UNREAL ENGINE

UNREAL FOUNDATIONS

16 WEEK SEMESTER SYLLABUS

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Arise: A Simple Story | Piccolo

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It Takes Two | Hazelight Studios

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Shaun Foster (MFA) is the Director of 3D Digital Design at the Rochester Institute of Technology. With over 20 years of experience in 3D graphics and interactive educational design, he has worked on multiple award-winning 3D, interactive, film and VFX projects, received multiple grants, publishes, and speaks regularly at top conferences. His work involves next-generation media, education, and understanding the evolving nature of technology and how it transforms fields and the learning process.

He published a book on the Integration of 3D Modeling, Photogrammetry and Design, as well as a chapter on technology convergence between fields. He has helped build interactive 3D for grants on an NSF BioFuel (levels), a historical Asylum reconstruction, Unreal simulations for Machine Learning training, an AR Tourism app, and VR for medical education and interactive archives.

His recent work involves virtual production and mixed-reality curriculum development. In addition, please check out published educational materials on edX, Pluralsight.com and YouTube.com

CLASS SYNOPSIS

In this course you'll be given an overview of Unreal Engine, a top platform not only for game development and the creation of cutting-edge real-time 3D environments, but an essential tool driving important fields like VR/AR, training, architectural visualization, and more. The structure of this course is set up to be a survey to offer a window into multiple areas essential to interactive 3D production, while laying the groundwork to go deeper in time. By the end of this class, you'll know many of the core tools and techniques needed to hone different 3D-related skills, as well as which resources will allow you to effectively continue your journey into the growing field of interactive 3D.

Because the nature of Unreal Engine is multidisciplinary, it could be taught in different ways depending on the age, background, and knowledge level of your students. Each of the topic chapters can also be used as a foundation for advanced focus courses on each subject. Feel free to use, adapt, and implement the curriculum as best fits your needs! This course follows a format developed for a sixteen week edX course. The content bullet points follow videos created for that curriculum. If it fits your needs, all of the videos are about one hour, broken into 5-10 minute segments per week and are available for free on the audit track version of the edX course. Additional resources will be also listed at the end of this document.

RECOMMENDED HARDWARE FOR STUDENTS

- PC Desktop or Laptop
- 16 GB or higher RAM
- 6 GB or higher VRAM
- Windows 10
- 200+ GB free space
    - If you plan to use Quixel assets, or numerous asset packs, then please make sure you have access to more storage.

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WEEK-BY-WEEK COURSE BREAKDOWN

WEEK-BY-WEEK COURSE BREAKDOWN

WEEK 01 | COURSE OVERVIEW & GETTING STARTED

1st Session

- Course Summary
- Installing Unreal Engine & Account Setup
- Unreal Engine Overview and Resources
- Editor Interface Overview
- Templates & Creating Your First Project
- View Modes & Navigation Basics
- Summary
- Assignment 01: First Interactive Environment

WEEK 02 | MESH TYPES, INPUTS, COLLISIONS

1st Session

- Importing Meshes Collisions
- Mesh Editor & Mesh Types
- Greyboxing
- Static Mesh vs. Skeletal Meshes and Other Mesh Import Types
- Brief Blueprint Basics
- Assignment 02: Interactive Grand Space

2nd Session

- View Modes, Snapping, and Hotkeys
- Skydomes
- Lights (Overview) & Rendering Quality
- Rendering & Performance Basics
- Session Summary
- Assignment 02: Interactive Grand Space

WEEK 03 | LIGHTING

1st Session

- Lighting Overview:
  - Science, Optimization & Measurement
  - Lighting Design & Terminology
- Setting Up Your Scene to Light
- Light Types
- Use Cases: Static, Stationary & Moveable
- Lights Baking Lighting & Lightmap Resolution
- Assignment 03: Lighting

