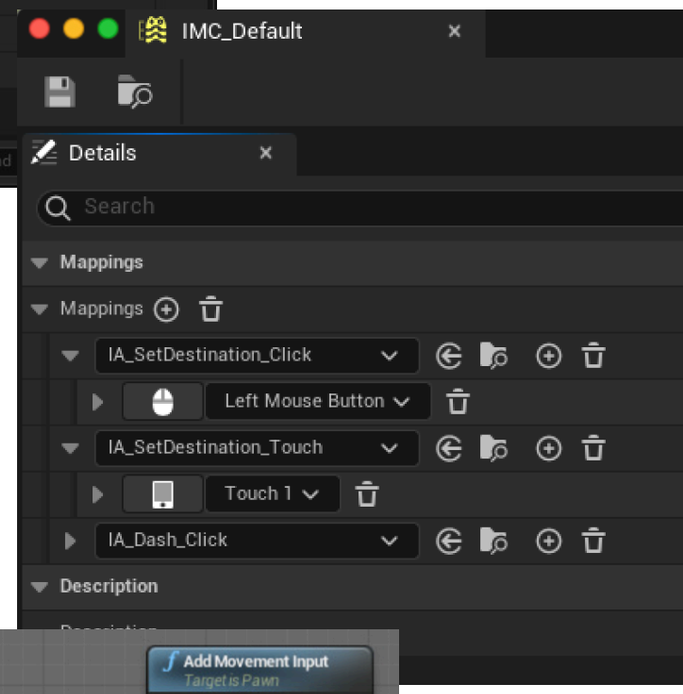


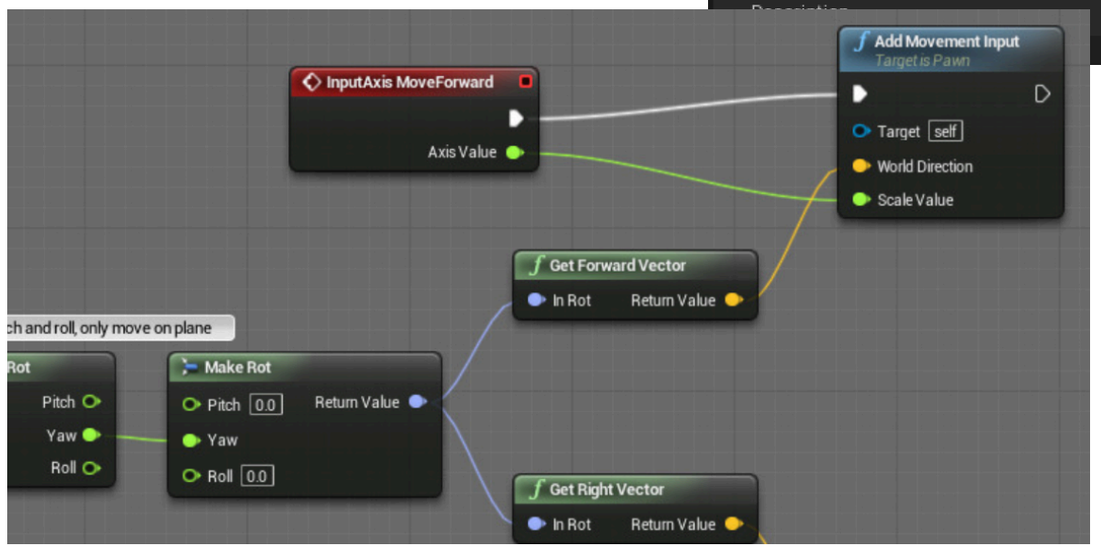


INPUT EVENTS

- Set input mappings via Input Actions
  - Handles axis (continuous) or action (press and release)
- Input Mapping Contexts link mappings to game actions within the controller to the pawn
- Input callbacks can be called from C++ or Blueprint