2nd Session

- Real Time Lighting & Shadows
- Lighting Effects: IES / Light Rays / Volumetrics
- External: Sun & Sky Actor Location & Time of Day
- The Road to Real-Time Raytracing
- Summary & Resources
- Assignment 03: Lighting

WEEK 04 | MATERIALS

1st Session

- Materials Overview
- Creating Your First Material
- Shading Models
- Masks Material Expressions
- Textures: Texture Map Types
- Assignment 04: Materials, Testing & Polish

2nd Session

- Instances & Master Materials
- Material: Parameters & Blueprints
- Non-UV Based Material Tools
- External: Quixel, Substance Designer Workflows
- Profiling & Baking Down
- Summary & Resources
- Assignment 04: Materials, Testing & Polish

WEEK 05 | PHYSICS: RIGID SIMULATION

1st Session

- Physics Content Examples
- Physics Bodies
  - Mass
  - Gravity
- Physics Forces
  - Motors
  - Forces
  - Constraints
- Assignment 05: Ready to Bounce Physics

2nd Session

- Physics Volumes
- Collisions & Complexity
- Introduction to Skeletal Physics & Rag Dolls
- Summary & Resources
- Assignment 05: Ready-to-Bounce Physics

WEEK 06 | POST-PROCESS VOLUMES (PPVS)

1st Session

- Overview
- Content Examples
- PPVs Key Settings
- Lens & Film Effects
- Tone Mapping
- Assignment 06: Post-Processing Playground

2nd Session

- LUTs
- Materials for UI
- Rendering & Stylization
- Visual FX Use Cases & Visual Warping Example
- Assignment 06: Post-Processing Playground

WEEK 07 | BLUEPRINT BASICS 01

1st Session

- Overview
- Content Examples
- Variables
- Debugging
    - Print
    - Breakpoints
- Blueprint Flow Control
- Blueprints Loops
- Assignment 07: Blueprint Basics

2nd Session

- Custom Events
- Blueprints: World & Local Space
- Randomization & Arrays
- Optimization
- Assignment 07: Blueprint Basics

WEEK 08 | BLUEPRINT 02: OBJECT ORIENTED

1st Session

- Review & New Content Examples
- Understanding Object Actors & Classes
- Actor Class
- Child Blueprints
- Interactive Door
- Assignment 08: Blueprints and Objects

2nd Session

- Interactive Key
- Cross-Blueprint Communication: Combining the Door and Key
- Line Traces & Physics Handles
- Assignment 08: Blueprints and Objects

WEEK 9 | LARGE ENVIRONMENTS & OPEN WORLDS

1st Session

- Overview of Landscapes
- Landscape Creation Tools
    - Landmass Plug-in
    - Sculpting
    - Displacement
- Landscape Materials
- Foliage vs Procedural Foliage Tool (Introduced)
- Assignment 09: Mountains & Valleys

2nd Session

- Lakes & Rivers
- Level Streaming
- Sky Dome (Review), Volumetric Cloud Example
    - Sky Lighting & Vocabulary: Mie, Rayleigh & Crepuscular Rays
- Review: Geographically Accurate Sun Position Tool
- GIS: Cities & Urban Planning
- Concept and Discussion – Open Worlds (Core Games Example)
- Summary & Resources
- Assignment 09: Mountains & Valleys

WEEK 10 | SKELETAL MESHES

1st Session

- Skeletal Mesh Overview
- Content Examples & Pipeline
- Tools & Terminology
- Socket Manager
- Control Rig (Introduction)
- Assignment 10: Skeletal Mesh

2nd Session

- Skeletal Mesh Overview
- Spline Animation
- Morphs
- Cloth
- Rag Doll Simulations & Secondary Motion
- Character Workflow Overview
- Assignment 10: Skeletal Mesh

WEEK 11 | **AUDIO AND AI**

1st Session: Audio

- Audio Overview
- Content Examples & Vocabulary
- Ambient & Triggered Audio
- Volume Occlusion & Focus
- Sound Cues
- Audio Cue & Physics
- Summary & Resources
- Assignment 11: AI & Audio: Spatialize and Randomize

2nd Session: AI

- Overview
- Content Examples
- AI Perception
- Sight
- Sound
- Behavior Trees
- Patrol
- Move to
- Wait
- EQS & ther AI
- Summary & Resources
- Assignment 11: AI & Audio: Spatialize and Randomize

WEEK 12 | TEAMWORK PIPELINES, SCRUM & TESTING

1st Session

- Overview
- Optimal Habits & Tools
- Communication
- Leadership, Teamwork & Group Process
- Organization, Pipelines & Optimization
- Assignment 12: Mini-Group Project

2nd Session

- Overview
- Teamwork Project Planning: The Gantt vs. Burndown
- SCRUM Process
- Scope Creep
- Testing, Multi User Editing & Version Control
- Summary & Resources
- Assignment 12: Mini-Group Project

WEEK 13 | SEQUENCER & CINEMATOGRAPHY

1st Session

- Sequence Overview
- CineCamera Actors & Optics 101
- Rigs & Track
- Sequencer Interface & Animating
- Creating a Sequence (Basic)
- Material Parameters Collection & Blueprints
- Summary & Resources
- Assignment 13: Sequencer

2nd Session

- Shots & Takes (Level Master & Subscenes)
- Triggering a Sequence
- Recording & Machinima
- Spawnable Workflow
- Output Video
- Assignment 13: Sequencer

WEEK 14 | UMG:UNREAL MOTION GRAPHICS INTERFACES

1st Session

- UMG Core Elements & Basics
- Widgets: Creating & Adding an Interface to Screen
- Displaying & Hiding Mouse
- Adding a Button Events & Property Binding
- Making the Button Work
- Assignment 14: UMG: HUDs and Diegetic Interfaces

2nd Session

- UI Design Basics Styling / Visual Control
- Interfaces Inside 3D Space (Diegetic UI for 3D Widgets)
- Intermediate / Advanced Topics (and Resources)
- Summary & Resources
- Assignment 14: UMG: HUDs & Diegetic Interfaces

WEEK 15 | VISUAL EFFECTS WEEK!

1st Session

- Overview
- VFX-related Content Examples
- Niagara Particle System Overview
- Chaos Engine with a Focus on Fracture Meshes
- Assignment 15: FX

2nd Session

- Effects Focus Content Review From Earlier This Semester
    - Lighting
    - Materials
    - Physics
- Introduction to Compositing with Composure
- Combos & Connections (Internal/External)
- Summary & Resources
- Assignment 15: FX

WEEK 16 | OPTIMIZATION AND PUBLISHING

1st Session

- Course Overview
- Pre-Publishing Steps
    - Adding Pause & Quit Buttons
- Publishing Your Project
- Publishing & Troubleshooting
- Assignment 16: Publishing & Optimization

2nd Session

- Performance & Profiling Basics
- Optimization by Category
- Profiling and Optimization Demo
- Looking Ahead, Unreal Engine Opportunities Across Multiple Disciplines!
- Assignment 16: Publishing & Optimization

ASSIGNMENTS

Courtesy of REWIND and HBO

ASSIGNMENT 01 | FIRST INTERACTIVE ENVIRONMENT

- Look at environments from both the real and virtual worlds that inspire you.
- Create a small environment using items from the Starter Content folder
- Add meshes (with snapping turned on)
- Add/confirm your collision meshes work the way you want them
- Lights: Use the hotkey (L) from the tutorial to add point lights to your scene
- Materials: Add materials to the environment from the Starting Content folder
- Files & structure: Did you save a level? How is a level different from a project?