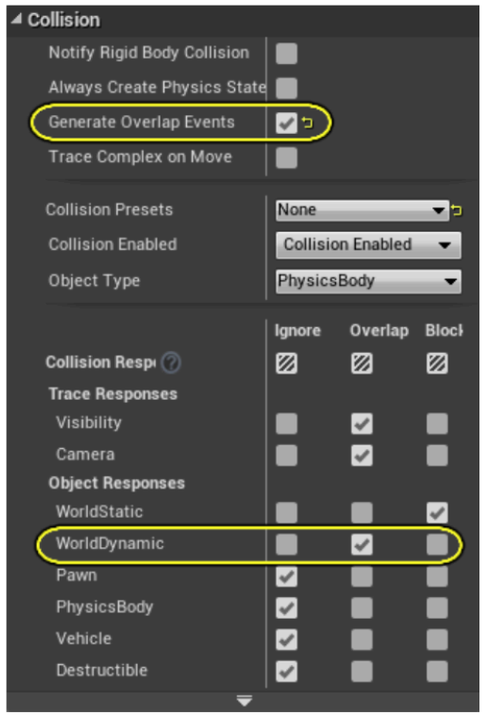


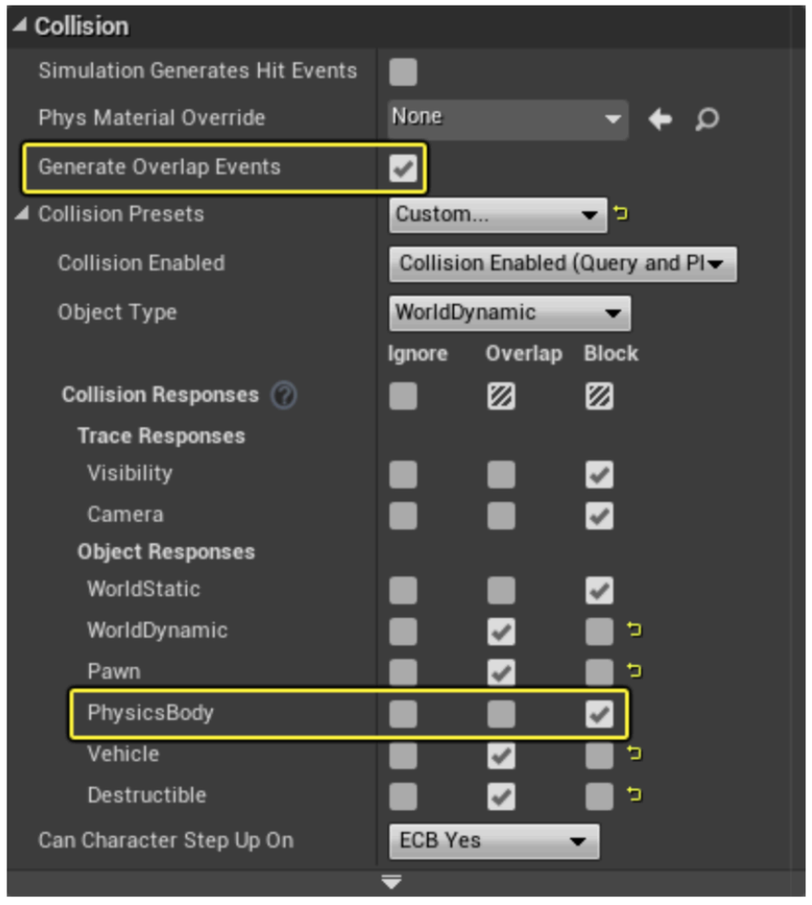




COLLISION AND OVERLAP EVENTS

- Can set actors to ignore, overlap or block other object types in the scene
  - Overlap will generate events but not result in a physical collision
- Block will result in a physical collision and generate events if flagged





WHAT ABOUT THINGS THAT AREN'T SPAWNED IN?

- Many "physical" things are spawned into a game level
- What sort of things are not spawned into a game level but are helpful to have/track?

GAME STATES

- Often we want to know something about the state of the game
  - How many people are playing?
  - Who is winning?
  - What are the rules?
- GameMode, GameState and PlayerState provide information about the current state and how to play

GAME MODE

- Game modes define the rules of the game and **exist only on the server**
  - Number of players/spectators present and allowed
  - How players enter and are spawn/respawned in the game
  - Pause-handling
  - Level-transitions and cinematic mode handling
- Two base classes to choose from:
  - AGameModeBase for simplified handling
  - AGameMode includes extra support for multiplayer and legacy systems
- Note: UE4 has two forms of Game Mode from its legacy as an arena shooter engine

GAME STATE

- Game states allow clients to monitor the state of the game and are **replicated to all clients**
  - Built around networked multiplayer but useful for local multiplayer/single-player as well
- Tracks game-wide properties such as:
  - List of connected players
  - Team scores
  - Missions completed

PLAYER STATE

- Player states are created for each player contain information about the player such as name, score, health, etc
  - Built around networked player but useful in local multiplayer/single-player games as well
- **Replicated to all clients** and contains network information (such as ping) about the player

HOMEWORK BEFORE NEXT CLASS...

- Makes sure you have completed Assignment 0 (creating an Epic account and downloading Unreal Engine 5.2.1) to the machine you will be working on for the rest of the semester
  - This will take a while and require a decent Internet connection so give yourself enough time!
- Next class will be Lab 1, where you will familiarize yourself with UE5
  - I will be streaming via Twitch in the classroom so you can choose to:
    1. Work from home
    2. Work in the classroom
    3. Work in the 1st floor lab