return

ASSIGNMENT 02 | INTERACTIVE GRAND SPACE

- Use Brush Actors to build a large environment.
    - What do Brush Actors do well compared to other modeling programs?
- Add materials to the environment pieces; set the tiling / scale
- Look carefully at how the materials are aligned to your brush objects. Do you need to move them? How do materials apply differently when using brushes vs. meshes?
- Practice using hotkeys and snapping to accelerate your work
- How much of a speed-up do you notice?
- Can you imagine how much that speed-up saves you over a year's time?
- Build one (or two) simple asset(s) and import it into the engine
- Set up their collisions and materials. Do you need custom collisions? Do any of the objects you brought into the engine have issues like the tunnel and need adjusting?
- What can make this more exciting to navigate?

return

ASSIGNMENT 03 | LIGHTING

- Pick the space you built in Assignment 01 or 02 and light it to feel "happy" or "moody"
- Choose two static mesh actors
    - Examine their UVs
    - Modify the Light map resolution (look at the different LODs)
    - How does this affect bake times and the look of the shadows?
    - Look at your frame rates (ctrl+shift+H)
    - Change to different view modes (Alt + 1 - 8)
- Review: Test out your previous levels with dynamic and baked lighting
- Imagine the space you build is used for a specific purpose. What lighting design would improve, or "intensify," this look / utility of the space?

- Add an “effect” type lighting to your level (IES profiles (free), light rays or volumetric fog)
- How can you add IES profiles in a way that helps guide the viewer's eye to key areas?

return

ASSIGNMENT 04 | MATERIALS, TESTING & POLISH

- How does adding color to your lights affect your material work? Combine lighting & material workflows
- Imagine what the space you build is used for. What types of materials would intensify this look and feel?
- Develop several of your own custom Master Materials
- Use a mask texture on one of your materials (advanced example)
    - Can you use the mask for different colors?
    - Transparency?
- How far / different can you push the materials with one master material?
- Build a decal or use vertex painting to add non-tiled looking customization

return

ASSIGNMENT 05 | READY-TO-BOUNCE PHYSICS

- Include at least two objects within this scene. Think of natural and human-caused events that involve physics and radically modify or transform an environment. Natural might be tree falling, practical could be a cart rolling down a hill. Whimsical could be a (small) Rube Goldberg machine

Technical requirements are:

- Make 2-3 objects dynamic.
- Has some of the objects not “awake on start”
- Have 1 or more constrained object(s) (**tutorial**: here is an idea)
- Attach a thruster
- Activate the sequence with Blueprints

return

ASSIGNMENT 06 | POST-PROCESSING PLAYGROUND

- Research films or games that use color palettes to help emphasize the mood
- Using the lesson videos use one or more Post Processing Volumes (PPVs) to create different color grading, or lens effects, to complement this environment. Is there a way to combine the physics and post-processing volumes in your environment?
- One possible post-processing challenge: Develop two different global looks:
- Use a LUT (Lookup Table - see tutorial link below). Build your own LUT inside of a program like GIMP or Photoshop
- Adjust: Saturation, Hue, Bloom or Vignetting etc. to develop your second look
- Take screenshots with / without your LUTs on (tutorial)

return

ASSIGNMENT 07 | BLUEPRINT BASICS

Practice your Blueprint skills by completing the following steps:

- Look at the Unreal Content Examples. Review and examine 1.1 Blueprint "Hello World" to 1.7. Ask yourself if you could duplicate these examples? Pick one for your own level

Create three Blueprints events inside the Level Blueprint:

- Add a trigger volume that modifies a text actor and changes the displayed text to a different message when you enter the volume
- Build off of the exercise in weeks one and two, where you turned on a light or triggered audio
- Use a variable counter (integer) so that each time any event is triggered in your scene you increase by one. Use Print commands to display the results of these actions
- Use Flow Control so that you either display a different message or you stop after you reach a number of your choice

Optional Bonus: Prefabricator is a free tool available in the Marketplace. Download and reverse engineer how it works

return

ASSIGNMENT 08 | BLUEPRINTS & OBJECTS

The tutorials demonstrate the creation of a reusable door and key actors. This is a good example of cross-blueprint communications. Follow those tutorials:

- Create a door Actor that opens when the user walks up to it. Add variables so that each door can be set to only work with a specific type of key
- Create a key Actor that can be set to a different door number type
- Design (on paper) a game that could use doors and keys. Consider a simple maze game. Could you add a time element or other random factors to make this more fun?
- **Bonus**: The tutorials combine lessons from week four, demonstrating interactive materials. Set up your Actors so the Key and Doors change color to reflect the type.
- **Bonus 2**: Use the key pick-up to give you temporary powers in some way (similar to the "power-up/jump" example)

Additional Support & Reference for Blueprint Communications:

Blueprint Communications | Live Training | Unreal Engine 2016 (2.2hrs)

return

ASSIGNMENT 09 | MOUNTAINS & VALLEYS

Following the examples of building a landscape, develop one that has sculpted areas:

- Apply 2-3 materials to the landscape
- Do some quick research on geology / geography. Is your environment real or fantasy?
- Can you combine the landscape with a static mesh? Example: build a pool in the landscape or a lake
- Add trees and grass
- Look at what materials are available on Quixel. What did you find that could accelerate your work?
- Optional: Add areas for roads (Landscape Spline Tool tutorial link)

Look at

- Building Natural Environments to the Unreal Engine by Paulo Souza 6/2020
- Brushify tools
- ESRI City Engine

How could you use these workflows or tools to accelerate your environment development and design?

return

ASSIGNMENT 10 | SKELETAL MESH

Choose two:

- Create an animation with the Control Rig.
    - **Bonus**: Can you turn on partial physics to achieve secondary motion?
- Create one or more objects that object move around the scene on a spline
- Morph an object that transforms into two to three different forms
- **Bonus**: Corrective blend shape: make the object transform based on the rotation of joints
- Make the skeletal mesh transition from animating to a rag doll. Can you do a partial rag doll?

return

ASSIGNMENT 11 | AI & AUDIO: SPATIALIZE AND RANDOMIZE

- Create an audio source that attenuates and spatializes
    - **Optional**: Randomize them (example from videos: choose different bird tweets that randomly play at different time intervals)
    - Create an Actor Blueprint that will trigger sounds when the user overlaps them
- Use the third-person character template and build an AI system that can see you
- **Optional/Advanced**:
    - Connect your work with materials, to have different walking sounds that respond to different materials the character walks on: Example: walking across wood, metal, stone, etc.
    - Can you set up your scene so that audio not only attenuates, but the audio is blocked (or muffled) by objects in the scene?

return

ASSIGNMENT 12 | MINI-GROUP PROJECT

- Plan to participate in a mini-group project, anijam, or collaborative contest
- Develop a burn-down chart or Gantt chart (but make sure to use SCRUM principles) for
- production
- Describe how your team would:
    - Divide up labor
    - Organize your assets in a repository
    - Use naming conventions
    - Communicate
- Given this is a one week assignment, practice a minimized version of the above
- Research ways of doing intermediate workflows of one of the previous pieces with intermediate workflows. Examples: Height-driven materials changes for landscapes, synesthesia (drive movement or color with audio).

- End-of-week post mortem
    - Give (constructive) feedback
    - Write down what went well, what you learned, and how you would improve a group process next time

return

ASSIGNMENT 13 | SEQUENCER

- Pick a 2-5min scene from one of your favorite films
- Use the log sheet (duplicate it, so you can type on it)
- Fill in and identify how the scene is shot
- Rapidly build a previs of the scene
- Block in your lighting
- Add (a minimum) of two CineCameras

Bonus:

- Set up one shot with a rack focus or zolly
- Set up a multi-shot sequence with several shots reflecting the scene:
- Develop your Level and Master tracks
- Add a Material Parameters Track to your level sequence (tutorial)

return

ASSIGNMENT 14 | UMG: HUDS AND DIEGETIC INTERFACES

HUD (Heads-up display) interfaces are used to provide feedback and often may also provide an on-screen set of controls for the user. Use UMG to build a simple interface. Follow the videos in the chapter to build your own system which keeps track of points and health (or follow the Quick Start Guide).

Challenge:

- Create a customizable Blueprint(s) that allows you to modify different point values that reflect on the user interface
- Review the videos in this chapter and in the Week 8 Blueprints content where we build a “power-up” that modifies the players ability to jump
- Build a “debuff” (an effect that negatively impacts the player character in some way other than reducing their health). Perhaps one that temporarily slows the character? How about reducing or blurring the players vision?

Research; Design & Critical Thinking:

- What interfaces do you use every day?
- What makes them more or less effective?
- Look on the Unreal Marketplace: User Interface
- If you had to develop a user interface, would you build one from scratch or use one from the Marketplace?
- Review some of the icons available in: The Noun Project
- What do you think makes a good icon, and why? (research Semiotics)

Diegetic interfaces (interfaces that exist in 3D space) are becoming more important in games and virtual reality experiences. The games Dead Space, Far Cry 2, and the Fallout franchise are often written about. Research how the interface was implemented in these games and contrast with how new interfaces are being implemented in virtual reality or augmented reality.

- Example article 01: Game UI
- Example article 02: VR UI

return

ASSIGNMENT 15 | **FX**

Use a Niagara particle system within the sequence to add sparks to an environment.
Have the particles:

- Change color as they age
- Spawn more particles on collide

Unreal Chaos destruction can be used to create visual effects. How is it different from a "destructible mesh?"

Using tools and techniques from earlier in the class develop visual effects:

- Light the "flashes" brightly
- Material that is strongly emissive, uses a flipbook or rotator
- Post-process volume or material

return

ASSIGNMENT 16 | PUBLISHING & OPTIMIZATION

Review elements from the entire class:

- What areas do you remember best?
- How do you plan to go deeper in the future?
- What advantages do teams have over solo developers?

Choose one of the levels you have built that you want to turn into a playable system.

Examine the running frame rate

- Key statistics (GPU / CPU) (ms) in your project
- Look at your project through the lens of the performance profiler
- Are there areas you can optimize?
- Try some of the listed "high impact" elements on your scene and look at the impact on frame rate:
    - Particles (overdraw)
    - Lots of interactive lighting
    - Big transparent objects, large decals, etc.
- Write down the optimizations you've made and how much they have improved gameplay
- If possible, compare on different system configurations of stronger / weaker computers
- Publish an executable for your project

return

RESOURCES AND UNREAL ONLINE LEARNING CONTENT

edX – Unreal Foundations
Three mini-course certificate (free and paid)
For the free Audit version—go to each separate course at the bottom and choose Audit
The course contains over **170 videos** in 16 units!

Overview & Links **Mind Map (**video**)**
Unreal Foundations *Interactive* Mind Map

Resources Page
Resources Doc

Vocabulary Page
Vocabulary Doc

Unreal Online Learning Courses

Introducing Unreal Engine
Introducing Unreal Engine

Lighting in Unreal Engine
Lighting Essential Concepts and Effects

Materials
Unreal Editor Fundamentals - Materials

Blueprints
Blueprints - Essential Concepts

Materials and Instancing
Materials - Exploring Essential Concepts
Materials - Understanding the Production Workflow

Environment Lighting
Sky, Cloud and Environment Lighting in 4.26

Volume Lighting
God Rays Using Volumetric Fog

Sequencer

Your First Hour in Sequencer

Sequencer Training for Cinematic Shot Production

Landscape / Environment

Landscape Essential Concepts

UMG

Your First Hour with UMG

Optimization

Analyze Performance & Apply Common Optimizations

Image courtesy of Andrew Svanberg Hamilton

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